



## Catalog 25

DAY TANKS  
FLAME SCANNERS  
FUEL OIL SPECIALTIES  
BOILER CONTROL SYSTEMS  
LINEAR & ROTARY ACTUATORS  
FLAME SAFEGUARD CONTROLS  
FUEL OIL TRANSFER PUMP SETS  
DISTRIBUTED CONTROL SYSTEMS  
BOILER MONITORING INSTRUMENTS  
PHYSICAL AND CFD FLOW MODELING  
TANK GAUGE & LEAK DETECTION SYSTEMS  
MODULATING LEAD/LAG CONTROL SYSTEMS  
HIGH EFFICIENCY, LOW NOx COMBUSTION SYSTEMS  
COMBUSTION CONSULTATION / FLOW MODELING SERVICES

Preferred Utilities Manufacturing Corporation

31-35 South St • Danbury • CT • 06810

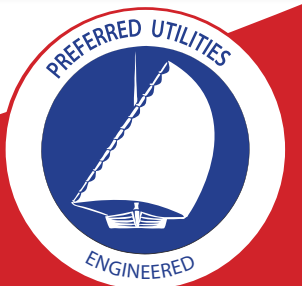
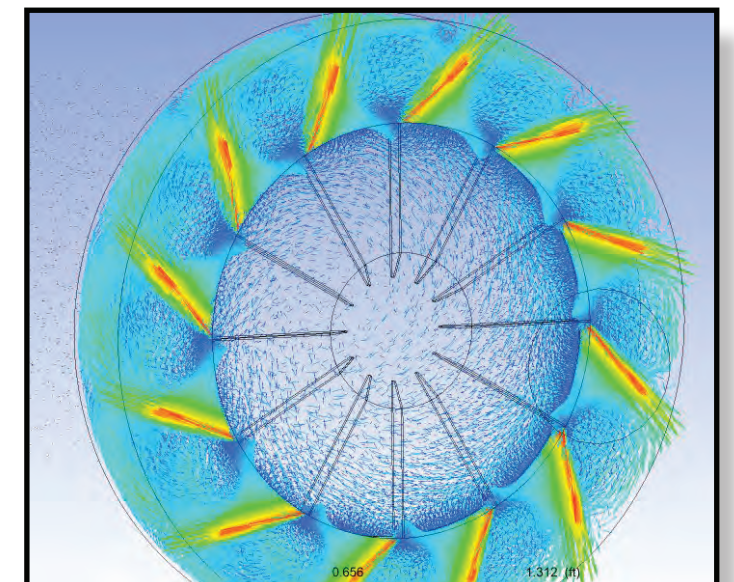
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*"People. Products. Results."*



MADE IN THE USA





# Catalog 25



## Combustion Systems & Fuel Handling Handbook

**PREFERRED**  
**UTILITIES MFG CORPORATION**



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**Independent Sales & Service**  
Representative offices located  
throughout North America

*“When a man’s ways please the Lord, he maketh even his enemies to be at peace with him. Better is a little with righteousness than great revenues without right. A man’s heart deviseth his way: but the Lord directeth his steps.”*

*—Proverbs 16:7-9*

## People

The engineers at Preferred come from diverse backgrounds and have unique specialties. Some come from a utility boiler background and design combustion systems for field-erected boilers the size of high rise buildings, while others came up through the basement boiler rooms of New York City.

Preferred’s engineers pull from decades of practical experience and fundamental engineering practices. Their long experience dates back to the development of some of the earliest Low NOx burners. In the 1980’s, these burners redefined what low emissions meant for the industry. Our severe duty rotary cup burners became the golden standard of combustion, and many of these robust units are still in service today.

Preferred has taken this experience to another level, and utilizes both physical scaled Plexiglas models and computational fluid dynamic (CFD) computer models to understand and resolve challenging combustion-related issues. This deep passion for combustion and investment in our people has allowed us to remain on the cutting edge of combustion technology.



## Products

While you may see a Preferred controller on your new boiler, or a Preferred pump set feeding your new generators, our real passion is engineering complete projects that draw on our expertise in combustion, industrial controls, flow modeling, and fluid handling, to provide a complete system that works for our clients.

The burners, control systems, pumps, valves, and other items in this catalog are the building materials Preferred engineers put together to make complete systems. Preferred’s representatives, sales engineers, and factory engineers are constantly in our customer’s offices and plants developing new projects, evaluating upgrades to existing equipment, and steering existing projects through to completion.

How can we better meet our customers’ goals for efficiency and reliability? What can be done to make these systems easier to operate? How can we increase safety without increasing downtime? What can be done to make these systems less expensive? The products in this catalog were developed with these questions in mind.

## Results

Combustion engineering is our most important discipline. Our burners, flame safeguard systems, combustion control systems, and fuel supply/blending systems are all designed by combustion engineers for use in our combustion projects. Although our fuel oil handling group does mostly diesel generator work now, its roots are in the pump and heater sets that once supported our heavy oil fired burners.

From the company ownership to the field service technicians, all have a background in and a passion for combustion. Our goal is to be the best in the world at combustion projects, including boilers, burners, fuel handling, controls, and all the accessories that make these systems work.

Since publishing our last catalog, Preferred has grown considerably in capabilities, personnel, and revenue, so we are inclined to think we’re doing something right.

***Let’s get results—  
Together.***

## What's New?

### Flexible System Controller (FSC)

The FSC controller is an inexpensive control platform when used in single node applications. In multi-node configurations, up to ten FSC controllers can be combined using a peer-to-peer, redundant communication network for large control applications. A multi-node system can include large numbers of inputs and outputs, reduce system cost by using pre-programmed individual nodes, reduce installation cost by linking FSC nodes using a digital communication network, and increase reliability by using a redundant communication network, and a master-less system architecture that allows remaining nodes to continue operating if individual nodes go down. Applied first to fuel oil handling systems, the FSC control platform will be extended to all of our common control applications.



### Waterproof Pumps

Preferred's WP series of patented waterproof fuel oil pumps are the first fuel oil pumps contained in waterproof enclosures for use in areas subject to flooding. Designed for use in facilities with underground fuel oil tanks, these high pressure pumps can supply oil to boilers and generators high up in high rise buildings, and withstand sea water submersion to keep critical pumps running in an emergency.



### Fuel Gas Blending Systems

In collaboration with generator manufacturers and biogas suppliers, Preferred developed fuel gas blending systems for boilers and generators. These systems are designed to accurately blend biogas with natural gas, with preference given to the biogas to reduce natural gas consumption. Perfect for facilities that have their own source of digester gas, landfill gas, or other manufactured fuel gas, and want to minimize natural gas consumption and expense.





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## History Since 1920

Preferred Utilities Manufacturing Corporation was founded in 1920 by oil heating engineers who foresaw the demand for accessories designed specifically for oil burning applications.

In 1927, virtually at the request of the rapidly growing industry, "Preferred" published its first Oil Burning Accessory Catalog. This service was immediately accepted and its continued success confirms customer satisfaction.

In 1946, a new and modern manufacturing plant, located in Danbury, CT was completed. Shortly after, the larger and comprehensive Catalog 16 was completed.

From 1946 to this day, the work of responding to the requirements of commercial, institutional, and industrial plants continues. Today, Preferred engineers are designing equipment for use during nuclear power plant outages, new and improved emergency diesel generator fuel transfer pump sets, instrumentation, and complete combustion systems for hot water and steam generating plants. This new Catalog 25 includes our fuel handling, instrumentation, and combustion products. Consult our factory for your custom engineered product requirements.

### Fuel Oil Handling Systems

Since 1920, Preferred has been actively and prominently identified with the oil burning industry in all its phases. Over the years the company has been developing and manufacturing new and advanced fuel oil pump sets and accessories.

Preferred has been providing fuel oil transfer system single source responsibility since 1989 by packaging together its pump sets, day tanks, tank gauges and accessories with sophisticated microprocessor-based control and monitoring systems.

### Burners/Boilers

In the war years of the 1940s, Preferred served the war effort by developing and manufacturing new and advanced automatic No. 2 through No. 6 fuel oil and natural gas burners.

In 1941, Preferred designed and produced its first factory packaged four pass down draft firetube boiler with integral burner, controls and accessories. Production of the "Unit Steam Generator" continued for 30 years, with over 3000 boilers shipped.

In 1972, W.N. Best Combustion was purchased, bringing in a line of heavy industrial and specialty waste burners.

In 2001, W.N. Best Combustion retrofitted its first XPlus Combustion System to a 20,000 pph water tube boiler. Using our unique design focus and capability, this burner system achieves and maintains high efficiency and low emissions.

### Instruments and Controls

In 1964, Preferred purchased the instruments division of General Controls, Inc. adding draft, flue gas temperature, and boiler lead/lag control product lines.

In 1972, Preferred installed its first digital combustion control system. These controls were part of a series of retrofit projects wherein



*Preferred's Danbury, CT  
Factory Around 1950.*

Preferred engineered, designed, and manufactured a complete and integrated package of burners, flame safety systems, pump and heater sets, sensors and controls.



In 1978, Preferred purchased Rimcor Instruments and their line of analog combustion and oxygen trim controllers. Preferred-Rimcor Instruments then began the design and production of microprocessor-based boiler efficiency instruments, controls and digital oil tank gauges.

Since 1982 Preferred has designed, manufactured and commissioned microprocessor-based controllers, Supervisory Control and Data Acquisition Systems (SCADA), and boiler monitoring equipment. This equipment has been installed on thousands of boilers and in hundreds of process plants.

Preferred purchased G.N. Electronics in 2007, offering flame detection and supervision for the boiler and process heat industry.

In 2010, Preferred Special Combustion Engineering (PSCE) was established to specialize in our most challenging projects including: multiple burner boilers and burners fired on unusual fuels, and the associated controls, instrumentation, and project management to make these projects successful.

### Nuclear Industry

In 1980, the Preferred Engineering division was formed to service the nuclear industry with tools and services that speed and improve the safety of outage activities.

### Complete Combustion Systems

Today Preferred is a trusted supplier of burners with a unique ability to provide single source responsibility for performance of the burner, controls, flame safety system, SCADA and fuel handling systems.







Preferred Utilities Manufacturing Corporation is an engineering-based manufacturer of products for commercial, institutional, industrial and nuclear power facilities. Our products include fuel oil handling systems and components, boiler instrumentation and controllers, high quality burners and nuclear power plant outage reduction tools and component parts. Continuous research and development is applied to our existing products and is helping us to lead the industry with new and innovative power plant solutions.

Preferred Utilities' manufacturing, engineering and administrative headquarters is located in Danbury, Connecticut. Preferred Special Combustion Engineering is located in Tulsa, Oklahoma. Regional sales and service offices are located throughout the United States. Preferred Utilities' regional sales offices serve to continuously strengthen the sales and service capabilities of our independent representative organizations.

## Five Divisions

### PREFERRED

Utilities

Preferred Utilities engineers, designs, and fabricates fuel oil handling systems for boilers and diesel generators. Typical systems include fill containers, transfer pumps, day tanks, tank monitoring equipment, filtration systems, and control systems.

Preferred specializes in engineered systems for mission critical facilities such as data centers, emergency response centers, hospitals, and pumping stations. The new FSC controller was specifically designed for large, spread out fuel systems for data center customers.



*Above: Custom pump set with duplex basket strainers.*

### PREFERRED

Instruments

Preferred Instruments manufactures microprocessor based controllers, flame detectors, instruments, and electric actuators for combustion and process applications. Preferred Instruments' products include linkageless controllers, boiler lead/lag controllers, boiler monitoring instruments, draft controllers, and actuators.

Through the acquisition of G.N. Electronics in 2007, Preferred became a major supplier of flame safeguard and control systems for the process heating industry. With a complete line of flame safeguard products including flame safeguard controllers, annunciators, and flame scanners, Preferred has the product and expertise for your process control application.

## **PREFERRED ENGINEERING**

Preferred Engineering was formed in 1980 and engineers and manufactures outage support equipment for nuclear power plants. Products include: Main steam line plugs for MSIV testing, RPV plugs, remotely-actuated lifting devices, quick lock fastening and seal systems and many others. Preferred Engineering furnishes a full Nuclear Quality Control program.

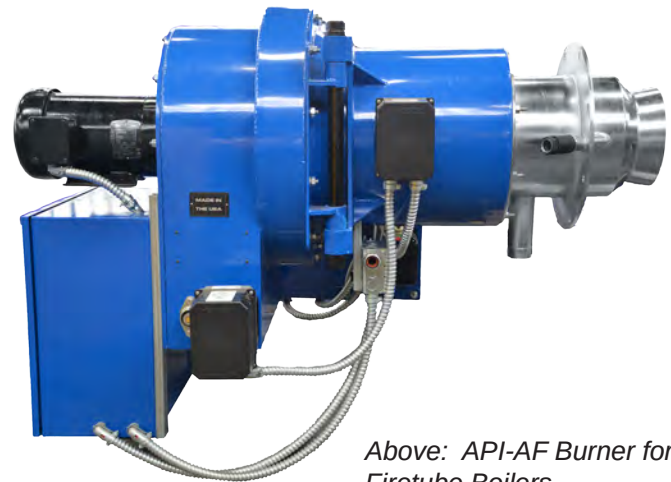


*Left: Fuel Plug*

## **PREFERRED** W.N. Best Combustion

W.N. Best Combustion, founded in 1890, manufactures industrial low NOx No. 2 - No. 6 oil and gas burners, along with specialty systems and burners for thermal decomposition of sludges and contaminated petroleum products for product regeneration and heat recovery.

W.N. Best specializes in sulfuric acid sludge decomposition and elemental sulfuric acid production. In 2001, W.N. Best introduced its new, industrial, high efficiency, low emissions burner for No. 2 - No. 6 oil and gaseous fuels. This low emissions burner utilizes state-of-the-art control and mechanical technology to produce low-NOx combustion at the highest efficiencies possible in the marketplace today.

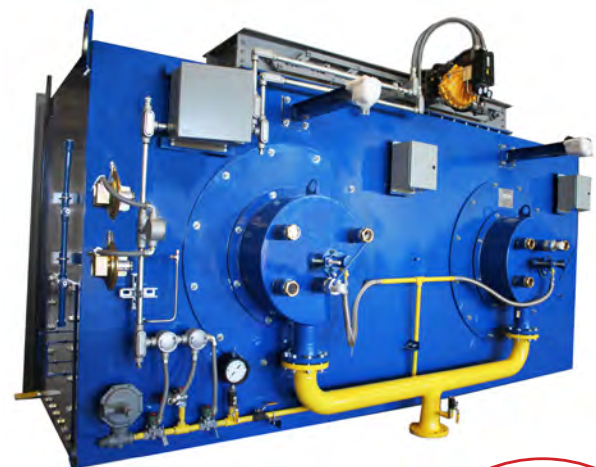


*Above: API-AF Burner for  
Firetube Boilers*

## **PREFERRED** Special Combustion Engineering

Preferred Special Combustion Engineering builds high-end burner systems for industrial, utility, and refinery applications. Typical burner systems include burners and fuel trains, flame safeguard and combustion control systems, project management and field start-up.

Projects may include blending stations for simultaneous firing of multiple fuels including natural gas, light or heavy oil, digester gas, landfill gas, refinery gas, or blast furnace gas. Combustion projects are often supported by computational fluid dynamics software as well as physical flow modeling of furnaces and ductwork.



*Above: Coal-to-Gas  
Burner Conversion*







## High End Burners for any application.

Innovative combustion systems designed to meet the rising demand of greater efficiencies and lower emissions.

**W.N. Best Combustion** delivers the new standard for boiler equipment upgrades. The XPlus combustion System fully integrates the burner with state-of-the-art monitoring and controls. Throughout the entire development process, the burner design has included the requirement for repeatable, balanced and optimum fuel and air flow control. The result is a high quality burner that achieves and maintains overall fired equipment energy efficiency and low emissions. Most importantly, boiler owners are offered a single source for engineering, manufacturing, and field commissioning responsibilities that is unrivaled in the industry.

The system delivers low NOx performance on natural gas without flue gas recirculation while also providing 1.5 to 2.5% flue gas oxygen operation, 12:1 turndown, 200% per minute ramp rate and low electrical energy consumption. Further, with the included SCADA/Flex System, the end user will have a key tool for maintaining optimum performance of not only the burner, but also the entire plant:

- Show cycle times and operating hours for equipment prominently



*The efficient "XPlus" burner achieves Low NOx without sacrificing burner stability, low excess air operation, or fuel and electrical energy consumption.*

- Monitor fuel consumption, compare fuel consumption energy use per degree day to last year
- Monitor boiler efficiency in relation to historical trending in real time

The development of the XPlus returns to the philosophy of the 1980s in which low excess air operation (2% excess O<sub>2</sub> or less) and "economical" levels of FGR (15-17%) were considered by all to be normal operating goals. The requirement for Ultra Low NOx levels has forced everyone in the Industry to choose an excessive FGR approach to meet the requirements as expeditiously as possible, but we feel that burner stability, low excess air operation and fuel and electrical energy consumption have all been sacrificed.

We do not claim that emissions levels achieved by the XPlus are significantly better than that achieved by others, rather that we will not sacrifice low excess air operation, "economical" FGR input levels, turndown and/or reduced electrical energy consumption, to meet emissions levels that are at a minimum comparable to others.

Preferred has demonstrated emissions levels can be reduced, turndown maximized and fuel and electrical energy consumption minimized on a repeatable basis by the direct measurement and control of all inputs (fuel, air, draft, O<sub>2</sub> and FGR) and outputs to the system. A burner with induced FGR and a single point positioning control system without O<sub>2</sub> Trim or draft control can be made to work; however, we believe that excess air and FGR levels are inputted at unnecessary levels to overcome variations in draft, air temperature, hysteresis and fuel pressure variations. Preferred offers single source responsibility for overall performance of the burner, controls, and even commissioning to ensure project success. Please consult our factory engineers for your next power plant upgrade.



## Standard and Custom Products for Fuel Oil Management

A wide array of standard fuel oil handling products, as well as custom-engineered solutions.

**Preferred Utilities** designs and manufactures oil pumping, filtration and heating systems that provide a reliable supply of No. 2 through No. 6 fuel oil for:

- Emergency Diesel Generators
- Boiler Systems

**Fuel Handling Engineers** – Preferred designs, engineers and manufactures fuel handling systems every day. Preferred's fuel handling systems reflect generations of fuel handling experience. This experience, along with today's state of the art control technology, has placed Preferred in the unique position to solve any specialized fuel handling problem.

### Typical Systems Include:

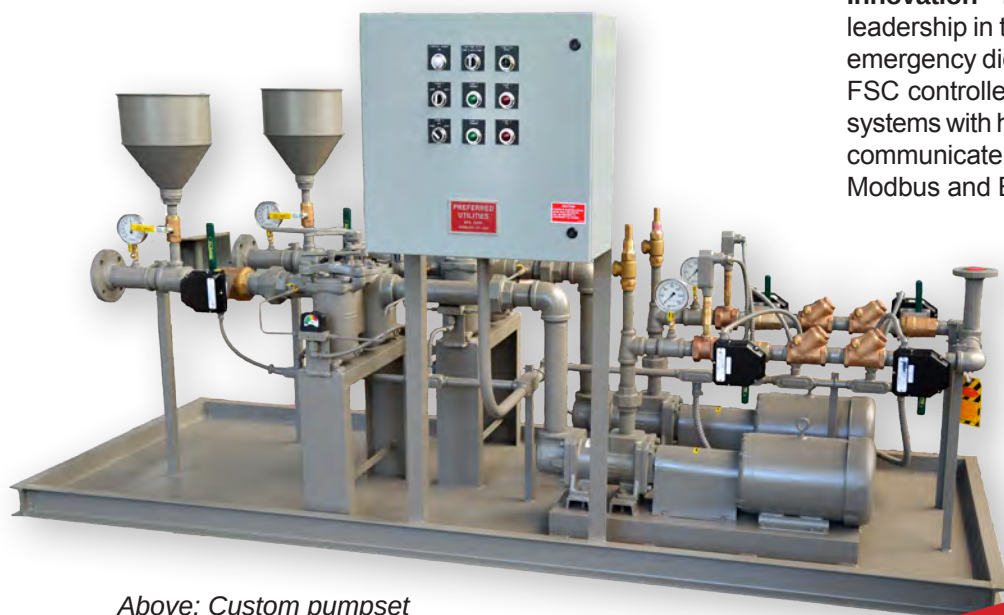
- Pump Sets
- Pump and Heater Sets
- Filtration Sets
- Day Tanks
- Tank Gauge/Leak Detectors
- Control Cabinets
- Fuel Oil Specialties (Switches, Anti-Syphon Valves, Vent Protectors, Fire Safety Valves, Spill Containers, etc.)



*Filtration system with water holding system and chemical injection fuel oil additives - 10" color touch screen optional.*

**Single Source Responsibility** – Incorporating a total systems approach to fuel management, each job is treated as a unique design project. Pumps are chosen to meet required flow and pressure criteria for the fuels being pumped. A control strategy is chosen to provide the desired degree of automation while assuring the highest levels of reliability. Monitoring and alarm points are selected to alert operations staff of any change in status. By combining pumps, day tanks, controls, level and leak monitoring into a single package, an optimized system with single source responsibility is assured.

**Innovation** – Preferred occupies a position of acknowledged leadership in the manufacture of fuel oil transfer systems for emergency diesel generators and dual fuel boilers. Our new FSC controller provides distributed control for large fuel oil systems with higher reliability and less field wiring. Controllers communicate to building automation systems via Ethernet Modbus and BacNet IP protocols.



*Above: Custom pumpset located in World Trade Center 3.*





## Instrumentation and Control Systems for Boilers and Process Heat

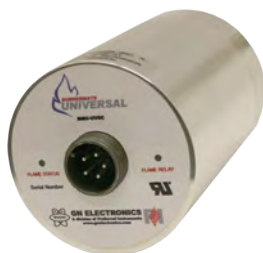
Cutting-edge control solutions that produce savings for combustion and process applications.



*Chief Dispatcher Lead/Lag System*



*BurnerMate Universal*



*Ultra-Violet  
Flame Scanner*



*PCC-III Multiple Loop Controller*

### Preferred Instruments

#### **Control and Instrumentation Products**

- BurnerMate Universal Controller
- Chief Dispatcher Lead/Lag Controller
- PCC-III Multiple Loop Controller
- Combustion Instrumentation
- Actuators
- Complete Combustion Control & Monitoring Systems
- SCADA/Flex Distributed Control

**A History of Safety and Reliability** – Safety and reliability are not options; they are musts. Here at Preferred, we engineer and manufacture combustion systems for commercial, industrial, and institutional facilities. When we engineer combustion controls, we consider safety and reliability to be of paramount importance. Working with such inherent risks has driven Preferred to develop products with fastidious attention to security and reliability. Since developing our first digital and microprocessor-based controllers, Preferred has provided safe and reliable control for thousands of combustion and process installations. Today, our controllers provide new levels of power and flexibility with the same rock solid security and rugged reliability found in our earlier controllers. Preferred designs and builds combustion control systems, burner management systems, and complete combustion solutions. Preferred's integrated combustion systems provide a single source of responsibility, ensuring a comprehensive and trouble-free project conclusion.

**Custom Engineering Ability** – At Preferred, we accept the fact that no two projects are ever exactly alike. We boast a fully staffed engineering department ready to work on your project and provide custom drawings, panel wiring drawings, sequence of operations, SAMA drawings, and O & M manuals. Our engineering department uses state-of-the-art engineering tools to streamline the engineering process. Complex systems can now be engineered more quickly, providing you with lower costs, faster response and a custom engineered solution.

# PREFERRED ENGINEERING

## Nuclear Outage and Support Responding to the Challenge

Reduce critical path time. Minimize radiation exposure. Decrease maintenance and refueling costs. Preferred Engineering has been responding to this challenge with innovative solutions since 1981.

### Preferred Engineering

#### **Nuclear Outage Support Products**

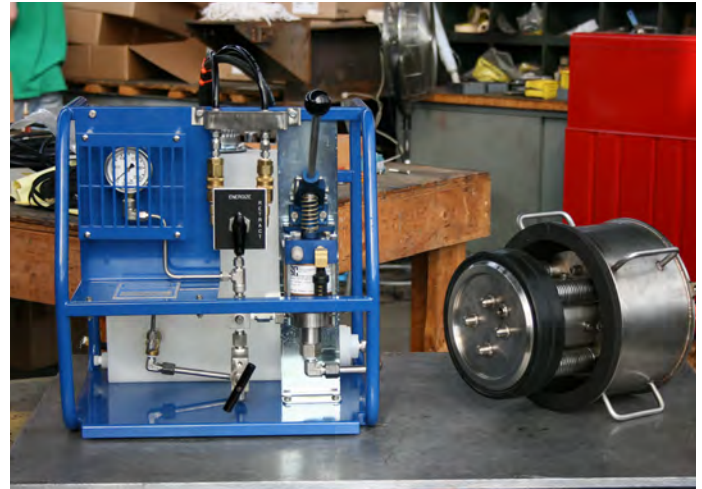
- Main steam line plugs
- RPV plugs
- Cavity seal systems
- Remotely actuated lifting devices
- Quik-Lok® fastening systems
- Fuel transfer systems
- Temporary RPV covers
- Remote fuel transfer closure systems

**Recognized for innovation** – Preferred Engineering has gained wide recognition for developing successful solutions to some of the industry's more difficult maintenance and refueling challenges. We are particularly proud of these contributions and are committed to the continuing pursuit of practical solutions to the industry's needs.

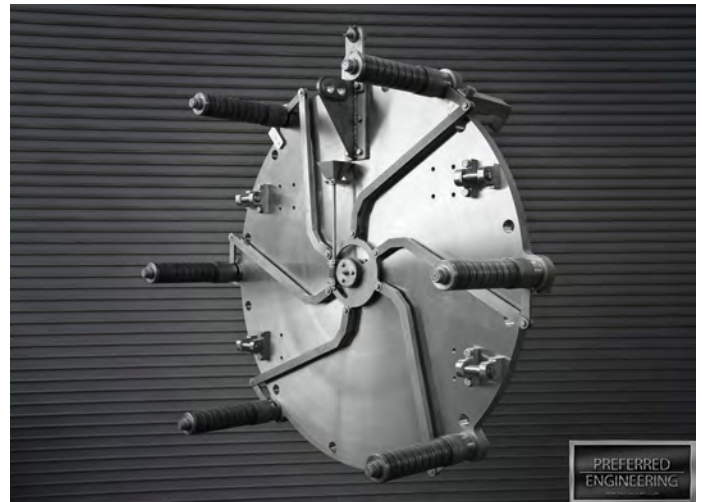
**Responsiveness** – Recognizing the need to pay special attention to the individual needs of each client, Preferred Engineering works closely with the client at all stages of a project. Direct top management involvement in each project ensures the availability of essential resources and responsiveness to changing client requirements. We are committed to satisfying every client to the best of our ability.

**Extensive resources** – Preferred Engineering is a subsidiary of Preferred Utilities Manufacturing Corporation, and is fully supported by the management and resources of the parent company. We benefit from the engineering and manufacturing expertise acquired through Preferred Utilities' more than 95 years of leadership in combustion technology. In addition, the company's extensive manufacturing facilities support Preferred Engineering's product development, fabrication, and testing endeavors.

**Quality Assurance and Standards** – The unique types of problems that we solve for our customers require the implementation of an effective quality assurance program. Preferred Engineering's record of strict adherence to established quality standards and industry practices has made us the leader in our field. Preferred Engineering maintains a full NUPIC-Audited Nuclear Quality Assurance program, meeting all the criteria of 10CFR50 Appendix B.



*Above: Actuated Pipe Plug*



*Above: Transfer Flange*







## Field Service

Local Product and System Experts

Behind every successful system implementation stands Preferred's highly trained staff of service engineers.

We offer expert field service for the commissioning of both new systems and the routine maintenance of existing systems. In addition to our staff of field service engineers, our factory authorized representative companies maintain service departments to provide prompt local service. When it comes to technical support for our SCADA/Flex™ systems, Preferred provides modem support, linking directly with your system from our factory in Danbury, CT.

This arrangement can provide substantial time and cost savings. Combustion systems, like any precision process, can only operate at peak efficiency when all control systems are properly commissioned and then maintained and calibrated on a regular basis. Regularly scheduled service from Preferred can help achieve optimum performance, reducing wasted fuel and maintenance dollars. Quality service is never far away.

### Continuous Field Service Engineer Training

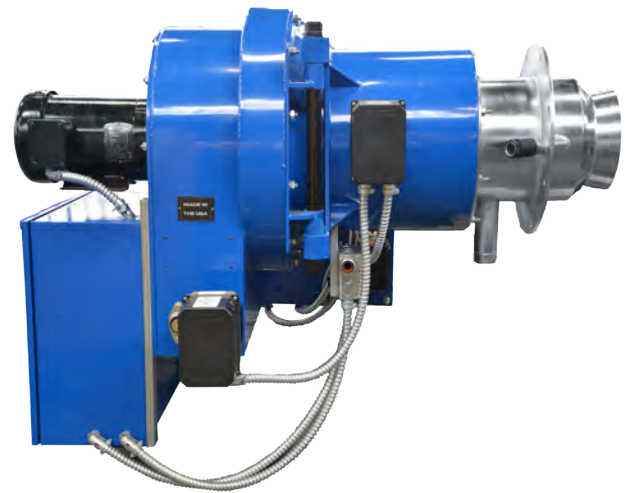
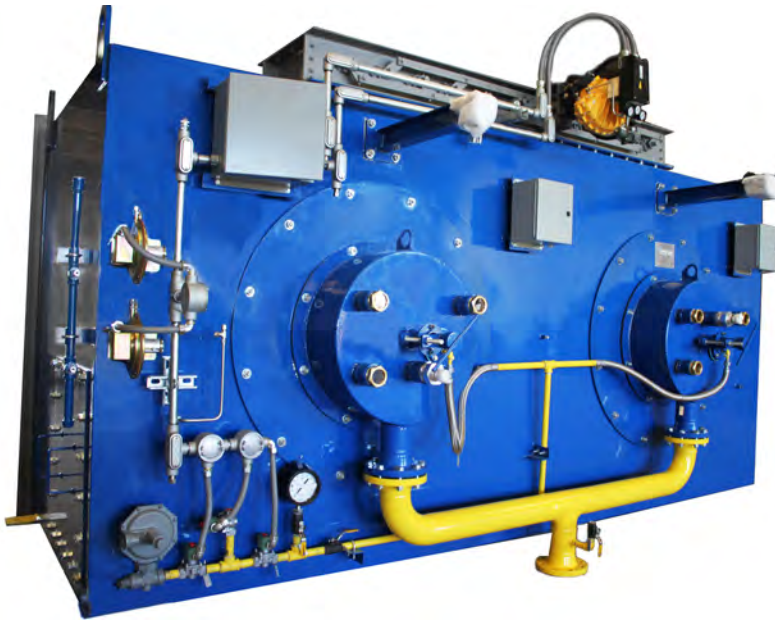
Preferred Services is continuously training new field service engineers and customers as well as retraining existing field service engineers on new products.

Refer to our website ([www.preferred-mfg.com](http://www.preferred-mfg.com)) for the date and time of upcoming monthly training sessions. Additional training programs are regularly conducted as our systems are commissioned and local group trainings can be organized upon request. In order to maximize the benefit of our products and services, we are committed to a process of continuous training.



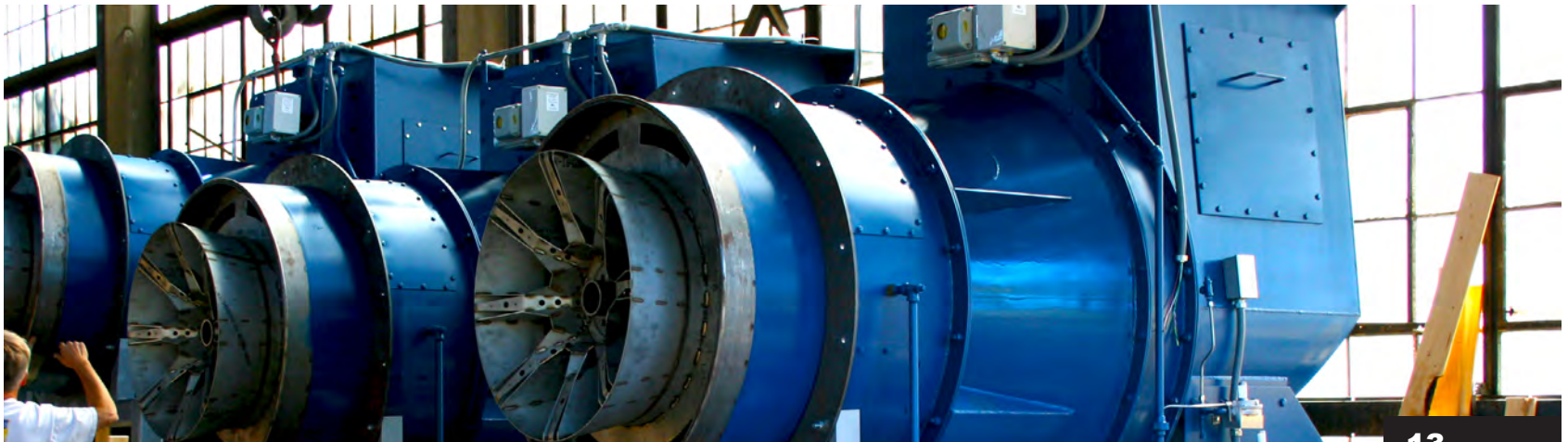
*The training center at Preferred's headquarters in Danbury, CT is geared for both lectures and hands-on training.*

# Combustion Systems



**PREFERRED**   
Special Combustion Engineering

**PREFERRED**   
W.N. Best Combustion





## COMBUSTION SYSTEMS

### Introduction

Combustion systems in general, and the Preferred Special Combustion Engineering (PSCE) group in particular, is where all the different disciplines at Preferred come together into one project. A typical combustion project includes:

- Burners
- Flame safeguard
- Fuel-air ratio control
- Draft and feedwater control
- Balance of plant control (boiler lead/lag, feedwater/deaerator control, monitoring of instrumentation, or SCADA)

In addition, many combustion projects involve:

- Flow Modeling (physical scale modeling or computational fluid dynamics)
- Liquid fuel handling (tanks, pumps, leak detection, or heating of viscous fuels.
- Research and development (combustion applications that have never been done before)

With all these disciplines in one company, Preferred project managers have a great deal of expertise and experience to draw from.

Routine projects firing gas and/or fuel oil in firetube or watertube boilers are handled throughout the company.

The PSCE group's forte is in the handling of unusual projects that include:

- Firing of multiple fuels simultaneously
- Firing unusual fuels such as biogas, refinery gas, blast furnace gas, or hydrogen.
- Multiple burner boilers
- Solid fuel-fired boilers
- Oxidation of hazardous substances

The project manager for a combustion system project will read and understand all the drawings, specifications, site survey notes, and other information related to the project. The project manager will determine if any necessary information is missing, and makes sure that information is provided before preparing an engineering submittal.

Once the project is approved for production, the project manager supervises the efforts of mechanical engineers, controls engineers, programmers, and manufacturing staff to make sure the equipment is designed, built, and programmed per the requirements of the project. The project manager is the single point of communication and responsibility for the customer.

Being a project manager at Preferred is a difficult job. If they weren't doing the job they love, and weren't good at it, they wouldn't be able to handle this high performance job.



*A Preferred combustion engineer and project manager work together to test the 9 ppm NO<sub>x</sub> NanoNO<sub>x</sub> burner. This production model burner was thoroughly tested in the Preferred factory to ensure a quick start-up in the field.*

# COMBUSTION SYSTEMS

## Introduction

**Preferred has multiple burners available depending on the heat input and performance requirements:**

- Preferred X-Plus (Gun Style and Register Style)
- Preferred Utility Burner
- Preferred NanoNOx Burner (Ultra Low NOx)
- Preferred API-RF and AP-AF Burners

### Applications:

- Single Burner Boilers
- Auxiliary Burners
- Multiburner Boilers and Furnaces
- Tangential Boilers
- Utility Boilers

**Capacities:** 5 mmBtu/hr through 400 mmBtu/hr

### Fuel Type:

- Natural Gas
- Light/heavy fuel oil
- Propane
- Hydrogen

**Emissions:** Ultra Low NOx, Low NOx without FGR, and Low NOx with minimal FGR are available.

Preferred offers the **complete combustion system solution** through single-source responsibility and value-added offerings including:

**Fuel Piping Trains** - offered in ANSI B31.1, Class 1 Div 2, NEMA 4, Stainless Steel, and Carbon Steel Construction. Stand-alone Fuel Blending skids are engineered for your Boiler or Gas Fired Generator to offset primary fuel consumption.



*PLC-based flame safeguard and combustion controls system in a free-standing enclosure*



*Windbox-style burner for watertube boiler.*

### Burner Management and Combustion Control Systems

- engineered to your specifications in PLC, Microprocessor, Multiloop, or Combination Platforms. Control systems available in Class 1 Div 2 and Safety Integrated Level (SIL) designs.

### Combustion Consultation

Physical Flow Modeling and Computation Fluid Dynamics (CFD) can help optimize proper air flow distribution with your proposed application. It is also offered as a service for existing field applications, including:

- Site and Energy Surveys
- NFPA 85 Audits
- Turnkey Installation
- Installation Supervision Services
- Startup and Commissioning Services
- Aftermarket Support



*Blending skid for combining natural gas and biogas*



## COMBUSTION SYSTEMS

### API Advanced Performance Inject-Aire Burner

Preferred Utilities Manufacturing Corporation is proud to offer our new Advanced Performance, high efficiency, Inject-Aire Low NOx burner. With the ability to test fire burners up to 40 mmbtu/hr in-house, Preferred can mitigate much of the risk of burning new or uncommon fuels. The packaging of the burner, flame safeguard/combustion control systems, and piping has been designed to eliminate field errors, reduce space requirements, and facilitate maintenance. Factory demonstrations are always available upon request.

The Advanced Performance Inject-Aire Low NOx burner (API) produces an exceptionally stable flame at all firing rates.

#### Fuel Variety

Capable of firing natural gas, light oil, heavy oil, digester gas, ethanol, and more, the API offers a wide range of fuel burning capability.

#### Advanced Design

Our engineers specifically designed this burner to eliminate field errors, reduce space requirements, and facilitate maintenance when needed.

#### High Efficiency

Low 1.5 -2.5% excess oxygen operation from 50 - 100% firing rate significantly reduces fuel consumption. To save electricity, the API burner employs a variable frequency drive (VFD) to reduce forced draft fan speed at low fire. Burner manufacturers must be very conservative in their fan sizing, so in many applications, a VFD can reduce burner electrical consumption even at high fire.

**Applications:** Single burner firetube, firebox (cast iron sectional), watertube boilers, or HTHW generators.

**NOx Emissions:** Natural gas: as low as 30 ppmc without FGR; No. 2 fuel oil: less than 90 ppmc (maximum 0.01% FBN) without FGR; No. 6 fuel oil: less than 250 ppmc (maximum 0.30% FBN) without FGR.

**Operation:** Turndown: 10:1 on gas firing; 8:1 on oil firing.

**Supply Pressures:** The API burner accommodates a wide variety of combustion applications and fuels. Specific information relating to fuels intended to be used, as well as pressures and temperatures, must be provided.

**Burner Control & Monitoring:** Parallel positioning with oxygen trim or full metering control using any Preferred controller.

**Monitoring:** SCADA/Flex remote monitoring and control system.

**Additional Options:** Draft control, drum level control, low fire fuel changeover, dual/redundant flame scanning, smoke opacity monitoring and alarm, atomizer post purge capability, flue gas temperature indication alarm, emergency boiler shutdown.



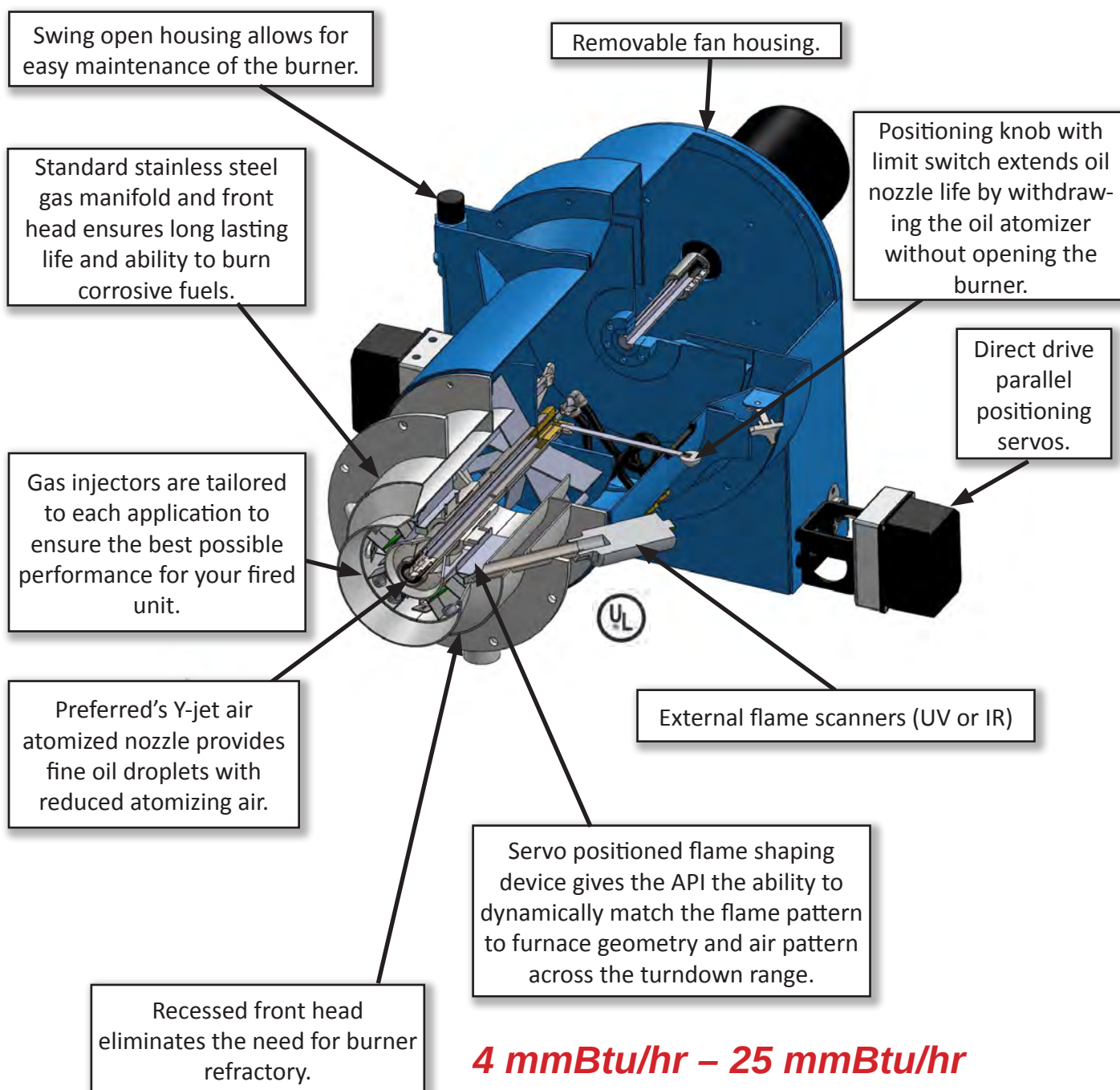
API-AF (for axial flow) Low NOx Burner



API-RF (for remote fan) Low NOx Burner



## API-AF BURNER FEATURES





## COMBUSTION SYSTEMS

### XPlus High Efficiency, Low Emissions Burner

The XPlus Combustion System is a new standard for boiler equipment upgrades. It delivers extremely low excess air operation throughout the firing rate to significantly reduce fuel consumption. Variable Speed Drives (VSDs) on the combustion air fan reduce electrical consumption. The XPlus Combustion System fully integrates the burner with state-of-the-art monitoring and controls. Throughout the entire development process, the burner design has included the requirement for consistent, balanced, and optimum fuel and air flow control. The result is a high quality burner that achieves and maintains overall fired equipment energy efficiency and low emissions. Most importantly, boiler owners are offered a single source for the burner, controls, and field commissioning responsibilities that are unrivaled in the industry.

#### Firing Equipment

- **Low Emissions Design** - Gas tube injectors and atomizer sprayer plate produce stable, staged, low temperature fuel and air combustion.
- **Stable Combustion** - Center-fired gas, or very fine fuel oil droplets are ignited in the Stabilizing Combustion Zone. This feature produces outstanding flame stability during load changes and at very high excess air levels.
- **Energy Efficient** - Low electrical consumption is obtained by variable speed fan control with a Variable Speed Drive (VSD). When required, "pinpoint" injection of Flue Gas Recirculation (FGR), via the FGR Injection Plenum achieves the required NO<sub>x</sub> emissions with reduced FGR flow. Variable speed FGR Fan control can be used for additional energy reduction.
- **Exceptional Turndown** - The combustion air plenum with "in-line" characterized damper is dynamically modeled to assure exceptional turndown and balanced cross-sectional air flow. Higher turndown reduces boiler cycling during low load periods, reducing fuel consumption and thermal stress to the boiler.
- **No Refractory Maintenance** - The burner throat is a high temperature metal. Custom refractory brick installation or maintenance are not required.
- **"Locked" Design** - No moving parts or adjustments necessary.
- **Recessed Plenum** - Minimizes atomizer length and withdrawal clearance requirements.
- **Atomizer Coupling Block With Disengagement Safeties** - Protects operating personnel from hot oil or steam discharges.



XPlus Burner

#### Controls

- **Integrated Primary Flow Elements** - Integral combustion air, fuel gas and FGR measurements are used as the basis for combustion control. The integral FGR injection plenum allows independent measurement of combustion air and FGR flows.
- **Minimized "Hysteresis" Induced Control Errors** - A direct-coupled damper/ actuator is used. Damper linkage is not required.
- **Optimum Combustion Air Flow** - VSD control of the FD Fan allows "trimming" of fan speed to exactly meet field conditions, thereby eliminating the need for fan oversizing, damper "short-stroking" or linkage adjustments.

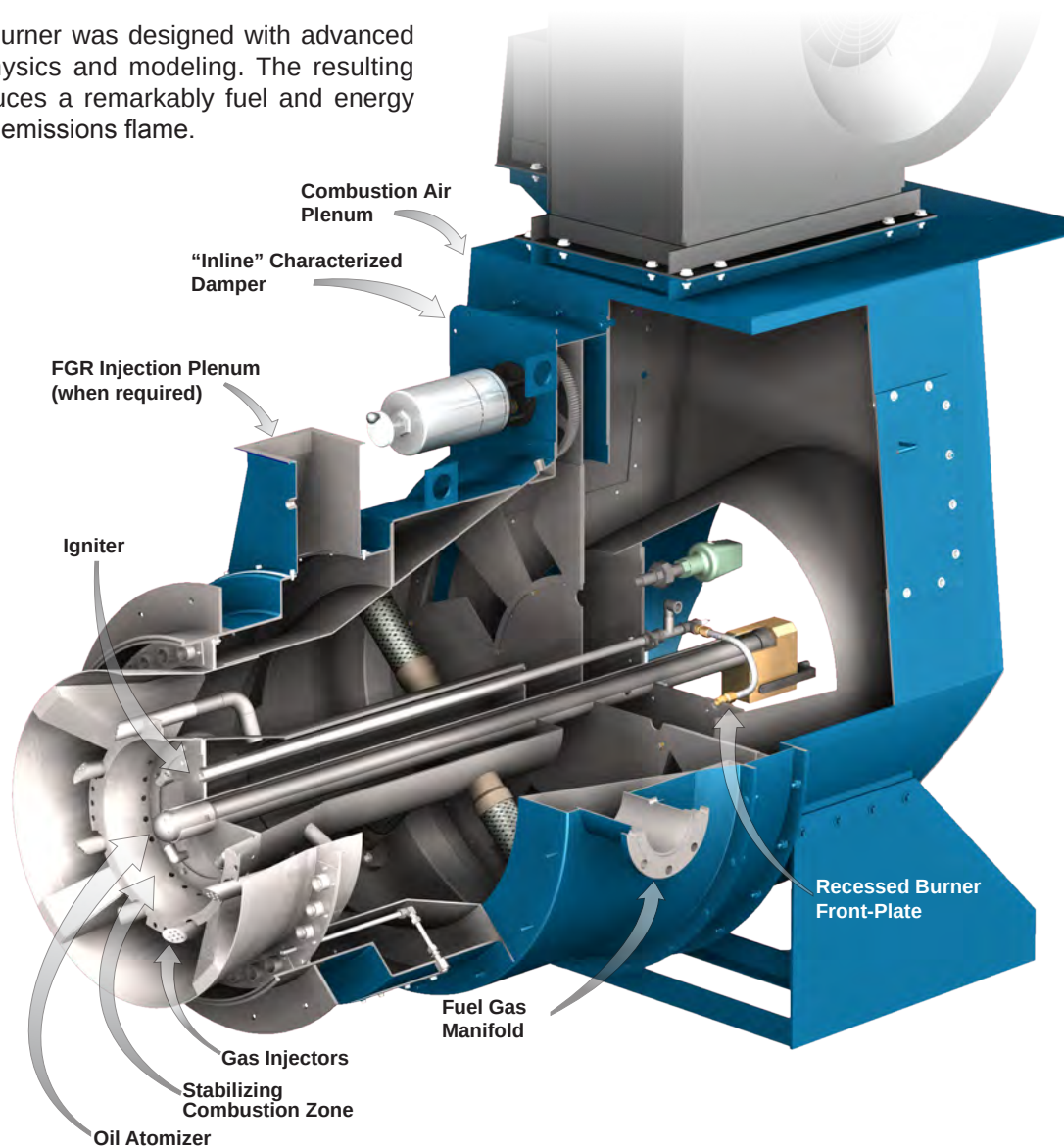
#### Fuel-Efficient Design

- **BurnerMate Universal Combustion Control** - Fully metered combustion control strategy with oxygen trim and variable speed fan-based combustion air flow control is used. Any deviation from the required oxygen set point caused by changes in fuel stoichiometry, atmospheric conditions or boiler resistance, is automatically acknowledged and corrected, maintaining the highest fuel economy possible.
- **"Low-fire" Fuel Changeover** - Permits fuel transfer without requiring a burner shutdown and purge.
- **Enhanced Boiler Safety** - Flue gas oxygen and temperature monitoring protects against excessive flue gas temperature and incomplete combustion.

## COMBUSTION SYSTEMS

### XPlus High Efficiency, Low Emissions Burner

The XPlus Burner was designed with advanced computer physics and modeling. The resulting design produces a remarkably fuel and energy efficient, low emissions flame.



*The Xplus piping train includes limit devices and all necessary fittings. All trains are NFPA 85 compliant.*



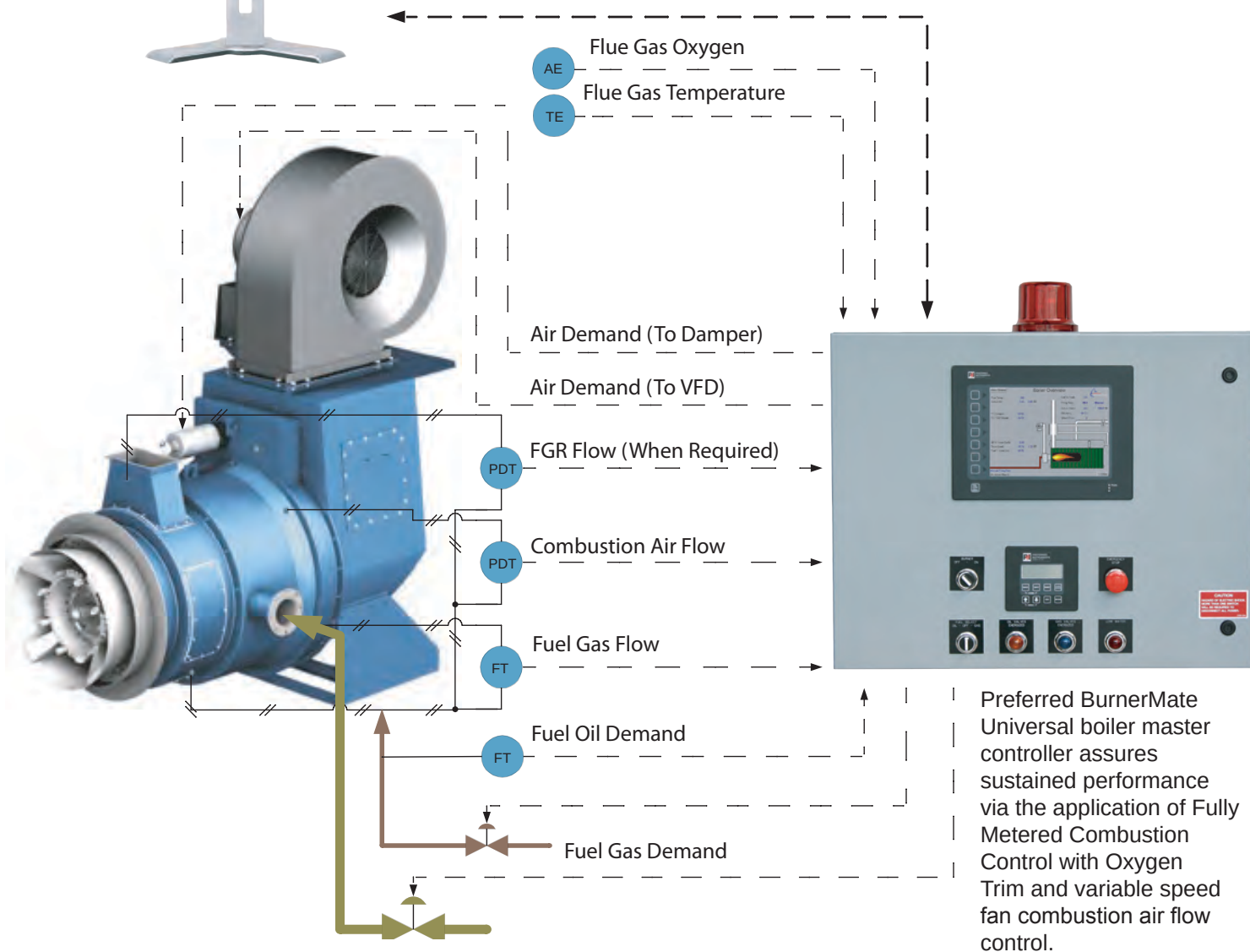
## COMBUSTION SYSTEMS

### XPlus High Efficiency, Low Emissions Burner



Optional SCADA/Flex Remote Monitoring and Control System continuously monitors the XPlus Combustion System performance:

- Combustion Monitoring and Troubleshooting
- Historical Trending Of Flame Signal Strength, Fuel Flow, Air Flow, FGR Flow, Burner Cycles And Operating Hours.
- Maintenance "Reminder" Messages
- Boiler Efficiency Trends And Alarms



## COMBUSTION SYSTEMS

### XPlus High Efficiency, Low Emissions Burner

#### Application

Single burner: Firetube/Watertube Boilers or HTHW Generators.  
Fuel: No. 2 through No. 6 and/or Natural Gas (consult factory for special or waste fuels)

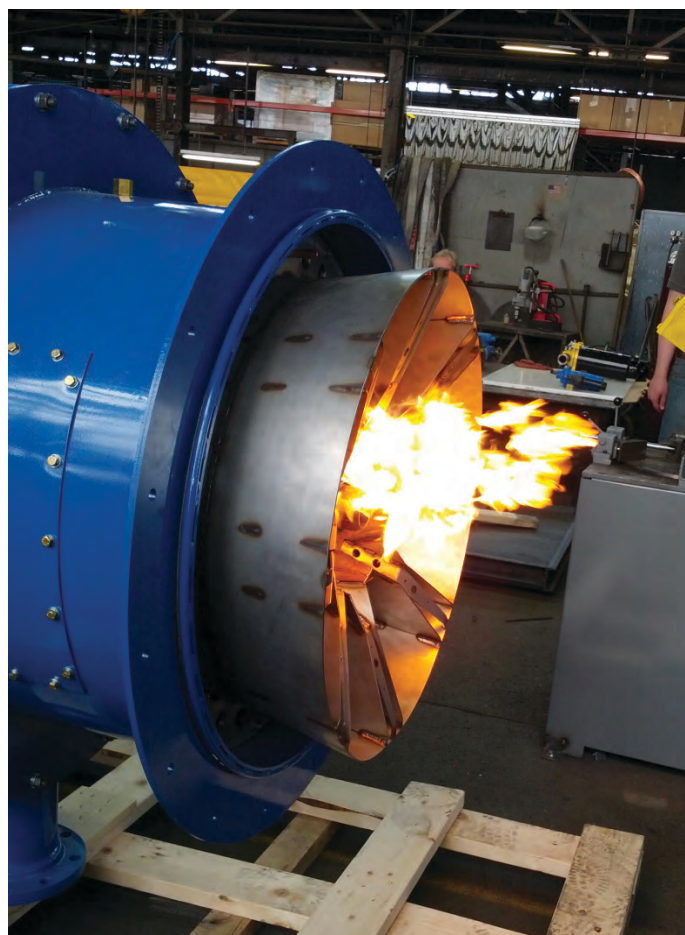
**Heat Input Ranges** 15 to 125 mmBtu/hr

#### NOx Emissions

Natural Gas: as low as 30 ppmc without FGR  
No. 2 Fuel Oil: 90 ppmc (maximum 0.01% FBN) or less without FGR  
No. 6 Fuel Oil: 250 ppmc (maximum 0.30% FBN) or less without FGR

Note: NOx performance is dependent on furnace geometry and heat release rate. Lower NOx emissions are attainable with the application of FGR. CO emissions are less than 100 ppmc at all firing rates (excluding "short-circuiting").

#### Burner Efficiency



Pilot testing an XPlus Burner

Any Fuel: **1.5 - 2.5% Excess O<sub>2</sub>**  
50 - 100% Firing Rate (exclusive of "tramp" air)  
Electrical: **80% kW Reduction**  
@ 40% Firing Rate

#### Operation

Turndown: 10:1 on gas firing  
8:1 on oil firing  
Ramp Rate: 200% per minute  
Back-up Fuel: Oil or gas may serve as either the backup or supplemental fuel on simultaneous fuel firing applications

#### Supply Pressure

Natural Gas: 2-10 PSIG (at Gas Manifold Inlet)  
Fuel Oils: 70-125 PSIG (No. 2 through No. 6 at Atomizer Coupling Block inlet)  
Atomizing Media: Nominally 20 PSI higher than fuel oil pressure.

Note: consult factory for available pressures outside of the ranges given.

#### Burner Control & Monitoring

Firing Rate: BurnerMate Universal or BurnerMate TS Fully Metered Combustion Control with Oxygen Trim and Variable Speed Fan Combustion Air Flow Control  
Oxygen Sensor: Model "ZP" In-Situ Sensor, reliable zirconia oxide detector  
Monitoring: SCADA/Flex Remote Monitoring and Control System  
Controller: Standard and Custom Available  
Instruments: Standard and optional equipment available

#### Options

- Dual Scanners - for added security and availability
- Simultaneous Fuel Firing
- Automatic Atomizer Post Purge - to prevent post combustion discharge of fuel oil into the furnace
- FGR Fan VSD control for energy savings, noise reduction and flow control
- BurnerMate Universal, BurnerMate TS, or PLC-based control systems are available.



## COMBUSTION SYSTEMS

### Flow Modeling Services

The root cause of many combustion problems is uneven air flow or unexpected turbulence through the furnace, ductwork or stacks. Flow modeling can often reveal the root cause of these problems and can be used to determine and implement corrective actions. Typical symptoms of a fluid flow problem include:

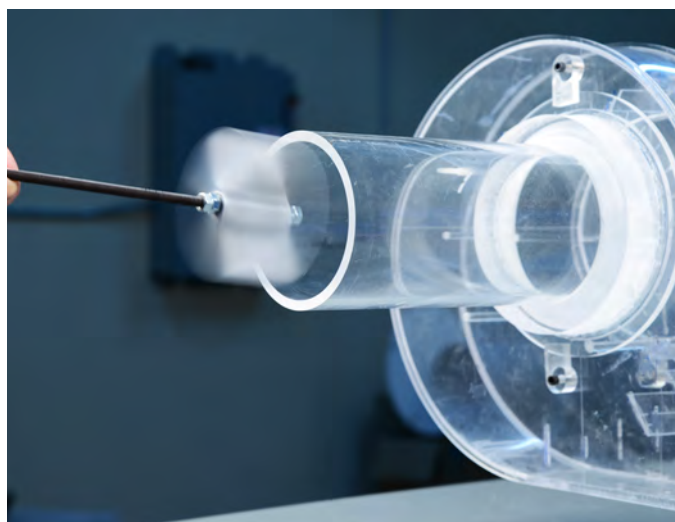
- Excessive vibration
- Inability to meet emission requirements at certain loads
- Higher than expected temperatures in parts of the combustion system--sometimes leading to burned up components
- Inability to meet design heat transfer requirements

Preferred uses flow modeling during burner development, and to help fix field issues. Our flow modeling services are also available for hire, to fix existing field problems.

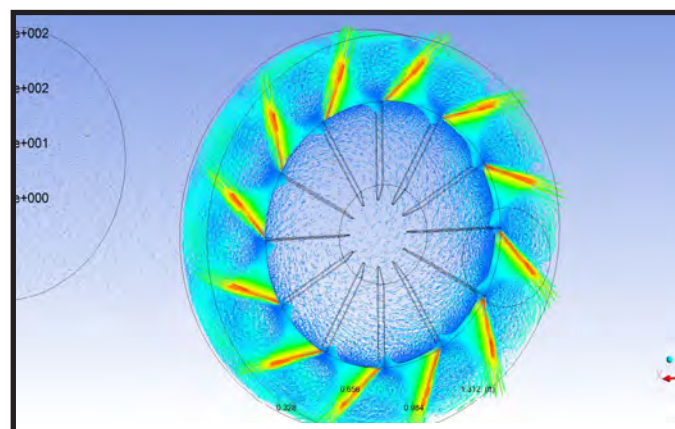
#### Potential Flow Modeling Applications Include:

- Burners
- Duct systems
- Cooling applications
- Heat exchangers
- Selective Catalytic Reduction (SCR)
- Process burner systems
- Swirlers or stabilizers
- Optimization of overfire air ports
- Breeching design for multiple-boiler duct work
- Corner-fired boilers
- Multi-stream blending systems

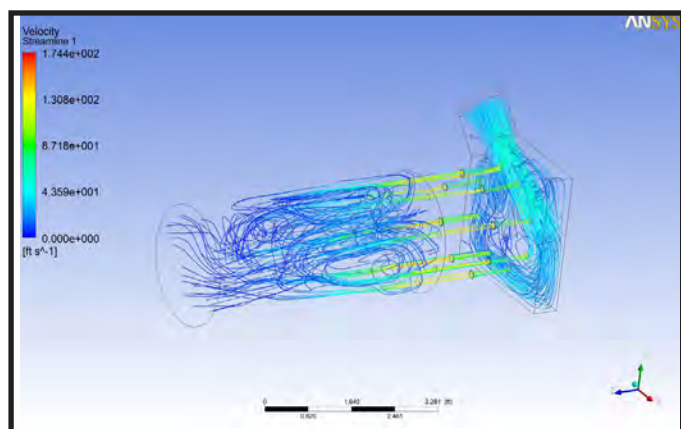
Flow Modeling can typically be performed in one of two ways: Physical Flow Modeling or Computational Fluid Dynamics (CFD). CFD modeling is typically less expensive, but physical flow modeling is often the best way to find and correct an airflow problem.



*Plexi-glass physical model of a centrifugal combustion air blower showing the swirl induced in the incoming combustion air. Smoke or bubble generators are often used to show the path of air molecules through the model.*



*CFD model of a flat-bladed, backwardly-inclined, centrifugal fan wheel showing the velocity distribution of the air as it moves over the fan blades.*



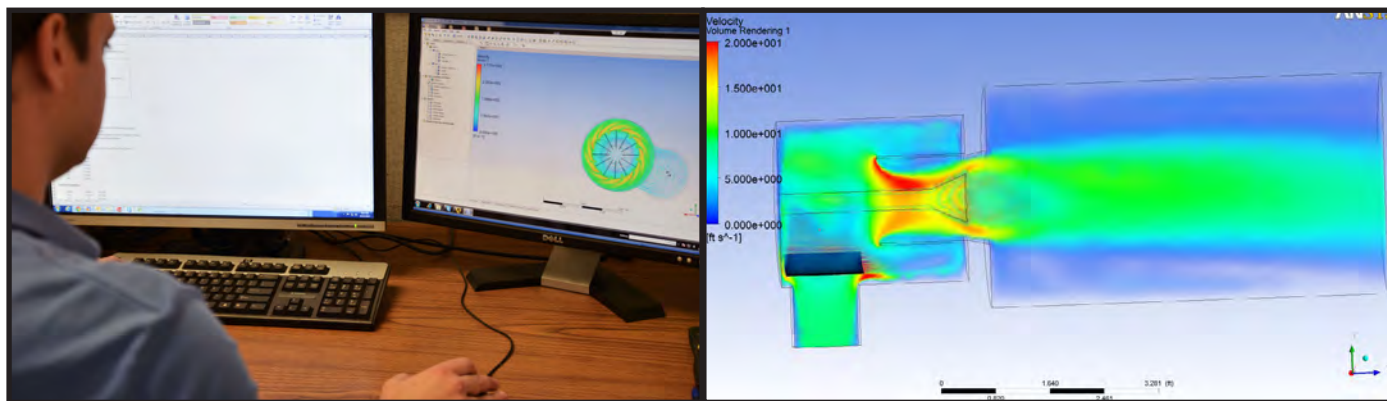
*CFD model of air injectors and plenum*

Flow modeling is an iterative process. Whether performed using physical scale models or CFD, the modeling expert works to recreate the problems seen in the field. The flow model usually uncovers the root of the problem (unexpected turbulence, air imbalance, etc.) The engineer performing the model determines corrective actions, builds them into the model, and simulates the flow again. This process continues until the fluid flow problems are corrected in the model. Then drawings and instructions are prepared to implement the solutions in the real world equipment.

Occasionally the fixes don't yield the desired result and the model is run again. Experienced flow modelers are the key to fixing a fluid flow problem in the fewest iterations.

## COMBUSTION SYSTEMS

Flow Modeling Services



The advantages of CFD modeling include:

- A faster solution for relatively complex systems.
- Taking temperature and density into account.
- Modeling various gases, liquids, particles, and their interactions.
- Predicting heat transfer through various materials and mediums.
- Optimizing the mixing of different fluids.
- Predicting performance of rotating machinery such as pumps or fans

In some circumstances, physical flow modeling will reveal flow problems that CFD modeling will not. Preferred offers both modeling tools—which can be used both separately or combined—in order to provide the most cost-effective solution to solve an air/fluid flow problem.



*The behavior of fluids through a system of ducts is often counter-intuitive. An experienced flow modeler has a unique understanding of fluid dynamics and is the key to quickly solving fluid flow related issues.*



## GAS BLENDING SYSTEMS

### Description



Boiler or generator owners who have invested in a source of biogas (typically digester gas or landfill gas) want to burn as much of their “free gas” as possible. Preferred’s gas blending stations monitor the availability and flow of biogas. During low load situations, the Preferred blending station discharges as much biogas as is available. If the boiler or generator load exceeds the available supply of biogas, additional natural gas is blended into the mixed gas stream to meet the load. This blending action is carefully balanced against the fuel quality and variability constraints of the connected boilers or generators. Variable Btu fuels, gas engine applications, and cold start considerations are factored into the control strategies.



*Anaerobic lagoon producing biogas from hog manure in California's San Joaquin Valley*

### System Components

- Supply Pressure Transmitters - Pressure transmitters at the inlet of the biogas train and natural gas train are used to confirm the availability of gas. They may also be used to pressure compensate the gas flow meters.
- Gas Flow Meters - Pressure and temperature compensated flow meters are the primary input to the control system.
- Flow Control Valves - Electric or pneumatic flow control valves are used to modulate the flows of both biogas and natural gas to achieve the desired gas mixture.
- Discharge Pressure Transmitter - Sometimes used to maintain discharge blended gas pressure within acceptable limits.
- Wobbe Index Analyzer - Certain combinations of biogas fuels and fired devices will require a Wobbe Index analyzer or Btu analyzer to determine the heating value of the fuel.
- Controls - A Preferred PWC or third-party PLC provides the brain of the Preferred gas blending system. Color touchscreens provide the interface for operators and service technicians.

### Materials of Construction

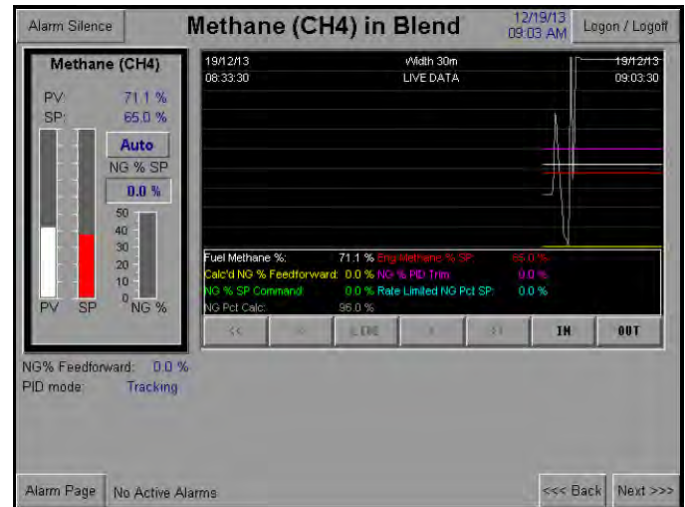
Natural gas trains are usually made from carbon steel valves and steel pipe. Biogas trains are made from 304 or 316 steel depending on the composition of the biogas. Electrical enclosures are NEMA 4, NEMA 4X, or NEMA 7 depending on the local area requirement.

# GAS BLENDING SYSTEMS

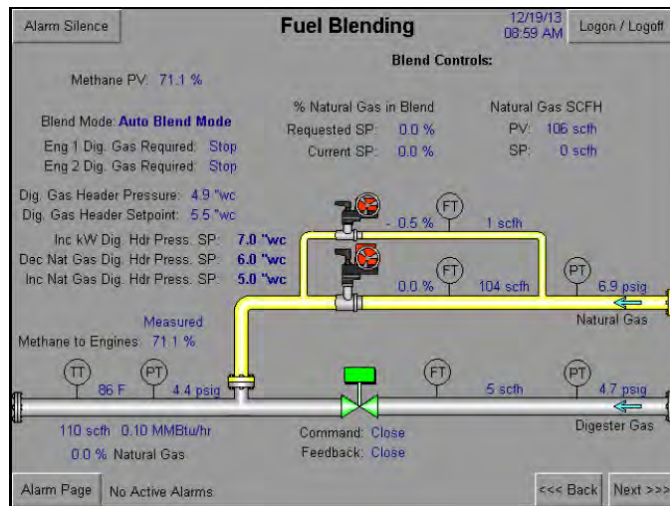
## Application



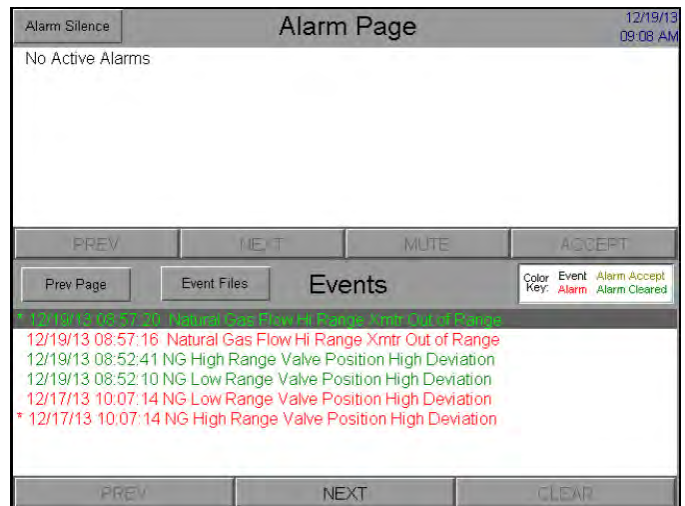
Natural Gas and Digester Gas Blending Station with Preferred PWC controller and 10" Color Touchscreen



Touchscreen Graphic Page used for Setup, Tuning, and Trending Control Loops.



Typical Color Touchscreen Graphic Page Showing an Overview of a Gas Blending System



Touchscreen Graphic Page Indicates Current Alarms and Keeps a Complete History of Alarms and Events



## GAS BLENDING SYSTEMS

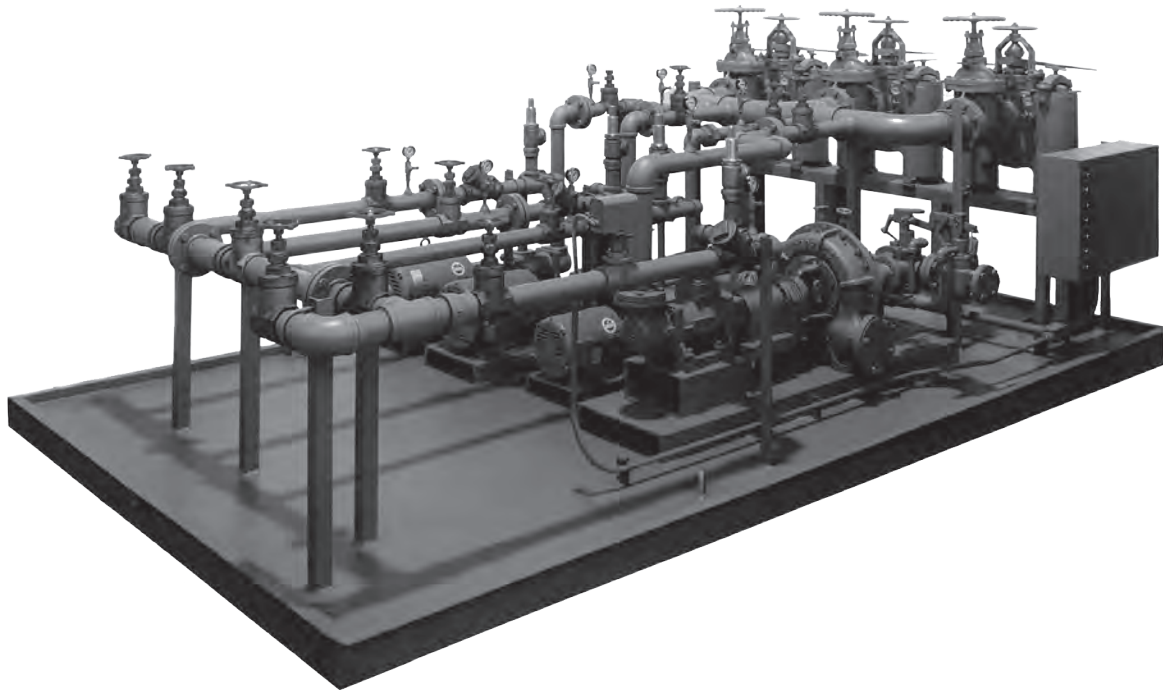
### Application

#### Application Considerations

Preferred gas blending systems are custom engineered for each application. A successful project depends upon gathering good job site information before the blending system is designed, built, and programmed. The worksheet below indicates the information needed for Preferred to provide a gas blending station proposal.

| Preferred Utilities Blending System Design Criteria                                          |                                                       |                         |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------|
| Biogas Type: Digester Gas? Landfill Gas? Anaerobic Lagoon Gas? (circle one)                  |                                                       |                         |
|                                                                                              | Biogas Pressure at Skid Inlet (PSIG):                 | Regulated? Unregulated? |
| Biogas Composition                                                                           | Does the Biogas Composition Vary by more than +/- 3%? | Yes No (circle one)     |
| %CO <sub>2</sub>                                                                             | Is the Biogas Scrubbed to Remove Siloxanes?           | Yes No (circle one)     |
| % O <sub>2</sub>                                                                             | Is the Biogas Scrubbed to Remove Hydrogen Sulfide?    | Yes No (circle one)     |
| %N <sub>2</sub>                                                                              | Is the Biogas Scrubbed to Remove Moisture?            | Yes No (circle one)     |
| %CO <sub>2</sub>                                                                             | What is the Pressure Drop Across the Scrubbers?       | Yes No (circle one)     |
| %H <sub>2</sub> O                                                                            | Are Gas Boosters Upstream of the Blending Skid?       | Yes No (circle one)     |
| ppm H <sub>2</sub> S                                                                         | Pipe Length from the Boosters to the Skid?            |                         |
| HHV (Btu/FT <sup>3</sup> )                                                                   | Pipe Length from Blending Skid to Fired Equipment?    |                         |
| Supplemental Gas Firing Type: Natural Gas? Propane Gas? (circle one)                         |                                                       |                         |
| Available Pressure: Regulated? Unregulated (circle one)                                      |                                                       |                         |
| What Equipment is the Blending Skid Feeding: Engines? Boilers? Thermal Oxidizers?            |                                                       |                         |
| If this is an engine application, how many engines is the skid feeding?                      |                                                       |                         |
| If firing a gas fired engine, what is the max. Btu/min change in gas HHV permitted?          |                                                       |                         |
| Control Power Voltage:                                                                       |                                                       |                         |
| Communication Protocol to BAS System: Modbus? Ethernet? BacNet IP? BacNet MSTP? (circle one) |                                                       |                         |

# Fuel Management Systems



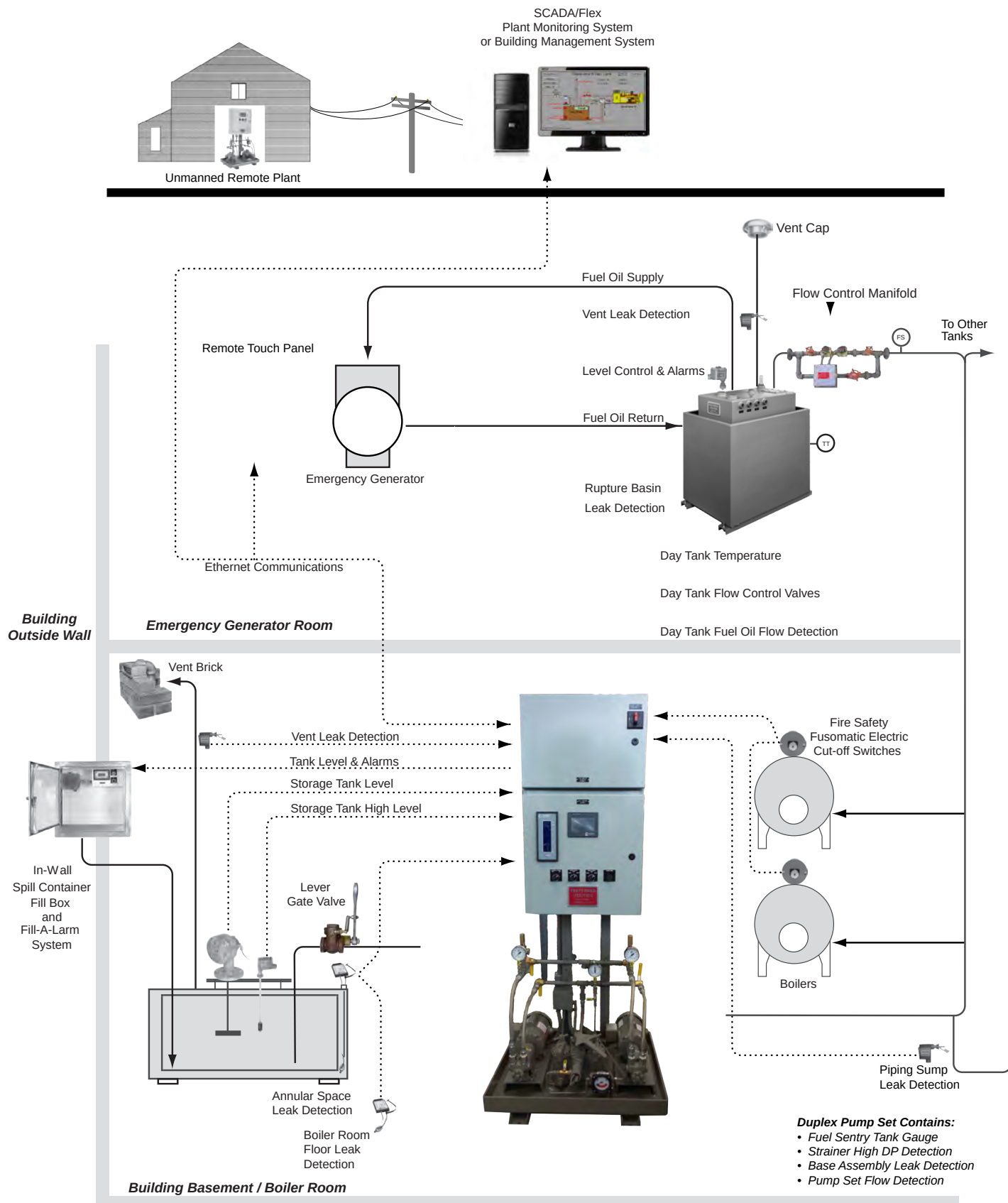
**PREFERRED**   
Utilities





# FUEL MANAGEMENT SYSTEMS

## Overview



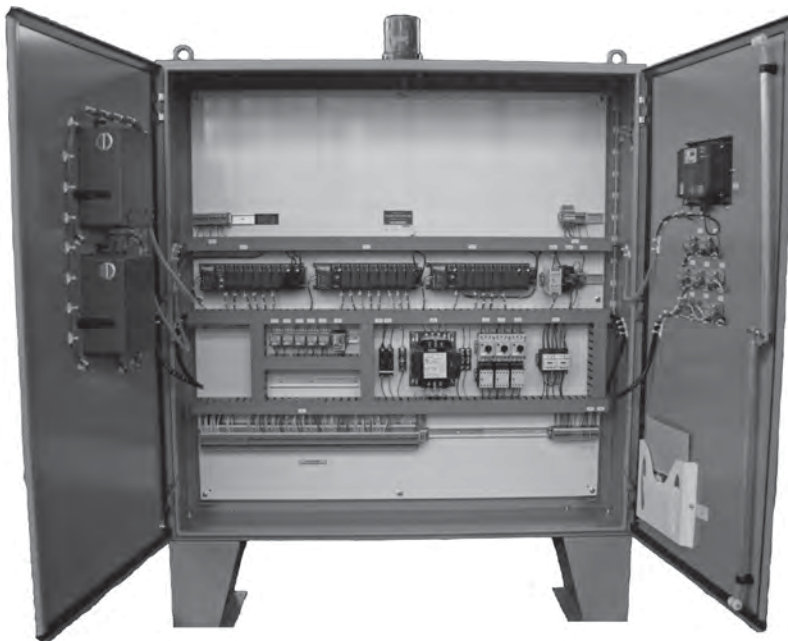
**Fuel Management System  
(Complete Monitoring and Control)**

## FUEL MANAGEMENT SYSTEMS

### Overview

- Flexible microprocessor-based control
- User-friendly local touch panels
- Fuel level, flow, and temperature monitoring
- Run time meters and pump maintenance monitoring
- Double wall piping leak maintenance monitoring
- Alarms via alphanumeric pagers
- Unmanned remote equipment monitoring
- Alarm history

Preferred Fuel Management Systems are designed to continuously monitor fuel levels, provide leak detection and alarms for double wall tanks and piping sumps, as well as control fuel pumps and valves for boiler and emergency generator fuel system applications.



*Custom Fuel Delivery System (inside)*



*Custom Fuel Delivery System*



*Fuel Management System  
Expandable and programmable to suit all common  
tank and pump configurations*

# FUEL MANAGEMENT SYSTEMS

## Suggested Specifications

### 1. Manufacturer Qualifications

The fuel oil handling system including the Pump Set(s), Control Cabinet(s), Day Tank(s), Tank Gauging, and accessories shall be supplied by one Original Equipment Manufacturer (OEM). The OEM shall have employees who manufacture, design, start-up and service fuel oil handling systems of this nature throughout the United States. Proof of manufacturing and starting up of the herein specified system(s) within the last five years must be supplied. This is to assure the highest standards of product quality and system integration capabilities for the customer. Basis of Design is Preferred Utilities Mfg Corp., Danbury, CT.

### 2. Certification

Day tanks shall be designed, constructed and labeled according to Underwriters Laboratories (UL 142) standards. The Fuel Management Control Cabinet shall be manufactured and labeled in accordance with UL 508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Laboratory (NRTL).

### 3. Submittals

Contractor shall submit a complete, project-specific submittal package containing scale drawings of all major components, complete bills of materials, control cabinet layouts, sequence of operations, electrical wiring diagrams, catalog data and proof of product liability Insurance. Partial submittals shall not be accepted. All drawings and product information shall be project specific, no catalog cuts or "standard drawings" shall be acceptable.

### 4. Substitutions

Where items of equipment and/ or materials are specifically identified herein by a manufacturer's name or model number, only such specified items may be used in the base bid. The successful contractor will be held responsible to furnish specified items under their base bid. If the contractor wishes to bid on equipment other than that specifically named in either the base bid or alternate, they must submit a request in writing, together with the full description and technical data on the equipment proposed, 7 days before opening of the bids. If such equipment is accepted as an alternate, all bidders shall be notified to allow them to include

an add or deduct from the base on the accepted equipment. It is further understood that this alternate will include any and all modifications or extra cost(s), regardless of the trade(s) involved, for any changes necessary due to the alternate equipment.

Submittal or shop drawings, if other than the base named equipment, must show detailed changes required by all other trades involved. The contractor shall be responsible for all additional costs involved. Under no circumstances shall the architect or engineer be responsible for the installation, operation, or performance of substitute materials or equipment, even though accepted; this shall be the sole responsibility of the contractor. In addition to any specific warranty in the heating, ventilating, air conditioning, plumbing, or electrical specifications, the manufacturers of all equipment to be supplied under any substitution shall warrant the same against all costs, including labor and material, arising out of defects in material and/ or workmanship, for a period coextensive with the guarantee period provided in the contract documents.

The calculations for capacities, quantities, dimensions, and all other attributes are based on the pertinent data of the base-named manufacturers. If submitted alternate manufacturer is accepted as an alternate, it shall be the contractor's responsibility to investigate in detail the products of these other manufacturers. The contractor shall be solely responsible for all changes in design, location, dimension, function, and installation involved in selection of other than the base-named manufacturer. The contractor shall be responsible for, and bear all costs for, any and all changes including any required work of any and all other trades, or the owner and including all of the architects and engineer's redesign or evaluation of submittal costs caused directly or indirectly by the use of equipment other than that listed on the drawings or called for in the specifications.



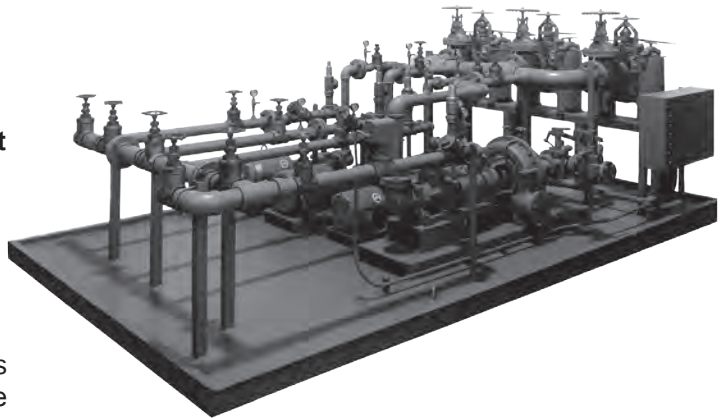
# FUEL OIL HANDLING SYSTEMS

## Overview

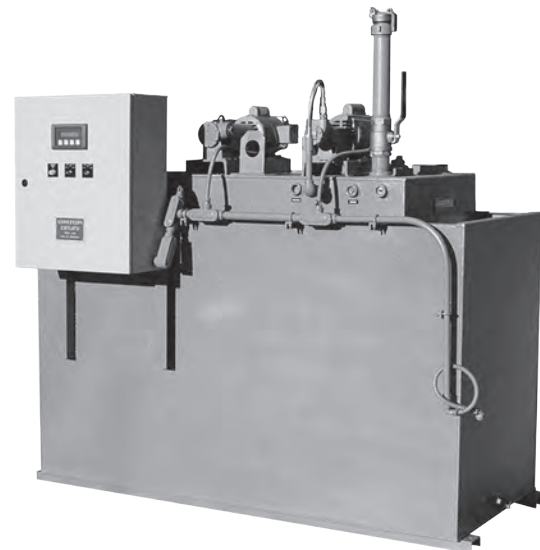
- No. 2 through No. 6 Fuel Oil, and Bio-Fuels
- Single Source Responsibility for Pump Sets, Tank Gauges, Fill Alarm Station, Day Tanks, Heaters and Fuel Oil Specialties
- Engineered as a complete system to deliver fuel at a pre-determined pressure and flow
- Simplex, duplex, triplex or quadraplex pumps available
- Ethernet and BacNet IP communication
- Factory assembled, tested and labeled

Preferred Utilities engineers, manufactures and supports fuel oil pumping systems every day. This experience provides expert handling of any specialized fuel handling application. Preferred offers complete custom-engineered solutions to satisfy virtually any special flow or pressure criteria that may arise. These sets offer several advantages over the field assembly of individual components. Typical applications include boiler/ burner and emergency generator fueling systems. Most important is the undivided responsibility of delivering fuel at a predetermined pressure and flow.

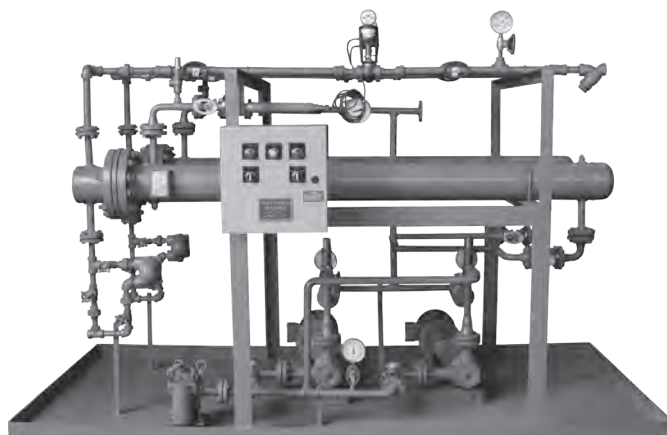
*Consult factory for suggested specifications*



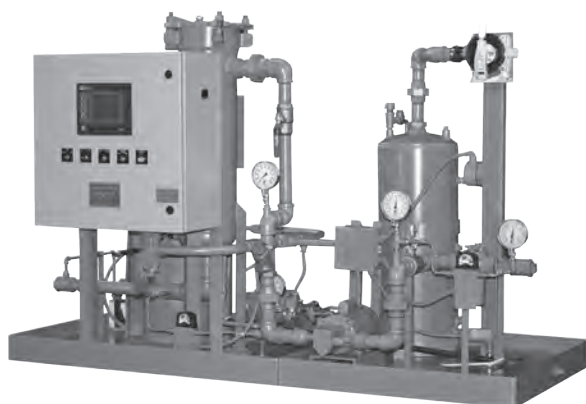
*Quadraplex Pump Set  
(One Electric 600 GPH, 160 PSI Pump, Two Electric 1200 GPH, 160 PSI Pumps, One Steam turbine pump 1800 GPH, 160 PSI One Integral Control Cabinet)*



*Fuel Oil Transfer Pump and Day Tank Set*



*Duplex Pump and Heater Set*



*Custom Filtration Duplex Pump Set*



*Automatic Transfer Pump Set ATPSF*

# FUEL MANAGEMENT SYSTEMS

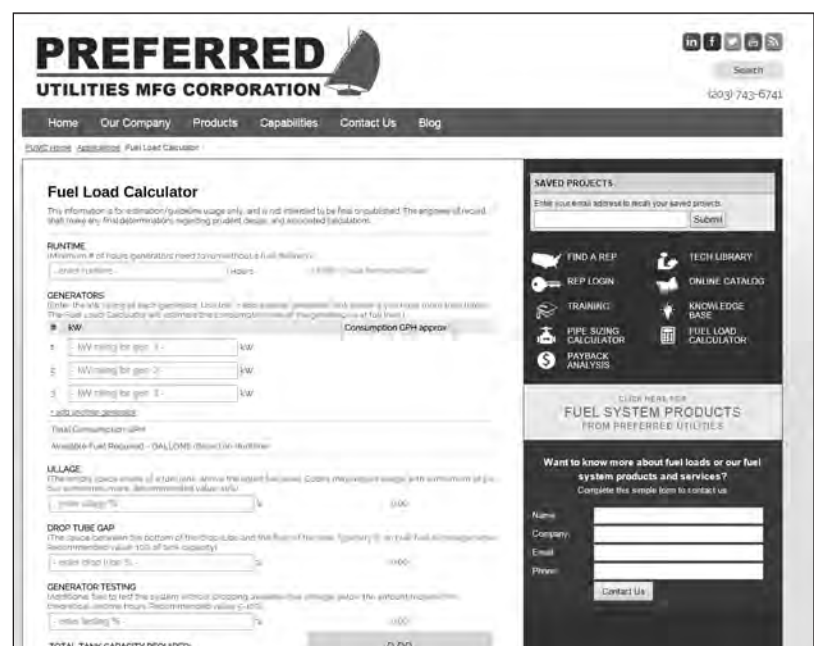
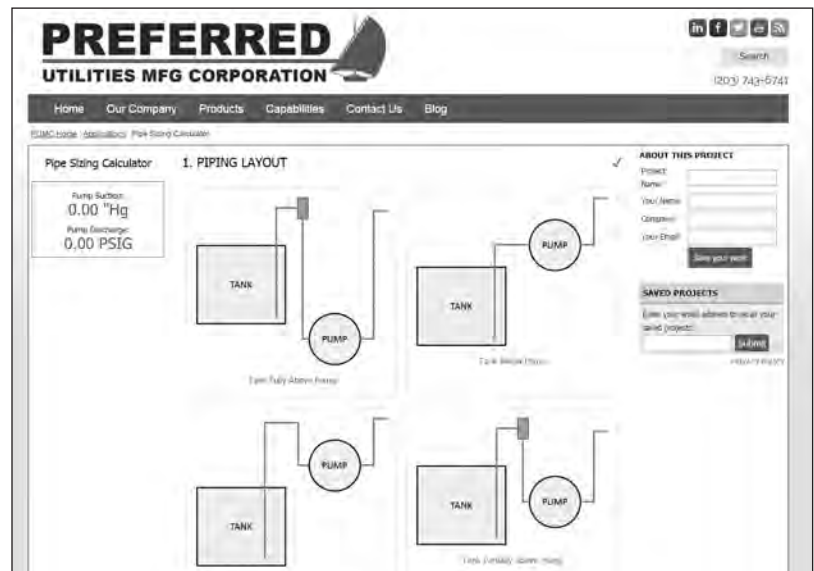
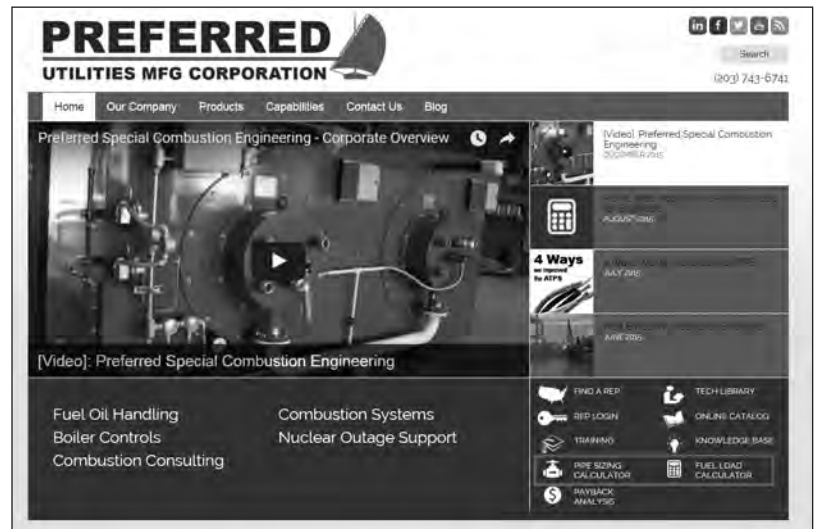
## Web-based Configuration Tools

Taking the place of the Fuel Sizing Program distributed by CD, Preferred has developed a variety of web-based tools to help with the design of fuel oil storage and handling systems.

### Key Features include:

- Tools to determine main storage tank volume, based on customer requirements
- Calculations to determine required pump flow based on connected generator KW and boiler horsepower.
- Inputs for main tank and pump elevation, line size, and pipe fittings to calculate suction at the transfer pump inlets. Excessive pump suction or other problematic suction line configurations are flagged for review by the user.
- Inputs for day tank elevation, line size, and pipe fittings to calculate required pump discharge pressure.
- Ability to choose from standard piping arrangements that include "Tank Below Pump," "Tank Below Pump With Overhead Piping," "Tank Partially Above Pump," "Tank Fully Above Pump."
- ASTM fuel oil grades selected from drop-down menu or custom fuel entered by adjusting specific gravity, temperature and viscosity.
- Altitude adjustments to ensure accurate NPSHA (Net Positive Suction Head Available).
- Anti-syphon valve, (if anti-syphon arrangement is selected spring size automatically selected).
- Detailed presentation of pump suction includes: priming suction, operating suction, piping loss, fitting loss, strainer loss and static lift.
- Pump set selectable from drop-down menu; the appropriate pump set is based on the desired flow rate and discharge pressure.

When the user is satisfied with the fuel system configuration, an option is available to export a sample specification for the fuel oil handling system. The output is a text file that can be copy-pasted into a larger document.



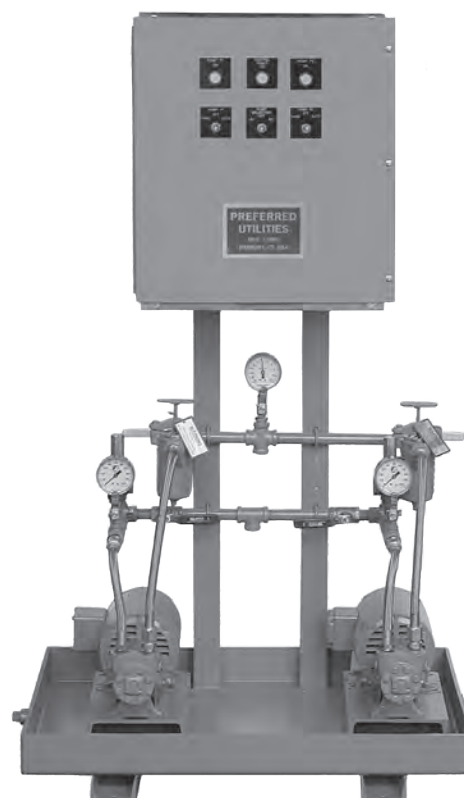
## SEMI-AUTOMATIC FUEL OIL TRANSFER PUMP SET

The Semi-Automatic Transfer Pump Set (SATPS) provides both manual "On" or "Off" operation or automatic operation in response to a "Call for Operation".

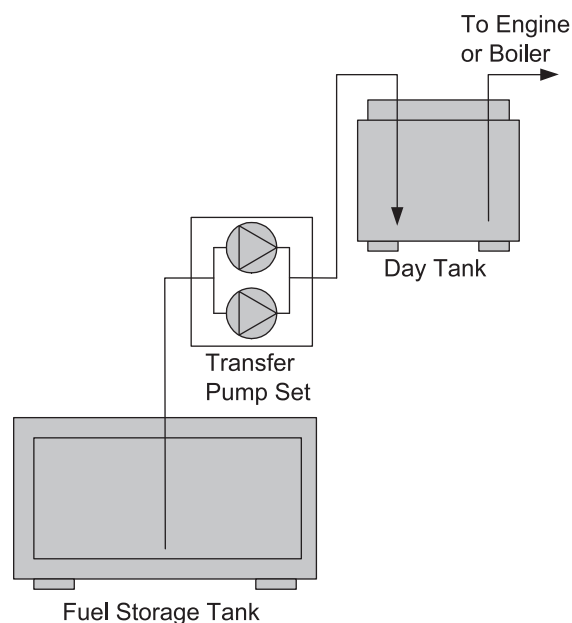
The Semi-Automatic Transfer Pump Set is a factory packaged, pre-engineered, pre-wired and pre-plumbed system that includes pumps, industrial motors and accessories. These systems are shipped to the job site, requiring only external fluid and electrical connections, ensuring undivided responsibility for delivering fuel at the required flow and pressure.

### Standard Equipment

- Two "Hand-Off-Auto" switches
- Two "Pump On" indicators
- "Lead Pump" switch
- "Power On" indicator
- Two magnetic motor starters with overload protection
- Two motor circuit breakers
- Two pump and motor assemblies
- Two relief valves, two check valves and four ball valves
- Two simplex inlet strainers
- Inlet compound gauge
- Discharge pressure gauges
- Three gauge isolation valves
- Base assembly



*Semi-Automatic Transfer Pump Set*



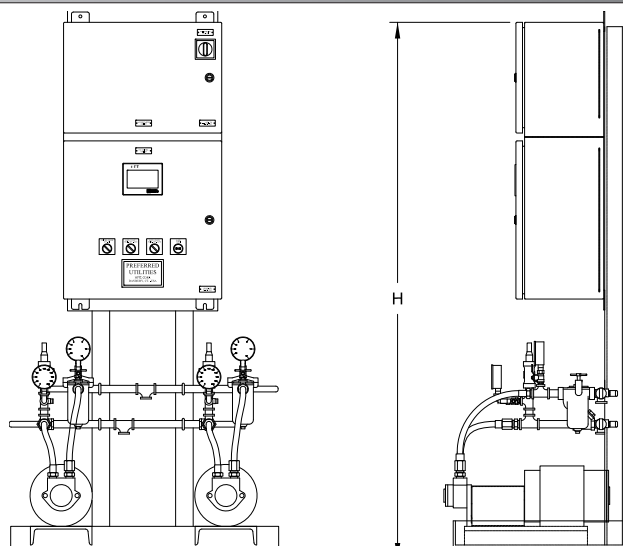
*Semi-Automatic Pump Set Application Example*



# SEMI-AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Specifications

- Motor Power: 120, 208, or 230 VAC 1 phase or  
208, 230, or 460 VAC 3 phase
- Control Circuit Power: 120 VAC 1 phase. Separate feed is required when selected motor voltage is other than 120 VAC
- Fluid: No. 2 or No. 4 Fuel Oil is standard. Consult factory for other fuel types.
- Pump: Bi-rotational, positive displacement type with cast iron housings and self-adjusting mechanical seals
- Motors: Base mounted, TEFC construction
- Strainer: Simplex ½", 1", or 1½" (according to inlet line size) complete with 40 mesh basket

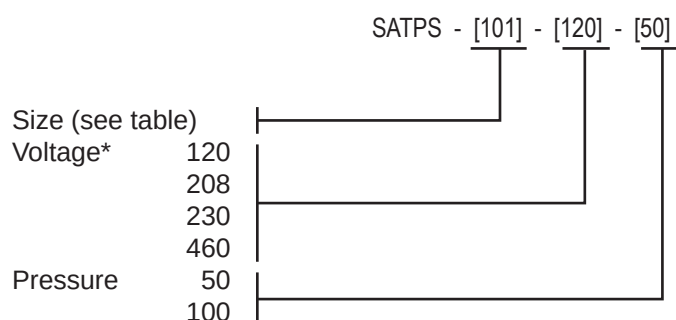


| Size | GPH Oil #2 / #4 | P.S.I. | Motor |     |                 |       | Dimension |       |     | Connection Size |        |              |
|------|-----------------|--------|-------|-----|-----------------|-------|-----------|-------|-----|-----------------|--------|--------------|
|      |                 |        | RPM   | HP  | Voltage         | Phase | L         | W     | H   | Inlet           | Outlet | Relief Valve |
| 101  | 20 / 23         | 100    | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
|      | 23 / 23         | 50     | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 102  | 27 / 33         | 100    | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
|      | 32 / 33         | 50     | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 103  | 80 / 93         | 100    | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
|      | 86 / 95         | 50     | 1725  | ⅓   | 120, 208 or 230 | 1     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 104  | 145 / 155       | 100    | 1725  | ½   | 208, 230 or 460 | 3     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
|      | 155 / 164       | 50     | 1725  | ½   | 208, 230 or 460 | 3     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 105  | 282 / 285       | 50     | 1725  | ¾   | 208, 230 or 460 | 3     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 106  | 277 / 285       | 100    | 1725  | 1   | 208, 230 or 460 | 3     | 30 ½"     | 22 ½" | 51" | ½"              | ½"     | ½"           |
| 201  | 340 / 415       | 50     | 1140  | ½   | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1"              | 1"     | ½"           |
| 202  | 300 / 410       | 100    | 1140  | ¾   | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1"              | 1"     | ½"           |
| 203  | 780 / 890       | 50     | 1140  | ¾   | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1 ½"            | 1 ½"   | ¾"           |
| 204  | 700 / 870       | 100    | 1140  | 1 ½ | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1 ½"            | 1 ½"   | ¾"           |
| 205  | 1100 / 1300     | 50     | 1140  | 1 ½ | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1 ½"            | 1 ½"   | 1 ¼"         |
| 206  | 1000 / 1200     | 100    | 1140  | 2   | 208, 230 or 460 | 3     | 65 ½"     | 30 ½" | 58" | 1 ½"            | 1 ½"   | 1"           |

Pump set ratings are nominal at pressures shown with a maximum 10" Hg vacuum at pump inlet.

## Ordering Information

Specify the pump set catalog number as follows:



\* Pump Set sizes 101 through 103 are single phase only, sizes 104 through 206 are three phase only.

Consult factory for custom sizes.

| Optional Features                                | Catalog Number  |
|--------------------------------------------------|-----------------|
| Duplex strainer in lieu of two simplex strainers | add "-D" suffix |

# SEMI-AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Suggested Specifications

### 1. Piping And Mounting

Provide a duplex pump and straining set that is factory assembled with components piped and mounted on a continuously welded steel plate containment basin with 3" steel side rails. Provide a ½" containment basin plugged drain connection. The basin shall be sized to contain (capture) potential leaks from all factory installed piping and components. Pipe shall be schedule 40 ASTM A-53 Grade "A" with ANSI B16.3 Class 150 malleable iron threaded fittings. Fuel Oil Transfer Pump and Straining Set shall be Preferred Utilities Mfg. Corp. Danbury, CT Model SATPS-\_\_\_\_ rated at \_\_\_\_ GPH of (No. 2), (No. 4), (Diesel) oil against a discharge pressure of \_\_\_\_ PSIG.

### 2. Positive Displacement Pumps

Provide and mount two (2) positive displacement rotary type pumps with cast iron housing and self-adjusting mechanical seals. Pumps that have aluminum, brass, or bronze housings or rotors are not acceptable. Packing gland equipped pumps, close-coupled pumps, Carbonator shaft-mounted pumps or centrifugal pumps are not acceptable.

### 3. Motors

Provide and mount two (2) TEFC, rigid base, standard NEMA frame motors. Pump and motor assemblies shall be factory assembled on a structural steel channel. Rotating parts shall have a steel OSHA guard.

### 4. Pump Isolation and Check Valves

Provide and mount four (4) pump isolation valves. Locate one (1) valve on the suction and discharge side of each pump. Isolation valves must allow off-line pump maintenance without system loss of availability. Isolation valves shall be ball type valves to provide full flow while open and positive shutoff when closed. Additionally, two (2) check valves shall be provided and mounted, one (1) located on the discharge of each pump.

### 5. Fuel Oil Strainer

Provide and mount two (2) simplex strainers with 40 mesh baskets, one (1) located on the suction side of each pump.

### 6. Vibration Reduction For Fuel System Life Extension

Careful dampening of positive displacement pump vibration is vital to the long life of the pumps, motors, control switches and entire fuel handling system. Pumps shall be connected to the piping via stainless steel flexible metallic braided jackets. Additionally, the pump and motor shall be connected via an elastomeric jaw-type flexible coupling.

### 7. Relief Valves

Provide and mount two (2) relief valves sized to relieve the full outlet flow of the pump without causing the pump motor to overload or any component's pressure rating to be exceeded if the discharge is inadvertently valved off. Relief valves must be externally mounted from the pumps and piped to the return line in the field according to NFPA 30. Pump internal relief valves shall not be accepted. Relief valves shall be Preferred Model R.

### 8. Compound And Pressure Gauges

Provide and mount a compound gauge on the suction side of the strainers. The gauge shall read 30" vacuum - 15 PSIG. Provide and mount a pressure gauge on the discharge side of each pump. Gauges selected must provide mid-scale readings under normal operating pressures. Each gauge shall be equipped with an isolation ball valve.

### 9. Control Cabinet

Provide a completely pre-wired and factory tested control cabinet to ensure job site reliability. The pump set and control cabinet shall be the product of one manufacturer for single source responsibility. The control cabinet shall be constructed to NEMA 4 standards. Doors shall be fully gasketed with a turned edge, piano hinges, and a three point lockable latching mechanism. Cabinet interior shall be primed and finished in a white gloss, chemical resistant enamel. Cabinet exterior shall be primed and finished in durable, chemical resistant, textured gray enamel, suitable for industrial environments.

All control wiring shall be terminated at a numbered terminal strip to facilitate field connections to remote equipment. All switches shall have maintained contacts. All cabinet front devices shall be identified by black phenolic labels with engraved white lettering. Cabinet shall consist of, but not be limited to, the following:

1. Magnetic motor starters with overload protection
2. Motor circuit breakers
3. "Hand-off-Auto" switch for each pump
4. Pump selector switch for selection of lead pump
5. Power on Indicating light
6. Pump running Indicating lights

### 10. Quality Assurance

The control cabinet shall be manufactured and labeled in accordance with UL 508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system must be manufactured by a nationally recognized trade union (I.B.E.W. or similar trade union). Lack of an NRTL certified UL508A wiring methods inspection and label or lack of a trade union label will be grounds for rejection.

### 11. Factory Testing

Pump sets must be fully tested prior to shipment. Testing shall include both a pressure and vacuum testing period. First, the complete pump set shall be pressure tested to rated pressure using an air pressure source. The test shall confirm that the pump set piping system can maintain rated pressure for four hours. Next, the complete pump set shall be brought to a vacuum greater than 25" Hg. The test shall confirm that the pump set piping system can maintain vacuum for four hours. Following a pressure and vacuum test the pump set shall be given a full operational test. The pump set shall be connected to a fuel oil supply and return. The pump set shall be operated normally. Motor amps shall be noted at no load and full load for each motor. The motor amps shall be within 10% of rated motor amps. During the test, the relief valve shall be set and tested. Operation of pump set instrumentation shall be tested.

A copy of the test procedures shall be sent to the consulting engineer and owner. The owners and or the consulting engineer at their discretion shall observe this and all other tests. A certificate of factory testing, together with a copy of the wiring diagram and arrangement diagrams shall be placed in the control cabinet prior to shipment.

# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Overview

The Automatic Fuel Oil Transfer Pump Set (ATPSF) is a state-of-the-art duplex pump sequencing and monitoring system. This system includes automatic lag pump back-up features that improve fuel system availability and safety. The ATPSF pump set has been upgraded to include the Preferred Flexible System Controller (FSC) to reduce field wiring and commissioning time.

- Loop or Day Tank Fuel Oil Transfer System
  - No. 2 or No. 4 fuel oil
  - Flows from 20 to 2200 GPH
  - Industrial type cast iron internal gear pumps
- Microprocessor-Based Monitoring And Control
  - 4" or 10" color touchscreen
  - Elapsed time recorders
  - Main storage tank gauge and discriminating leak monitoring by addition of optional Fuel Sentry tank gauge
- Automatic Lead/ Lag
  - Lead pump manual selection or automatic alternation on call for operation or run time hours
  - Automatic lag pump back-up based on lead pump thermal overload, failure to produce flow, fuel demand exceeds capacity of the lead pump
  - Automatic pump prime and suction line integrity check. Fuel transfer system suction piping, pump prime and pump operation are automatically verified each week (adjustable). Fuel system trouble can be identified and repaired before the unit is needed.
- Alarm and Event Summaries
  - Alarm and event summary with time and date stamp

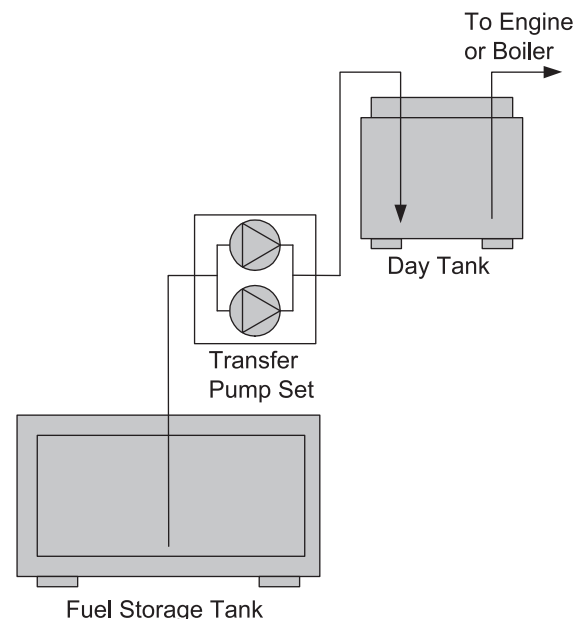
The Automatic Fuel Oil Transfer Pump Set is a factory packaged, pre-engineered, pre-wired and pre-plumbed system that includes pumps, industrial motors and accessories. These systems are shipped to the job site, requiring only external fluid and electrical connections, ensuring undivided responsibility of delivering fuel at the selected flow.

### Standard Equipment

- Microprocessor-based control with color touchscreen display and alarm/event and operator action log in a NEMA 4 enclosure.
- Included FSC controller communicates by redundant digital link to other FSC controllers on day tanks, filtration sets, and fill boxes to reduce field wiring.
- Control circuit transformer (if required)
- Alarm bell with alarm silence/reset pushbutton
- Two "Hand-Off-Auto" switches
- "Pump On" indicators
- Two magnetic motor starters with overload protection
- Two motor circuit breakers
- Two pump and motor assemblies
- Two relief valves, two check valves and four ball valves
- Two Simplex inlet strainers
- Pump discharge pressure gauges
- Pump set flow proving switch (shipped loose)



*Duplex Pump Set with Inlet Oil Strainer and Pump Control Cabinet*

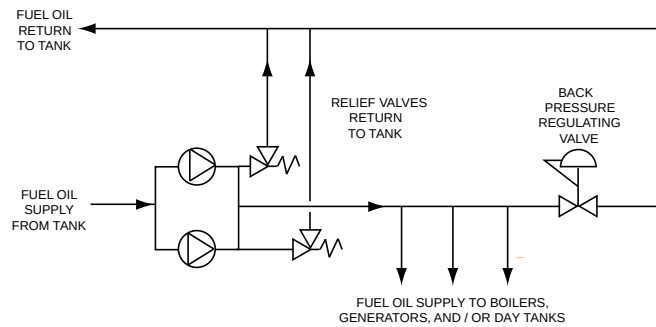


*Automatic Pump Set Application Example*

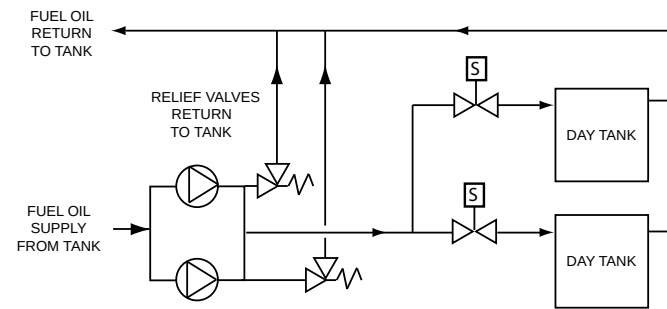


# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Overview



*Boiler Loop Fuel Oil Transfer System*



*Day Tank Fuel Oil Transfer System*

### Day Tank Fuel Oil Transfer System

The lead fuel pump is energized when day tank oil level falls below 50%. The lead pump continues to operate until the day tank level is greater than 80%. Upon the next call for fuel, the lead pump automatically alternates. The control system automatically energizes the back-up pump upon detecting a low level condition, (40% full condition). Both pumps then continue to operate until the level of oil reaches the high level point, 90% full condition. Upon detection of loss of flow or pressure or lead pump thermal overload the control system automatically energizes the backup pump and de-energizes the lead pump.

### Loop Fuel Oil Transfer System

The lead fuel pump is energized upon a call for oil and run continuously until the demand is removed. Upon the next call for fuel, the lead pump automatically alternates. The lead pump shall automatically rotate every 1 to 168 hours or shall be manually selected by the operator. Upon detection of loss of flow or pressure, or lead pump thermal overload the control system shall automatically energize the backup pump and de-energize the lead pump.

### Automatic Pump Prime And Suction Line Integrity Check

Fuel transfer system suction piping, pump prime and pump operation are automatically verified each week (adjustable). The lead pump is automatically energized. Once the lead pump has been proven, the lag pump is energized and run through the same test. These tests are recorded in the controller memory with a time-date stamp for later verification. If either lead or lag pump fails any of these tests, the control system generates an audible and visual alarm and logs the "failed pump" condition. To permit pump set testing, fuel oil piping system design must allow the pump set discharge to return to the main storage tank. The above diagrams show suitable Boiler Loop and Day Tank system arrangements. Additionally, system designs may include return flow pumps or solenoid valves. Consult factory for additional information.

### Modbus Communication Interface

Off-site monitoring and control is available via RS-485 Modbus, Ethernet TCP/IP, or BacNet IP digital communication.

### Alarms / Event Summary

Up to 200 alarms, system events and operator actions are listed in "first in-first out" order with time & date stamp. Alarms include "pump thermal overload," "pump loss of flow," and "pump set failure" with "day tank leak," "day tank high level" and "day tank low level" alarms added for day tank systems. The following events are recorded with time & date stamp: "pump started," "pump control switch in 'off' position," "pump set prime test OK" and "pump selected as lead."

### Building Automation System

Building Automation System (BAS) interface includes isolated relay contact outputs for "pump 1 fail," "pump 2 fail," "strainer high differential," "pump set leak," "day tank high," "day tank low" and "day tank leak" (all when applicable). Digital monitoring available via Ethernet TCP/IP or BacNet interface.

### Duplex Strainer (Option "-D")

A Preferred Model 72 duplex fuel oil strainer is provided on the suction side of the pump set instead of the two simplex strainers. Strainer baskets are 40 mesh stainless steel.

### Duplex Strainer Differential Pressure Switch (Option "-DP")

A differential pressure switch/ indicator with isolation cocks is provided to energize an audible and visual alarm should an excessively dirty strainer condition be detected (Option "-DP" can only be used with option "-D").

### Pump Set Leak Detector Switch (Option "-L")

A float-operated "containment basin leak" detection switch is provided to shut off the pumps and energize an audible and visual alarm should a pump set leak be detected.

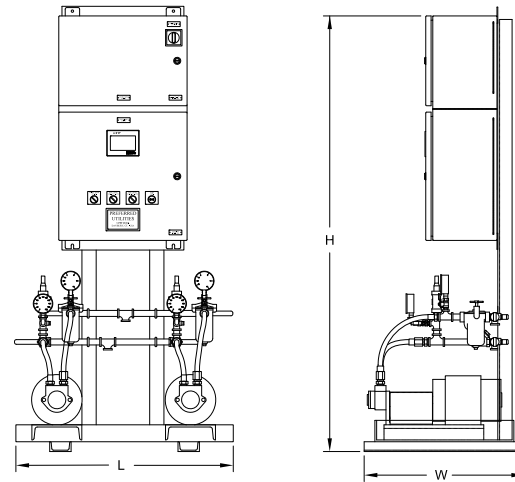
### Main Storage Tank Monitoring (Optional)

Fuel Sentry Model TG-EL-D4A tank gauges may be integrated into the Model ATPSF Transfer Pump Set.

# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Specifications

- Motor Power: 120, 208, or 230 VAC single phase or  
208, 230, or 460 VAC 3 phase
- Control Circuit Power: 120 VAC single phase step down transformer included when selected motor voltage is other than 120 VAC
- Fluid: No. 2 or No. 4 Fuel oil is standard. Consult factory for other fuel types.
- Pump: Bi-rotational, positive displacement type with cast iron housings and self-adjusting mechanical seals
- Motors: Base mounted, TEFC construction
- Strainer: Simplex, 1/2", 1", 1 1/2", or 2" (according to inlet line size) complete with 40 mesh basket

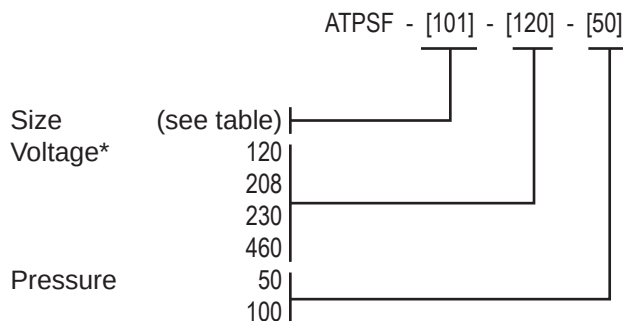


| Catalog Size | G.P.H. Oil #2 / #4 | P.S.I. | Motor  |       |                 |       | Dimension |         |     | Connection Size |        |              |
|--------------|--------------------|--------|--------|-------|-----------------|-------|-----------|---------|-----|-----------------|--------|--------------|
|              |                    |        | R.P.M. | H.P.  | Voltage         | Phase | L.        | W.      | H.  | Inlet           | Outlet | Relief Valve |
| 101          | 20 / 23            | 100    | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
|              | 23 / 23            | 50     | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 102          | 27 / 33            | 100    | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
|              | 32 / 33            | 50     | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 103          | 80 / 93            | 100    | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
|              | 86 / 95            | 50     | 1725   | 1/3   | 120, 208 or 230 | 1     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 104          | 145 / 155          | 100    | 1725   | 1/2   | 208, 230 or 460 | 3     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
|              | 155 / 164          | 50     | 1725   | 1/2   | 208, 230 or 460 | 3     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 105          | 282 / 285          | 50     | 1725   | 3/4   | 208, 230 or 460 | 3     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 106          | 277 / 285          | 100    | 1725   | 1     | 208, 230 or 460 | 3     | 30 1/2"   | 22 1/2" | 67" | 1/2"            | 1/2"   | 1/2"         |
| 201          | 340 / 415          | 50     | 1140   | 1/2   | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1"              | 1"     | 1/2"         |
| 202          | 300 / 410          | 100    | 1140   | 3/4   | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1"              | 1"     | 1/2"         |
| 203          | 780 / 890          | 50     | 1140   | 3/4   | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1 1/2"          | 1 1/2" | 3/4"         |
| 204          | 700 / 870          | 100    | 1140   | 1 1/2 | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1 1/2"          | 1 1/2" | 3/4"         |
| 205          | 1100 / 1300        | 50     | 1140   | 1 1/2 | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1 1/2"          | 1 1/2" | 1 1/4"       |
| 206          | 1000 / 1200        | 100    | 1140   | 2     | 208, 230 or 460 | 3     | 65 1/2"   | 30 1/2" | 74" | 1 1/2"          | 1 1/2" | 1"           |

Pump set ratings are nominal at pressures shown with a maximum 10" Hg vacuum at pump inlet

## Ordering Information

1. Specify the pump set catalog number as follows:



\* Pump Set sizes 101 through 103 are single phase only, sizes 104 through 206 are three phase only.

2. Supply a complete list of inputs and outputs intended to be hard-wired directly into the ATPSF controller including flow switches, leak detectors, and motor starters.

| Optional Features                                         | Catalog Number    |
|-----------------------------------------------------------|-------------------|
| Duplex strainer in lieu of two simplex strainers          | add "-D" suffix   |
| Duplex strainer differential pressure switch              | add "-DP" suffix  |
| Pump set leak detection switch                            | add "-L" suffix   |
| Building automation system (BAS) discrete output contacts | add "-BAS" suffix |
| Telephone modem                                           | 190604            |

3. Supply a complete list of additional FSC controlled devices in the system (day tanks, filtration systems, offloading skids)

4. Provide a complete list of TG-EL-D4A tank gauges to be connected to the ATPSF system.

# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Application

### ATPSF Pump Set Application

The ATPSF pump set is typically at the heart of a complete fuel oil storage and handling system. The FSC controller that makes up the brain of the ATPSF pump set has enough inputs and outputs to control a typical boiler loop system, or a typical generator system up to three day tanks. In this single-node configuration, all the day tank and main tank instruments hard-wire back to the FSC controller in the pump set enclosure.

Larger fuel oil handling systems, or systems where the tanks and generators are spread out geographically, will benefit from a multi-node FSC-based control system. In this configuration, each of the major components of a fuel oil handling system (pump set, day tank, filtration system, etc.) will include it's own FSC controller. Locally mounted-devices will hard-wire to the nearest FSC controller, and each of the FSC controllers will interconnect via a redundant digital communication system carried over a pair of three conductor shielded cables. This configuration can accommodate up to eighteen generator tanks, and greatly reduce the amount of field wiring and trouble-shooting.

### Reduced Field Wiring

As shown in the diagram below, using multiple, distributed FSC processors shortens the conduit and wire runs for the entire system. The NodeNetA and NodeNet B each consist of a single three conductor shielded cable.

### Reduced Programming Cost

By breaking a large fuel oil system into many small parts, Preferred is able to re-use programs from our library to reduce programming hours and shorten lead times. In the example below, the FSC controllers for each trio of day tanks, and the FSC controller in the filtration system, would be loaded with pre-coded configurations. Only the pump set controller would require a custom program.

### Lower Controller Hardware Costs

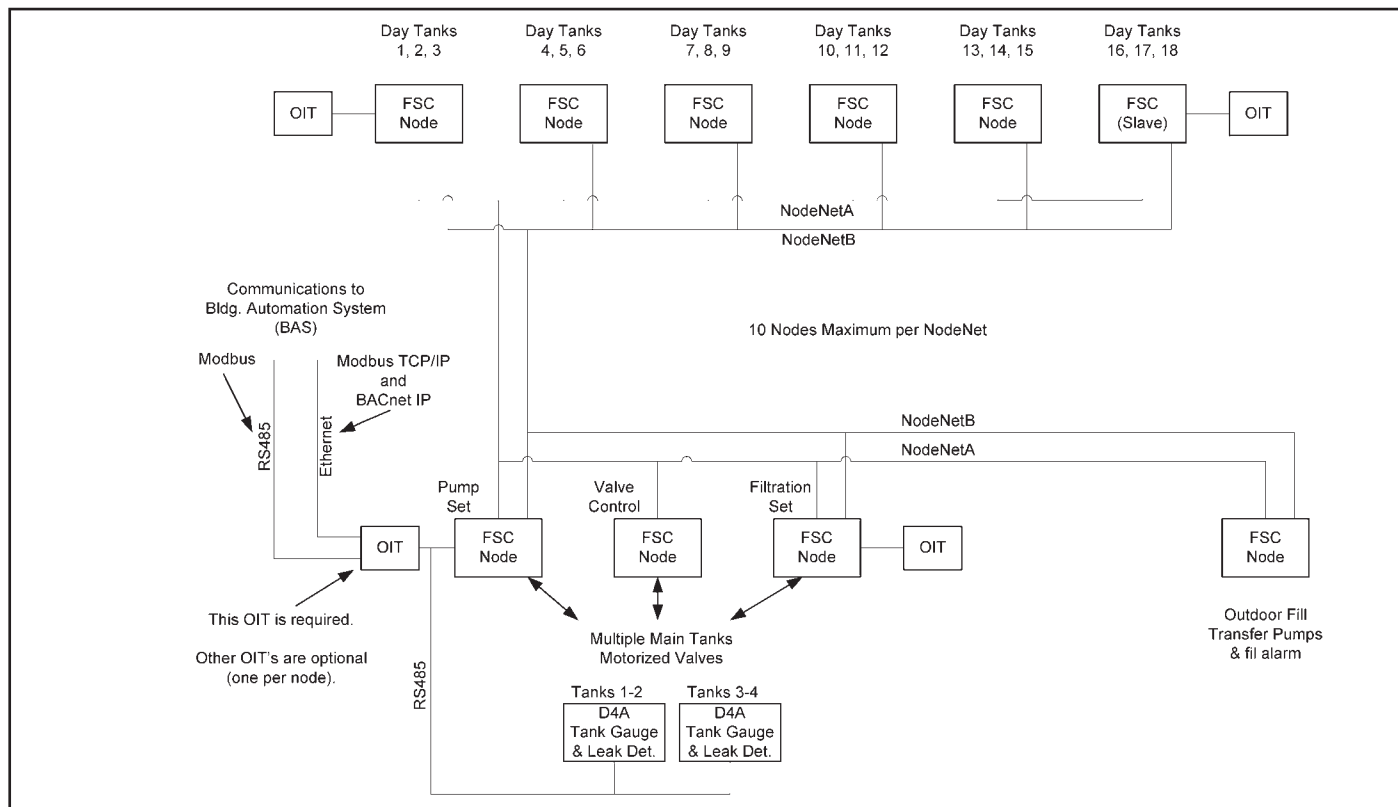
Each FSC controller is a relatively small microprocessor, purchased in large quantities. Several FSC microprocessors cost much less than a programmable logic controller with equivalent I/O.

### Easy to Interface

Each FSC controller can have it's own 4" color touchscreen local display. Through the NodeNet, each color touchscreen can access data from every FSC controller on the network and communicate that data via Ethernet or BacNet IP protocol to a Building Automation System (BAS). Pre-coded configurations mean Modbus address registers are pre-assigned.

### Increased System Hardening

The redundant NodeNet system linking all the FSC controllers runs two channels simultaneously. Loss of communication in one channel sounds an alarm, but communication continues on the other channel. The three conductor shielded cables for each NodeNet channel can be run in separate conduits for increased security.

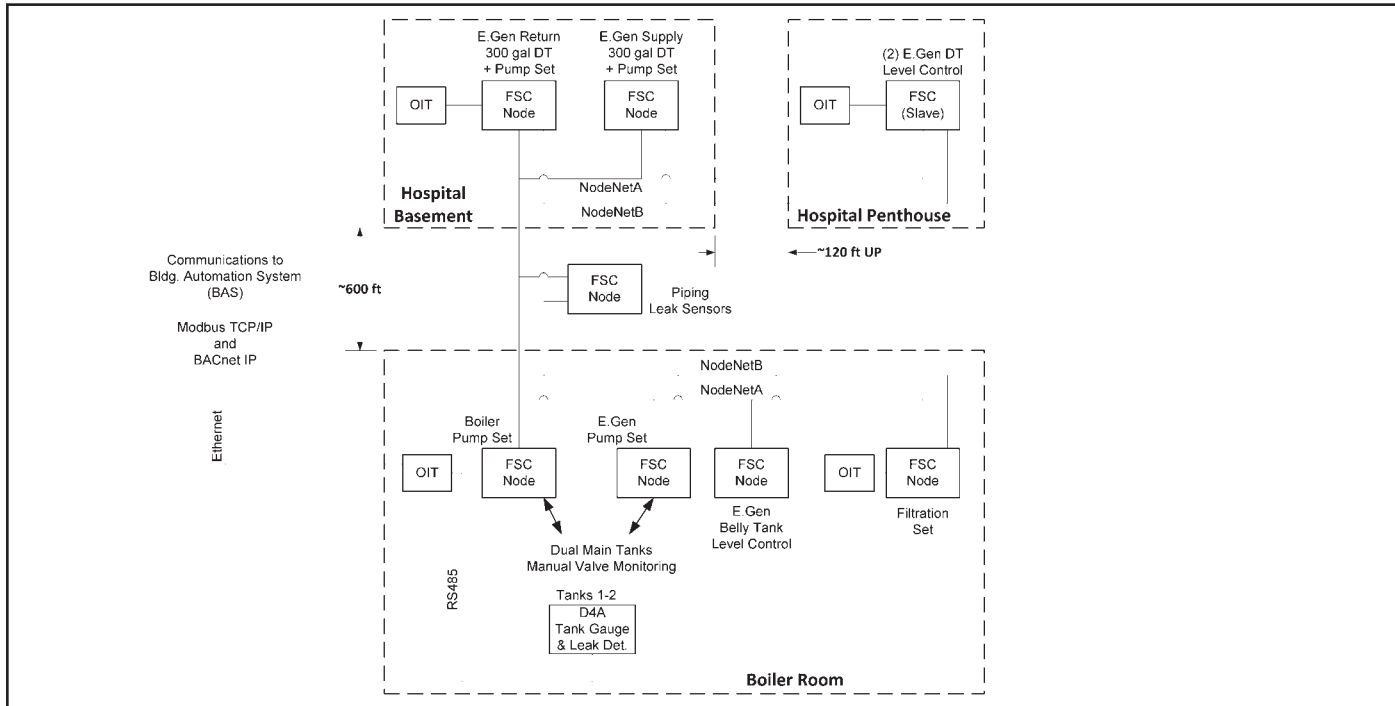


ATPSF pump set in a multi-node configuration.



# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Application



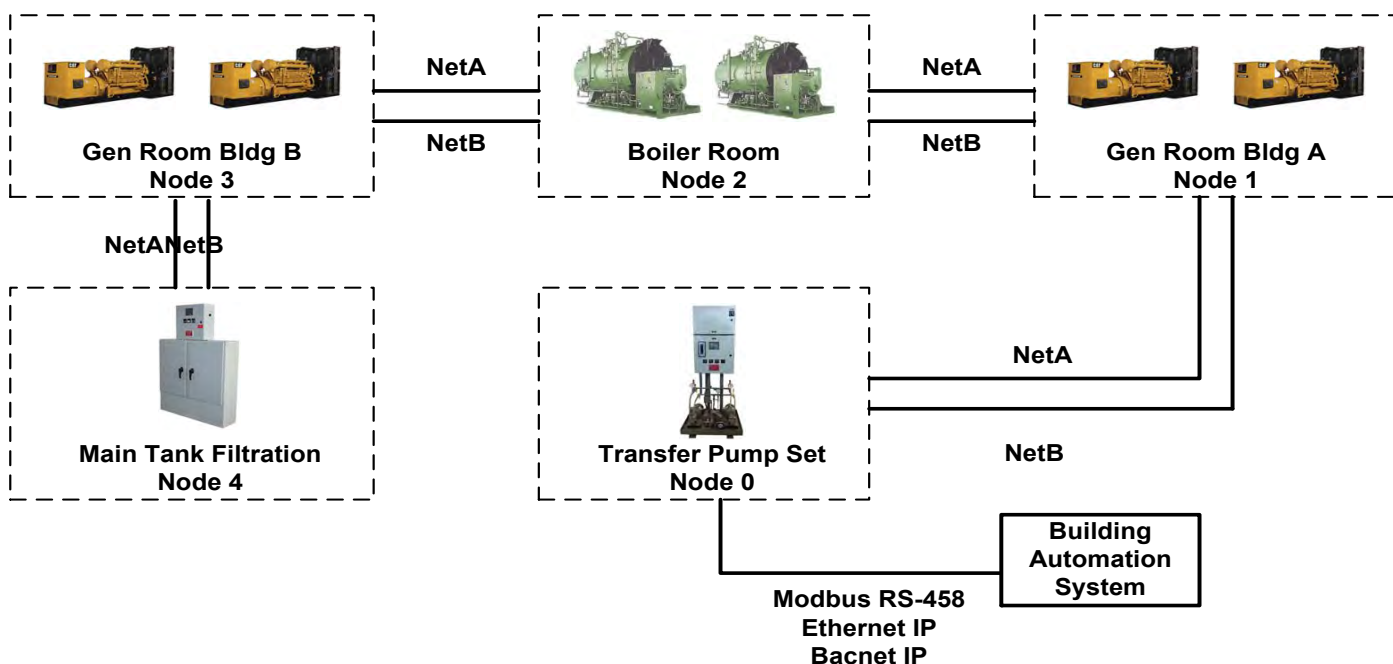
This real world example illustrates the reduced wiring requirements of the multi-node Preferred FSC controller system. Instead of running multiple hard-wires between floors in a typical hospital, the FSC controllers can communicate via a pair of two conductor shielded cables run in one or two 1/2" conduits.

### Enhances System Reliability

In a typical centralized PLC system, the entire system is down if the PLC goes down. With distributed control using a multi-node Preferred FSC system, loss of one FSC controller takes down just the components hard-wired to that controller.

Since all FSC controllers are identical, a spare FSC controller can be installed in a couple minutes using the quick disconnect terminals, and it's program reloaded from an SD chip for minimum downtime. Meanwhile, the rest of the FSC controllers

and hardware attached to them continues to run. Even in a critical day tank application, an operator will likely be able to replace a controller before the generator runs out of fuel in the day tank.



# AUTOMATIC FUEL OIL TRANSFER PUMP SET

## Suggested Specifications

### 1. Application

Supply a self-contained, automatic fuel oil transfer and monitoring system to ensure a reliable supply of fuel oil to the emergency generators or boilers included in this project. The system shall include automatic pump set lead/ lag, storage tank and day tank level monitoring, leak monitoring, LCD operator display, manual back-up stations, time and date stamped alarm and event summary, and the system shall include the capability to simultaneously communicate to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via Modbus protocol, and dial out to an alphanumeric pager system via field installable plug-in option modules in the future. The control system shall be microprocessor-based and can be expanded by adding additional FSC modules. The Automatic Fuel Oil Transfer Pump Set and monitoring system shall be Preferred Utilities Mfg. Corp. Danbury, CT Model ATPSF-\_\_\_\_ rated at \_\_\_\_ GPH of (No. 2), (No. 4), (Diesel) oil against a discharge pressure of \_\_\_\_ PSIG.

### 2. Pump Set and Control Cabinet

The pump set and control cabinet shall be completely pre-wired and tested to ensure job site reliability. The pump set and control cabinet shall be the product of one manufacturer for single source responsibility. Provide a factory assembled NEMA 4 steel enclosure with all operator interface control switches, indicators and displays physically separated from any field terminations.

### 3. Controller Hardware

Each microprocessor controller shall include the following inputs and outputs:

- (24) 120 VAC digital inputs
- (5) 2 A relay outputs
- (5) 1/2 HP (10 A) relay outputs
- (8) loop-powered 4-20 mA analog inputs
- (3) 4-20 mA analog outputs

Each controller shall include two RS-485 NodeNet communication ports for communicating to the other controllers in the distributed control system. In addition, each controller shall include two RS-485 communication ports for connection to a color touchscreen or other external device.

### 4. Operating Displays

The fuel system controller shall be equipped with a 4" color touchscreen Operating Interface Terminal (OIT) for pump set status, storage tank level indication, alarm listing, and trouble shooting functions. Provide dedicated pushbuttons for alarm silence and for the home page display and a "hand-off-automatic" control switch for each fuel pump. In "hand" position the pump shall be capable of manual operation in the event of a controller failure. The control system shall monitor the position of each "hand-off-automatic" control switch. Should a switch be put into the "off" position, the controller shall log the event with a time/ date stamp and store within the controller memory. Provide an Elapsed Time Recorder (ETR) to measure running time for each pump. Provide a fuel oil overview display (home page) capable of simultaneous viewing of pump set status, day tank status and main storage tank status. The fuel oil overview display shall include the following information:

- a) Lead pump selection – auto/manual
- b) Pump status – off/ run/ standby
- c) Day tank status – normal/ high/ low/ leak
- d) Main tank status – normal/ high/ low/ leak
- e) Three most recent alarms

The touchscreen shall communicate to the controller via RS-485 Modbus protocol. The touchscreen shall be pre-programmed at the factory with graphic pages for operation, setup, trouble-shooting, and alarm indication. Each touchscreen shall be capable of displaying information from any of the controllers in the distributed control system.

The touchscreens can communicate to an external controller, building automation system, or energy management system via RS-485 Modbus, Ethernet TCP/IP, or BacNet IP protocol.

### 5. Reliability

The controllers shall communicate using two NodeNet Communication Ports (A and B) that continuously communicate between all controllers wired in series (up to 10 controllers maximum). All of the information from all of the controllers will travel through all of the units. Upon start up NodeNet A will be the lead communication port with NodeNet B being the back up. In the event of a loss of communication NodeNet B will become the lead communication port. If one controller in the network fails, a common alarm will be activated and the other controllers will continue to function.

### 6. Alarm and event Logs

The control system shall include a 200 alarms, events and operator actions memory minimum. Provide an alarm display page for viewing the most recent eight alarms/ events with scrolling capability to view the complete 200 point alarm/ event memory. Each event and alarm condition must be displayed with a distinct, descriptive, English language description and time and date stamp. New alarms shall trigger the common alarm output relay. Events shall be recorded, but shall not trigger an alarm. A dedicated alarm silence button shall silence the alarm output. The control system shall record and annunciate the following alarms: pump thermal overload, pump loss of flow, pump set failure, day tank leak, day tank high level and day tank low level. The control system shall record the following events: pump started, pump control switch in "off" position, pump set prime test OK, and pump selected as lead.

### 7. Fuel Pump Alternation and Lead-Lag Operation [Day Tank Fuel Oil Supply Applications]

Provide automatic, microprocessor-based day tank level control. The lead fuel pump shall be energized when day tank oil level falls below 50%. The lead pump shall continue to operate until the day tank level is greater than 80%. Upon the next call for fuel, the lead pump shall be automatically alternated. The control system shall automatically energize the back-up pump upon detecting a low level condition (40% full condition). Both pumps shall then continue to operate until the level of oil reaches the high level point (90% full condition). Upon detection of loss of flow or lead pump thermal overload, the control system shall automatically energize the backup pump and de-energize the lead pump.

### 8. Fuel Pump Alternation and Lead-Lag Operation [Loop Fuel Oil Supply Applications]

Provide automatic, microprocessor-based fuel oil transfer pump control based upon a call for oil. The lead fuel pump shall be energized upon a call for oil from the boiler and run continuously until the demand is removed. Upon the next call for fuel, the lead pump shall be automatically alternated. The lead pump shall automatically rotate every 1 to 168 hours or shall be manually selected by the operator. Upon detection of loss of flow or pressure or lead pump thermal overload, the control system shall automatically energize the backup pump and de-energize the lead pump.

### 9. Automatic Pump Prime and Suction Line Integrity Check

The control system shall include a real-time clock and must be capable of automatically energizing the lead pump once every day. This is to verify suction piping integrity and pump prime and verify pump operation. Once the lead pump has proven satisfactory operation, the lag pump shall be energized and run through the same test. These tests shall be recorded in the controller memory with a time/ date stamp for later verification. If either lead or lag pump fails any of these tests, the control system shall generate an audible and visual alarm and log the "failed pump" condition.

## AUTOMATIC FUEL OIL TRANSFER PUMP SET

### Suggested Specifications

#### 10. Main Storage Tank Monitoring

The control system shall include main storage tank level sensor and discriminating leak sensor monitoring. Provide a continuous display of tank content, in both gallons and inches of product, within the main storage tank. Tank alarm displays shall not interfere with the display of the tank content. Provide data recall of the instantaneous display of tank content at the time of leak alarm condition. The control system shall include an overfill alarm circuit test pushbutton to provide instantaneous proving of audible and visual alarm circuitry associated with instrument overfill alarm contact. The system must be field expandable by adding additional FSC modules. Provide all equipment capabilities specified in this paragraph even if connecting level and leak sensors are not included in this project.

#### 11. Piping And Mounting

Provide a duplex pump and straining set that is factory assembled with components piped and mounted on a continuously welded steel plate containment basin with 3" steel side rails. Provide a ½" containment basin plugged drain connection. The basin shall be sized to contain (capture) potential leaks from all factory installed piping and components. Pipe shall be schedule 40 ASTM A-53 Grade "A" with ANSI B16.3 Class 150 malleable iron threaded fittings.

#### 12. Positive Displacement Pumps

Provide and mount two (2) positive displacement rotary type pumps, with cast iron housing and self-adjusting mechanical, carbon ring seals. Pumps that have aluminum, brass, or bronze housings or rotors are not acceptable. Packing gland equipped pumps, close-coupled pumps, carbonator shaft mounted pumps or centrifugal pumps are not acceptable.

#### 13. Motors

Provide and mount two (2) TEFC, rigid base, standard NEMA frame motors. Pump and motor assemblies shall be factory assembled on a structural steel channel. Rotating parts shall have a steel OSHA guard.

#### 14. Pump Isolation and Check Valves

Provide and mount four (4) pump isolation valves. Locate one (1) valve on the suction and discharge side of each pump. Isolation valves will allow off-line pump maintenance without system loss of availability. Isolation valves shall be ball type valves to provide full flow while open and positive shutoff when closed. Additionally, two (2) check valves shall be provided and mounted, one (1) located on the discharge of each pump.

#### 15. Fuel Oil Strainer

Provide and mount two (2) simplex strainers with 40 mesh baskets, one (1) located on the suction side of each pump.

#### 16. Relief Valves

Provide and mount two (2) relief valves sized to relieve the full outlet flow of the pump without causing the pump motor to overload or any component's pressure rating to be exceeded if the discharge is inadvertently valved off. Relief valves must be externally mounted from the pumps and piped to the return line in the field according to NFPA 30. Pump internal relief valves shall not be accepted. Relief valves shall be Preferred Model R.

#### 17. Compound And Pressure Gauges

Provide and mount a compound gauge on the suction side of the strainer. The gauge shall read 30" vacuum - 15 PSIG. Provide and mount a pressure gauge on the discharge side of each pump. Each gauge shall be equipped with an isolation ball valve.

#### 18. Pump Automatic Sequencing Flow Switch

Provide a time delayed flow sensing switch on the discharge of the pump set to energize the lag pump should the lead pump fail to maintain flow. Flow switch shall be vane operated to actuate a single double throw snap switch. Switch shall be factory wired to the control cabinet for alarm and backup pump operation. Switch shall be rated for 250 PSIG. Provide a flow switch outlet isolation valve for maintaining the flow switch without draining the fuel system.

#### 19. Quality Assurance

The control cabinet shall be manufactured and labeled in accordance with UL 508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system must be manufactured by a nationally recognized trade union (I.B.E.W. or similar trade union). Lack of an NRTL certified UL 508A wiring methods inspection and label or lack of a trade union label will be grounds for rejection.

#### 20. Factory Testing

Pump sets must be fully tested prior to shipment. Testing shall include both a pressure and vacuum testing period. First, the complete pump set shall be pressure tested to rated pressure using an air pressure source. The test shall confirm that the pump set piping system can maintain rated pressure for four hours. Next, the complete pump set shall be brought to a vacuum greater than 25" Hg. The test shall confirm that the pump set piping system can maintain vacuum for four hours. Following a pressure and vacuum test the pump set shall be given a full operational test. The pump set shall be connected to a fuel oil supply and return. The pump set shall be operated normally. Motor amps shall be noted at no load and full load for each motor. The motor amps shall be within 10% of rated motor amps. During the test the relief valve shall be set and tested. Operation of pump set instrumentation shall be tested. A copy of the test procedures shall be sent to the consulting engineer and owner. The owners and or the consulting engineer, at their discretion, shall observe this and all other tests. A certificate of factory testing, together with a copy of the wiring and arrangement diagrams shall be placed in the control cabinet prior to shipment.



## THERMOPUMP FUEL OIL TRANSFER PUMP AND HEATER SET

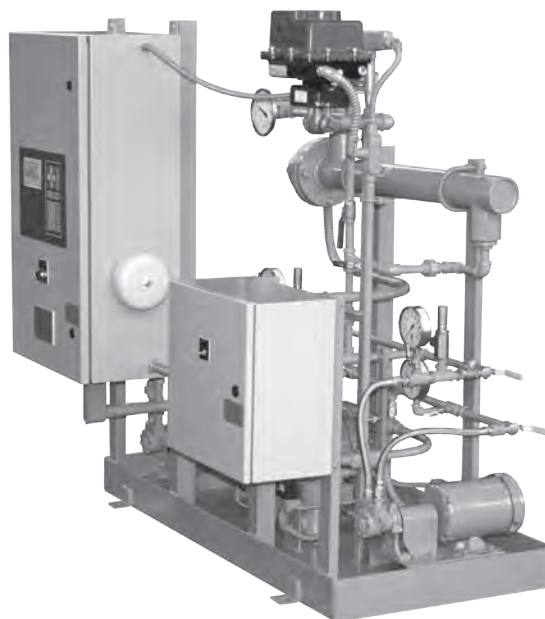
For No. 2 Fuel Oil Applications

- **No. 2 Fuel Oil**
- **Flows from 20 to 2200 GPH**
- **Above ground storage tanks supply & return oil line heating system and boiler loop or day tank fuel oil transfer system**
- **When heating is required, an electric heater is turned on and an automatic solenoid valve energized to recirculate fuel oil.**
- **Redundant safety features include an oil temperature switch and integral heater thermostat to protect against overheating, and guarantee that the oil returning to the tank will not be heated above 80°F.**
- **Dual temperature sensors measure both the in-line oil temperature, as well as the outdoor air temperature to activate the Thermopump in response to climatic or internal tank conditions.**
- **Lead pump manual selection or automatic alternation with automatic lag pump backup, alarms and safety shutdown interlocks.**

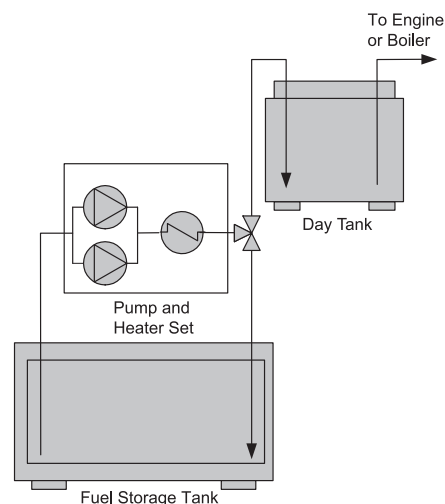
The Thermopump system provides the above ground oil storage tank and exposed suction and return lines with a recirculating flow of warm oil. Additionally, the Thermopump can provide automatic duplex pump sequencing and monitoring for boiler and day tank applications.

### Standard Equipment

- Microprocessor-based control with message display and keypad
- Two magnetic motor starters with overload protection
- Two motor circuit breakers
- Control circuit transformer (if required)
- Alarm bell with alarm silence / reset pushbutton
- Two "Hand-Off-Auto" switches
- "Power On" indicator
- Two pump & motor assemblies
- Three relief valves, two check valves and four ball valves
- Duplex inlet strainer with DP switch / gauge
- Inlet compound gauge
- Two discharge pressure gauges
- Three gauge isolation valves
- Flow switch and one base assembly leak detector switch
- Outdoor air temperature sensor
- Oil temperature switch
- Electric oil heater
- Integral heater thermostat
- Two temperature gauges
- Three-way motorized valve (optional)



*Thermopump Fuel Oil Transfer Pump and Heater Set*



*Thermopump Fuel Oil Transfer Pump and Heater Set  
Application Example*

When above ground storage tanks and exposed suction and return lines are exposed to temperatures below 40°F, fuel oil "gelling" can result. This problem becomes especially dangerous, and costly, in the case of idle diesel tanks that serve emergency generators. The gelling of oil in these tanks and fuel lines can render emergency generator and heating systems inoperative at a time when they are most needed.

# THERMOPUMP FUEL OIL TRANSFER PUMP AND HEATER SET

## Specifications

|           |                                                                                                       |
|-----------|-------------------------------------------------------------------------------------------------------|
| Power:    | Refer to table below                                                                                  |
| Fluid:    | No. 2 fuel oil is standard. Consult factory for other fuel types.                                     |
| Pump:     | Bi-rotational, positive displacement type with cast iron housings and self-adjusting mechanical seals |
| Motors:   | Base-mounted, TEFC construction                                                                       |
| Strainer: | Duplex 1", or 1½" complete with 40 mesh perforated basket                                             |

| Volume vs. Heating Capacity |          |         | Specifications |           |              |
|-----------------------------|----------|---------|----------------|-----------|--------------|
| Catalog Number              | Capacity | BTU     | Motor H.P.     | Heater KW | Set Voltage  |
| LO-101TP                    | 28.8 GPH | 5,000   | 1/3            | 1.5       | 115V-60Hz-1Ø |
| LO-102TP                    | 48.0 GPH | 8,500   | 1/3            | 2.5       | 115V-60Hz-1Ø |
| LO-103TP                    | 99.0 GPH | 17,000  | 1/3            | 5         | 230V-60Hz-1Ø |
| LO-104TP                    | 180 GPH  | 34,000  | 1/2            | 10        | 230V-60Hz-3Ø |
| LO-105TP                    | 312 GPH  | 61,000  | 1/2            | 18        | 230V-60Hz-3Ø |
| LO-201TP                    | 384 GPH  | 68,000  | 1/2            | 20        | 230V-60Hz-3Ø |
| LO-203TP                    | 810 GPH  | 143,000 | 3/4            | 42        | 230V-60Hz-3Ø |
| LO-205TP                    | 1140 GPH | 205,000 | 1 1/2          | 60        | 460V-60Hz-3Ø |
| LO-207TP                    | 2160 GPH | 368,000 | 2              | 108       | 460V-60Hz-3Ø |

*Note: All heating capacities are based on a delta T of 40° F.  
All pump capacities are based on zero PSIG*

## Ordering Information

1. Select catalog number (see table)

For non-standard or heavy oil pumping systems, consult factory.

# THERMOPUMP FUEL OIL TRANSFER PUMP AND HEATER SET

## Suggested Specifications

### 1. Piping And Mounting

Provide an electric heating and duplex pump and straining set that is factory assembled with components piped and mounted on a continuously welded steel plate containment basin with 3" steel side rails. Provide a ½" containment basin plugged drain connection. The basin shall be sized to contain (capture) potential leaks from all factory installed piping and components. Pipe shall be schedule 40 ASTM A-53 Grade "A" with ANSI B16.3 Class 150 malleable iron threaded fittings. Fuel oil heating and transfer pump and straining set shall be Preferred Utilities Mfg. Corp. Danbury, CT, thermopump Model LO-\_\_\_\_ rated at \_\_\_\_ GPH of No. 2 fuel oil against a discharge pressure of \_\_\_\_ PSIG.

### 2. Containment Basin Leak Detection Switch

Provide, mount and wire a float operated containment basin leak detection switch to shut off the pumps and energize an audible and visual alarm should a leak be detected. The level sensor shall be of a plasma welded stainless steel construction. Electrical connections shall be contained in a weatherproof junction box.

### 3. Electric Fuel Oil Heater

Provide, install and wire an electric fuel oil heater on the discharge of the duplex pump and motor assemblies. When the oil temperature in the system drops below 40° F the heater shall come on and be capable of heating [\_\_\_\_] GPH of fuel oil to a 40° F delta T to a maximum of 80° F. The heater shall shut off at a set point that is field adjustable. The heater shall have a maximum watt density of 18 watts per square inch, and shall contain an integral adjustable thermostat supplying [\_\_\_\_] Btu/hr to the system. The heater shall be controlled by a line voltage thermostat which shall be wired in the pilot circuit of a contactor of ample rating for the heater current. The heater shall be listed as standard by Underwriters' Laboratories, Inc. and shall be installed in a 150 PSI flanged manifold with oil connections not less than 2" i.p.s. Heater shall be Preferred Utilities Model L.

### 4. Positive Displacement Pumps

Provide and mount two (2) positive displacement rotary type pumps with cast iron housing and self-adjusting mechanical, Carbon ring seals. Pumps that have aluminum, brass, or bronze housings or rotors are not acceptable. Packing gland equipped pumps, close-coupled pumps, carbonator shaft-mounted pumps or centrifugal pumps are not acceptable.

### 5. Motors

Provide and mount two (2) TEFC, rigid base, standard NEMA frame motors. Pump and motor assemblies shall be factory assembled on a structural steel channel. Rotating parts shall have a steel OSHA guard.

### 6. Outdoor Differential Temperature Sensor

An outdoor differential temperature sensor shall be provided. It shall be wired to the differential temperature control in the fuel oil temperature control cabinet. This sensor and control shall turn the transfer pump on and circulate oil through the supply and return loop when the outdoor temperature reaches 40° F.

### 7. Oil Differential Temperature Sensor

An oil differential temperature sensor shall be provided and be wired to the differential temperature control in the fuel oil temperature control cabinet. This sensor shall control and turn on the heater based on oil temperature.

### 8. Temperature Controller

An immersion type controller shall be provided with a snap-action microswitch to operate on rise of temperature, and shall limit the temperature of the oil discharge on the Thermopump System. This device functions as a safety interlock with the thermostat on the electric oil heater and the flow sensing device in the pump discharge.

### 9. Heater "No-Flow Alarm" and Pump Automatic Sequencing Flow Switch

Provide a time-delayed flow sensing switch on the discharge of the pump set to alarm a "no-flow" condition when the heater is energized and bring on the lag pump should the lead pump fail to maintain flow. Flow switch shall be vane-operated to actuate a single double throw snap switch. Switch shall be factory wired to the control cabinet for alarm and backup pump operation. Switch shall be rated for 250 PSIG. Provide a flow switch outlet isolation valve for maintaining the flow switch without draining the fuel system.

### 10. Oil Temperature Gauges

Provide two (2) 5" dial oil temperature gauges calibrated for 0-250° F, for the supply and discharge sides of the pump set. The gauges shall be of welded construction, with a shatter-proof polycarbonate lens, and be hermetically sealed to prevent moisture from entering the case, or fogging the lens. Gauges shall be mounted in separable wells.

### 11. Pump Isolation and Check Valves

Provide and mount four (4) pump isolation valves. Locate one (1) valve on the suction and discharge side of each pump. Isolation valves will allow off-line pump maintenance without system loss of availability. Isolation valves shall be ball type valves to provide full flow while open and positive shutoff when closed. Additionally, two (2) check valves shall be provided, one (1) mounted on the discharge of each pump.

### 12. Automatic Motorized Valve

Provide and mount one (1) motorized, three way ball valve. The valve shall be ball type to provide full flow while in either position. The valve shall be equipped with position limit switches and a means to manually operate the valve in the case of a motor or pump set controller failure.

### 13. Fuel Oil Strainer

Provide and mount a duplex fuel oil strainer on the suction side of the duplex transfer pump set. Strainer baskets shall be fabricated of 40 mesh stainless steel. Provide a factory wired differential pressure switch/ indicator mounted with isolation valves. Strainer to be Preferred Model 72.

### 14. Relief Valves

Provide and mount two (2) relief valves sized to relieve the full outlet flow of the pump without causing the pump motor to overload or any component's pressure rating to be exceeded if the discharge is inadvertently valved off. Relief valves must be externally mounted from the pumps and piped to the return line in the field according to NFPA 30. Pump internal relief valves shall not be accepted. A third valve shall be provided for the electric heater. This valve shall have a set point of 5 PSI above the pump relief valves. This valve shall be used to relieve any build up in pressure due to an inadvertent isolation of an operating heater. Relief Valves shall be Preferred Model R.



# THERMOPUMP FUEL OIL TRANSFER PUMP AND HEATER SET

## Suggested Specifications

### 15. Compound And Pressure Gauges

Provide and mount a 4" dial compound gauge on the suction side of the strainer. The gauge shall read 30" vacuum - 15 PSIG. Provide and mount a 4" dial pressure gauge on the discharge side of each pump. Gauges selected must provide mid-scale readings under normal operating pressures. Gauges shall be liquid filled to dampen pulsation, with bright finished stainless steel case, brass movement, bronze bourdon tube, and shall be furnished with a pulsation dampening orifice. Each gauge shall be equipped with an isolation ball valve.

### 16. Control Cabinet

Provide a completely pre-wired and factory tested control cabinet to ensure job site reliability. The pump and heater set and control cabinet shall be the product of one manufacturer for single source responsibility. Cabinet shall be completely pre-wired, tested, and shipped as an integrated system to ensure job site reliability. The control system enclosure shall be constructed to NEMA 4 standards. Doors shall be fully gasketed with a turned edge, piano hinges, and a three point lockable latching mechanism. Cabinet interior shall be primed and finished in a white gloss, chemical resistant enamel. Cabinet exterior shall be primed and finished in a durable, chemical resistant, textured gray enamel, suitable for industrial environments.

### 17. Control Hardware

The control strategy shall be microprocessor-based. RELAY LOGIC SHALL NOT BE ACCEPTABLE. The control strategy shall be factory configured and stored on a EEPROM, and shall be safeguarded against re-configuration by unauthorized/unqualified personnel. The controller shall be designed so that it will "fail safe" in the event there is a microprocessor failure. Control hardware shall include combination magnetic motor starters with overload protection and circuit breakers. The control system shall provide common alarm dry contacts to be interfaced with the Building Maintenance System as required.

### 18. Automatic Standby Pump Operation

The standby pump shall be activated and operate in tandem with the lead pump upon low-low level in the day tank. The standby pump shall be activated and the lead pump shall be shutdown upon lead pump running and no flow produced and lead pump thermal overload.

### 19. Heating and Fuel Oil Transfer Pump Set Modes

When there is a "call for operation" from the boiler loop or day tank, the three way valve is automatically positioned to the fuel transfer position to deliver oil as required. When there is no "call for operation" and there is a heating requirement, the electric heater is turned on and the three way valve is automatically positioned to recirculate fuel oil to the main storage tank.

### 20. Safety Interlocks

Provide safety interlocks to shut down both pumps during any of the following conditions: heater on and "no flow" detected, over temperature, pump set "leak detected", day tank "leak detected" and "high" day tank level. These interlocks must continue to ensure safe pump operation even if the controller has failed or is out of service and the pump set is operated in manual "hand" mode.

### 21. Operator Interface

All operator interface shall be cabinet front door mounted. As a minimum, the following indications, alarms, control switches and pushbuttons shall be provided:

1. Alarm silence, manual reset, lamp/ alarm test pushbuttons
2. Lead pump selection and "Hand-off-Auto" control switches for the heater and each pump
3. "Pump 1 On", "Pump 2 On", "Flow Established" and tank level indications
4. Heater on and "No-Flow", three way valve "Failure", over temperature, strainer high differential pressure, pump failure, day tank leak, pump set leak, day tank high level and day tank low level alarms
5. An alarm bell shall be provided for alarm conditions.

### 22. Quality Assurance

The control cabinet shall be manufactured in accordance with UL 508A. Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet as a whole must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system must be manufactured by a nationally recognized trade union (I.B.E.W. or similar trade union). Lack of an NRTL certified UL 508A wiring methods inspection and label or lack of a trade union label will be grounds for rejection.

### 23. Factory Testing

The complete pump and heater set must be fully tested prior to shipment. Testing shall include both a pressure and vacuum testing period. First, the complete pump set shall be pressure tested to rated pressure using an air pressure source. The test shall confirm that the pump set piping system can maintain rated pressure for four hours. Next, the complete pump set shall be brought to a vacuum greater than 25" Hg. The test shall confirm that the pump set piping system can maintain vacuum for four hours. Following a pressure and vacuum test the pump set shall be given a full operational test. The pump set shall be connected to a fuel oil supply and return. The pump set shall be operated normally. Motor and heater amps shall be noted at no load and full load conditions. The motor amps shall be within 10% of rated motor amps. During the test the relief valve shall be set and tested. Operation of pump set instrumentation shall be tested.

A copy of the test procedures shall be sent to the consulting engineer and owner. The owners and or the consulting engineer at their discretion shall observe this and all other tests. A certificate of factory testing, together with a copy of the wiring and arrangement diagrams shall be placed in the control cabinet prior to shipment.

## AUTOMATIC FUEL OIL FILTRATION SET

Recommended by NFPA 110 Standard for Emergency and Standby Power Systems

The Automatic Fuel Oil Filtration Set, Model PF, is the most complete, efficient and reliable engine protection system you can install. These self-contained, fully automatic systems remove water, suspended rust, dirt and other contaminants in order to maintain the quality and purity of stored diesel fuel.

### Standard Equipment

- Preferred FSC-based control with color touch screen
- Pump “Hand-Off-Auto” switch
- Control power “On-Off” switch
- Leak detector switch
- Pump and motor assembly
- Simplex strainer
- Filter / Water separation cartridge
- Primary/secondary filter DP switch/gauge

Water enters fuel systems through vents, leaks, and sometimes with the delivered fuel. Microorganisms can grow in fuel, especially in the presence of moisture. The resulting sludge left in the system can cause tank, fuel line, strainer, pump and engine injectors to clog. Water induced corrosion (rusting) can reduce tank life expectancy and reliability of the emergency diesel generator or boiler.

The Model PF automatic fuel oil filtration set combines microprocessor-based control and monitoring with a “three stage” fuel oil de-watering and cleaning process:

1. Fuel Straining: Large contaminants are removed
2. Filtration: Fuel filtration to 5 micron
3. Water Removal: Removes water through special filter design.

Note: diesel engine manufacturers recommend 10 micron filtration of fuel oil. Filter elements smaller than 5 microns are prone to clogging and are not recommended. For more information, consult the maintenance manual for your engines.

### Key Benefits

- Standard flows from 180 to 1200 GPH
- Cleans and de-waters fuel with:
  - Nearly 100% water removal
  - 99% particulate removal (to 5 micron)
- Automatic cycling based on the time of day and the day of the week ensures continuous fuel maintenance.
- Alarm and safety shutdown for filter water level “High”, filter “Saturated”, system base “Leak” detected
- Microprocessor-based
- Factory mounted and wired control cabinet
- NEMA 4 cabinet (standard)
- Available for biodiesel applications

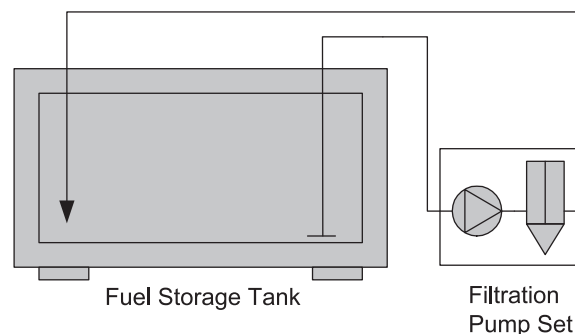


*Model PF Automatic Fuel Oil Filtration Set*

The separated contaminants and water are monitored by an integral filter water level detector. Depending on the size of the system, this waste water is piped to an optional Waste Water Holding and Removal System or connected directly to the customer's waste tank (by others). A differential pressure switch/ indicator is installed around the filter units to provide a visual indication of filter element condition. An alarm notifies plant personnel when the filter elements require replacement.

Systems are available in standard sizes ranging from 180 to 1200 gallons per hour, to custom units for processing 50 gallons per minute or more.

Integral Preferred FSC-based controller can communicate via NodeNet to other FSC controllers in the fuel system.



*Automatic Fuel Oil Filtration Set Application Example*

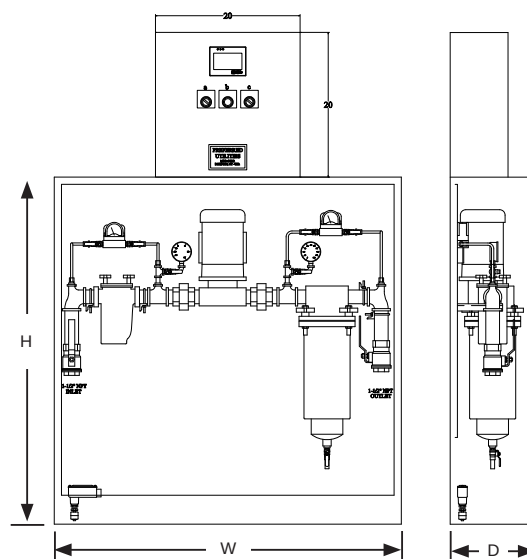
# AUTOMATIC FUEL OIL FILTRATION SET

## Specifications

For best results, use in conjunction with the waste water removal and storage option (WR-1) and Preferred fuel additives system (CA-1) option. See page 9 for photo.

### Specifications

|                     |                                                                                                                                                                    |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power:              | 120 VAC (external)                                                                                                                                                 |
| Fluid:              | No. 2 Fuel Oil (diesel fuel) is standard.<br>Consult factory for other fuel types.                                                                                 |
| Pump:               | Positive displacement type with cast iron housings:<br>Model PF-501, 502 & 503 are spur gear;<br>Model PF-504 & 505 are internal gear                              |
| Motors:             | Base mounted, Totally Enclosed Fan Cooled (TEFC) construction                                                                                                      |
| Strainer:           | Simplex 1" , or 1½" (according to inlet line size) complete with 100 mesh perforated basket                                                                        |
| Automatic Controls: | - Adjustable run-time period<br>- Indications/Alarms:<br>Control power on<br>Pump run<br>Filter saturated<br>Filter water level high<br>System basin leak detected |



### Tank Turnover Time In Hours

(Rounded to Nearest Hour)

|        | Storage Tank Size (Gallons) |       |       |       |        |        |
|--------|-----------------------------|-------|-------|-------|--------|--------|
|        | 1,000                       | 2,000 | 4,000 | 8,000 | 16,000 | 20,000 |
| PF-501 | 6                           | 11    | 22    | 44    | 89     | 111    |
| PF-502 | 2                           | 4     | 8     | 17    | 33     | 42     |
| PF-503 | 2                           | 3     | 7     | 13    | 27     | 33     |
| PF-504 | 1                           | 2     | 4     | 9     | 18     | 22     |
| PF-505 | 1                           | 2     | 3     | 7     | 13     | 16     |

### Notes:

1. Shaded hours are not recommended.
2. Due to the mixing of filtered fuel with unfiltered fuel, a minimum of three tank turnovers are recommended to ensure fuel quality.

### Ordering Information

Select catalog number from the table below.

| Catalog Number | G.P.H. Oil #2 | P.S.I. | Motor  |      | Dimension |     |     | Connection Size | Shipment  |
|----------------|---------------|--------|--------|------|-----------|-----|-----|-----------------|-----------|
|                |               |        | R.P.M. | H.P. | W         | H   | D   | Inlet - Outlet  |           |
| PF-501         | 180           | 15     | 1725   | ¼    | 48"       | 48" | 12" | ¾" - 1½"        | 2-3 Weeks |
| PF-502         | 480           | 15     | 3450   | ⅓    | 48"       | 48" | 12" | ¾" - 1½"        | 2-3 Weeks |
| PF-503         | 600           | 30     | 1725   | ½    | 48"       | 48" | 12" | ¾" - 1½"        | 2-3 Weeks |
| PF-504         | 900           | 30     | 1725   | ¾    | 48"       | 48" | 12" | 1½" - 1½"       | 2-3 Weeks |
| PF-505         | 1200          | 25     | 1725   | ¾    | 48"       | 48" | 12" | 1½" - 1½"       | 2-3 Weeks |

Note: All pumps are 115 V, 60 Hz , single phase.

### Optional Accessories

#### 1. Waste water holding and removal system:

A gear pump automatically pumps water from the secondary filter housing to the holding tank based on an integral filter water detector signal. Automatic isolating valves prevent water leakage into the fuel or fuel into the water holding tank when the system is idle. The holding tank is equipped with a high level switch to alarm and shutdown the fuel maintenance system until the tank is emptied. A hand pump is provided for periodic removal of waste water from the holding tank. Requires mounting skid. Specify P/N-WR-01.

#### 2. Chemical additive holding tank and injection system:

Chemical treatment helps to prevent fuel degradation and improve cetane rating. Higher cetane rating improves cold starting, reduces white smoke, and maximizes engine efficiency. A gear metering pump injects additives into the oil while the oil is circulating in order to ensure complete mixing. The additive feed pump operating cycle runs biannually, or it can be activated when new fuel is delivered. A welded steel chemical additive holding tank is provided. Separate skid if ordered in conjunction with standard PF series. Specify P/N-CA-01.



# AUTOMATIC FUEL OIL FILTRATION SET

## Suggested Specifications

### 1. Enclosure, Piping And Mounting

Provide a fuel oil filtration system as recommended by NFPA 110 Standard for Emergency and Standby Power Systems. The filtration system shall be factory assembled with components piped and mounted inside a continuously welded steel enclosure. The enclosure shall be constructed of 14 gauge steel as minimum, continuously welded and constructed to NEMA 4 standards and have an integral 2" steel containment basin with plugged drain options. The basin shall be sized to contain (capture) potential leaks from all factory installed piping and components. Doors shall be fully gasketed with a turned edge, piano hinges, and a three point lockable latching mechanism. The enclosure interior shall be primed and finished in a white gloss, chemical resistant enamel. The enclosure exterior shall be primed and finished in a durable, chemical resistant, textured gray enamel, suitable for industrial environments. Pipe shall be schedule 40 ASTM A-53 Grade "A" with ANSI B16.3 Class 150 malleable iron threaded fittings. The fuel oil filtration system shall be Preferred Utilities Mfg. Corp. Danbury, CT Model PF-\_\_\_\_ rated at \_\_\_\_ GPH of No. 2 fuel oil.

### 2. Containment Basin Leak Detection Switch

Provide, mount and wire a float-operated containment basin leak detection switch to shut off the pumps and energize an audible and visual alarm should a leak be detected. The level sensor shall be a plasma welded stainless steel construction. Electrical connections shall be contained in a weatherproof junction box.

### 3. Strainer

Oil strainer shall have cast iron body, threaded connection, size shall be suitable for the required flow and suitable for working pressures to 150 PSIG. Clamped cover and handle shall permit easy removal of the basket. Basket shall be constructed of 100 mesh stainless steel.

### 4. Pump and Motor Assembly

A base mounted, TEFC motor, and positive displacement pump with cast iron housing shall be provided. Pumps that have aluminum, brass, or bronze housing or rotors or centrifugal pumps are not acceptable. The pump shall be an industrial type intended for continuous heavy-duty service.

### 5. Filtration

One filter element shall provide both particulate and water removal. Filtration provided to 5 micron.

### 6. Element Replacement

No special tools are required to change the filter.

### 7. Filter Monitoring

Both filter stages shall have a differential pressure switch piped across them to indicate when the filters need to be changed. The switch shall provide indication on the main filtration control cabinet to alert operators and sound a horn. The differential pressure switch shall provide clear indication of strainer basket status with the use of a colored scale plate with GREEN denoting clean, and RED denoting dirty strainer. This switch shall have one piece aluminum body and shall be suitable for pressure to 200 PSIG.

### 8. Control Hardware

The control strategy shall be microprocessor-based. RELAY LOGIC SHALL NOT BE ACCEPTABLE. The control strategy shall be factory configured and stored on a EEPROM, and shall be safeguarded against re-configuration by unauthorized/ unqualified personnel. Control hardware shall include combination magnetic motor starter with overload protection and circuit breaker. The control system shall provide common alarm dry contacts to be interfaced with the Building Maintenance System as required.

### 9. Automatic Operation

In order to ensure automatic fuel maintenance the filtration system shall have an adjustable automatic start and run time. The operator shall be able to set the system to run at a certain time every day or week.

### 10. Safety Interlocks

Provide safety interlocks to shutdown pump when a "leak" is detected.

### 11. Operator Interface

All operator interface shall be cabinet front door mounted. As a minimum, the following indications, alarms, control switches and pushbuttons shall be provided:

1. Alarm silence, manual reset, lamp/ alarm test pushbuttons
2. Pump "hand-off-auto" control switch
3. "Pump on", indicator
4. "Filter saturated", "Filter water level high" and "system basin leak detected" alarms

### 12. Quality Assurance Inspection, Labeling and Testing

The control cabinet shall be manufactured in accordance with UL 508A. Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet as a whole must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system must be manufactured by a nationally recognized trade union (I.B.E.W. or similar trade union). Lack of an NRTL certified UL 508A wiring methods inspection and label or lack of a trade union label will be grounds for rejection.

## FUEL OIL TRANSFER PUMP AND DAY TANK SET

- No. 2 or No. 4 fuel oil
- Flows from 23 to 1600 GPH
- Integrated pump set and day tank helps reduce installation cost and occupied floor space
- Return pump is applied when day tank is located below the storage tank and gravity overflow is not possible. Return pumps facilitate commissioning and testing of fuel system.
- Supply pump is applied when day tank is located above the fuel oil storage tank and will generate less than 15" HG priming suction
- Supply and/ or return pump combinations
- One or two supply pumps, and/or one or two return pump configurations available
- Microprocessor-based Preferred FSC controls available
- Visual and audible alarms for day tank "high" or "low" levels, day tank "leak" and pump failure
- Safety shutdown for "high" level switch, day tank rupture basin leak detection
- Industrial type cast iron internal gear pumps

### Duplex Supply or Return Pump Features

- Automatic start on "call for operation"
- Lead pump manual selection or automatic alternation
- Automatic lag pump back-up based day tank level and lead pump thermal overload
- Standard FSC control programs for one, two, and three day tank configurations available. Optional supply and return pumps, and other day tank accessories integrated by parameter selection.

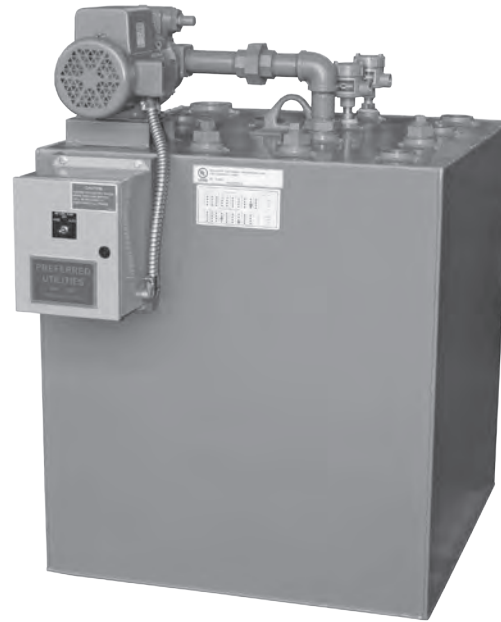
### Simplex Supply and/or Return Pump Features

- Automatic start on "call for operation"
- Monitoring of day tank level switches and leak detectors.
- Optional day tank level sensor available for tank gallon indication.

The fuel oil transfer pump and day tank package offers a quick and economical fuel pumping solution and provides a local supply of distillate or diesel fuel for boilers, emergency generators or other stationary engine driven or oil fired equipment. The fuel oil transfer pump and day tank packages include our UL approved series DT day tanks, supply and/or return pump(s), and an FSC-based control cabinet.

### Standard Equipment

- Day tank assembly with rupture basin
- Pump and motor assemblies
- Level control probe
- Vent cap
- Fill cap
- Preferred FSC-based control with 4" color touchscreen



*Fuel Oil Transfer Pump and Day Tank Set with Optional Enclosed Rupture Basin*

- Can be integrated via NodeNet to other FSC controllers in the fuel system.
- Magnetic motor starters with overload protection
- Motor circuit breakers
- Control circuit transformer (if required)
- Alarm bell with alarm silence / reset pushbutton
- "Hand-off-auto" switches
- "Power on" indicator

### Specifications

|         |                                                                                        |
|---------|----------------------------------------------------------------------------------------|
| Power:  | 120 VAC (external)                                                                     |
| Fluid:  | No. 2 or No. 4 fuel oil is standard. Consult factory for other fuel types.             |
| Pump:   | Positive displacement type with cast iron housings and self-adjusting mechanical seals |
| Motors: | Base mounted, TEFC                                                                     |

| Catalog Number | Motor |     |
|----------------|-------|-----|
|                | RPM   | HP  |
| 11871          | 1725  | 1/3 |
| 11872          | 1725  | 1/3 |
| 11873          | 1725  | 1/3 |
| 11874          | 1725  | 3/4 |
| 11815          | 1725  | 3/4 |

*Note: all pumps are 115V 60 Hz single phase. (The height of the unit is calculated by adding 18" to the day tank's height)*

# FUEL OIL TRANSFER PUMP AND DAY TANK SET

## Suggested Specifications

### 1. Day Tank System Manufacturer Qualifications

Manufacturer shall have a minimum of ten years' experience in the design and construction of Underwriters Laboratories (UL) listed day tank systems.

### 2. Day Tank System Construction

Provide one (1) \_\_\_\_ gallon, UL 142 labeled day tank constructed of reinforced 10 gauge steel with channel side supports, 1" drain, removable gasketed 6" square inspection plate, fuel level gauge, level control probe, vent cap (shipped loose), and a 2" gasketed manual fill cap. Exterior shall be finished in an oil resistant textured gray enamel. Day tank(s) shall be as supplied and coordinated by the pump set manufacturer. The fuel oil day tank shall be manufactured by Preferred Utilities Mfg. Corp. Danbury, CT, Model DT-S-R-UL.

### 3. Tank Connections

Tank connections shall include fuel inlet, required vent openings, manual fill, overflow to main tank, engine supply, and engine return. All piped with reinforced, welded pipe adapters. Fuel inlet and return must be supplied with factory installed drop tubes to prevent surging and foaming in the day tank.

### 4. Rupture Basin

Rupture basin (indoor applications only): the rupture basin shall consist of an open-top, welded heavy gauge steel structure sized a minimum of 160% capacity of tank capacity. Rupture basin (outdoor applications): the rupture basin shall consist of a welded steel top, welded heavy gauge steel structure sized to a minimum of 160% capacity of tank capacity. Exterior shall be finished in an oil resistant, textured gray enamel. Provide a factory installed rupture basin leak detector for alarming and fuel supply pump shut down. Electrical connections shall be contained in a weatherproof junction box. Switch shall be a Preferred Model RBS.

### 5. Level controls

Level Controls shall have four (4) float operated switches rated at 100 watts and factory installed in the day tank. Levels of control: emergency high-level alarm and total pump shutdown (90% capacity), pump off (80% capacity), pump on (50% capacity), and emergency low-level secondary pump on and annunciation (40% capacity). Unit shall be suitable for pressures to 150 PSIG, and shall be made entirely of non-ferrous material. Electrical connections shall be contained in a weatherproof junction box. Level control shall be Preferred Model PLS-xx-4.

### 6. Supply Pump

The tank shall include a fuel oil supply pump to draw oil from the main storage tank to the day tank. Locate day tank in a position that will generate less than 15" of priming suction.

### 7. Return pumping (when main tank's maximum fuel level is at a higher level than the day tank)

The return pump shall return fuel to the main tank in the event the day tank level exceeds 90% of its normal capacity. The return pump shall be activated by a separate, high-level float switch. The return pump capacity will be equal to or greater than the capacity of the supply pump.

### 8. Duplex Supply Pumps (or Return Pumps)

The two (2) pumps shall alternate as the lead when the tank is pumping fuel. The lead pump shall be activated when the fuel level declines to 50% of tank capacity; the standby pump shall be activated and operate in tandem with the lead pump if the fuel level declines to 40% of capacity. The standby pump shall be activated and the lead pump shutdown upon a lead pump thermal overload.

### 9. Pump Construction

Pumps shall be positive displacement rotary type pumps with cast iron housing and self-adjusting mechanical, Carbon ring seals. Pumps that have aluminum, brass, or bronze housings or rotors are not acceptable. Packing gland equipped pumps, carbonator shaft mounted pumps or centrifugal pumps are not acceptable. Pump shall be Preferred Model \_\_\_\_ rated at \_\_\_\_ GPH.

### 10. Motors

Provide and mount two (2) TEFC, rigid base, standard NEMA frame motors.

### 11. Control Cabinet

Provide a completely pre-wired and factory tested control cabinet to ensure job site reliability. The pump set and control cabinet shall be the product of one manufacturer for single source responsibility. The control system enclosure shall be constructed to NEMA 12/13 standards. Doors shall be fully gasketed with a turned edge, piano hinges, and a three point lockable latching mechanism. Cabinet interior shall be primed and finished in a white gloss, chemical resistant enamel. Cabinet exterior shall be primed and finished in a durable, chemical resistant, textured gray enamel, suitable for industrial environments.

### 12. Control Hardware

The control strategy shall be Preferred FSC-based with 4" color touchscreen. RELAY LOGIC SHALL NOT BE ACCEPTABLE. The control strategy shall be factory configured and stored on a EEPROM, and shall be safeguarded against re-configuration by un-authorized / un-qualified personnel. The controller shall be designed so that it will "fail safe" in the event there is a microprocessor failure. Control hardware shall include combination magnetic motor starters with overload protection and circuit breakers. The control system shall provide common alarm dry contacts to be interfaced with the Building Maintenance System as required. Additionally, the Preferred FSC controller shall communicate via NodeNet redundant communication network to other FSC controllers in the fuel system. The color touchscreen shall communicate via Ethernet or BacNet IP to the Building Management System.

### 13. Safety Interlocks

Provide safety interlocks to shutdown both pumps during any of the following conditions; day tank "leak detected" and "high-high" day tank level for supply pumps and "low-low" day tank level for return pumps. These interlocks must continue to ensure safe pump operation even if the controller has failed or is out of service and the pump set is operated in manual "hand" mode.

### 14. Operator Interface

All operator interface shall be cabinet front door mounted. As a minimum, the following indications, alarms, control switches and pushbuttons shall be provided:

1. Alarm silence, manual reset, lamp/ alarm test pushbuttons
2. Lead pump selection and "hand-off-auto" control switches for each pump
3. Pump status and tank level indications
4. Pump failure, day tank leak, day tank high level and day tank low level alarms
5. Alarm bell shall be provided for alarm conditions



## FUEL OIL TRANSFER PUMP AND DAY TANK SET

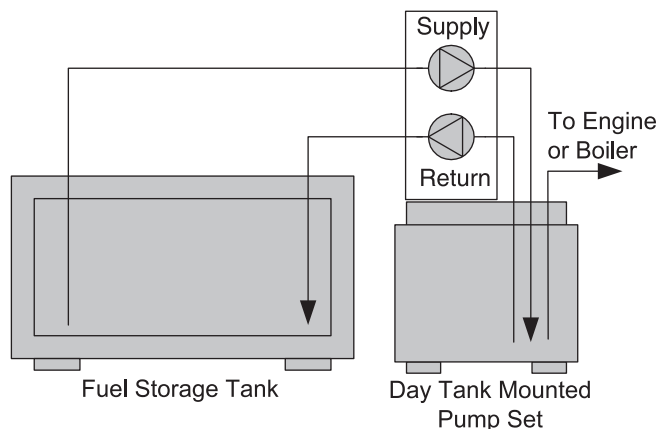
### Suggested Specifications

#### 15. Quality Assurance Inspection, Labeling and Testing

The control cabinet shall be manufactured in accordance with UL 508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components are not sufficient. The assembled control cabinet, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system must be manufactured by a nationally recognized trade union (I.B.E.W. or similar trade union). Lack of an NRTL certified UL 508A wiring methods inspection and label or lack of a trade union label will be grounds for rejection.

#### 16. Factory Testing

Fuel oil storage tank and day tank hydrostatic testing is required to ensure tightness prior to shipment. The minimum pressure for testing the tank shall be five (5) PSIG. The hydrostatic pressure shall be maintained until all joints and connections have been visually inspected for leaks, but in no case for less than one-half hour. The tank shall not show any permanent deformation as a result of the test. The rupture basin (open top) shall be hydrostatically tested prior to shipment. The basin shall maintain a full water level while all joints and connections are visually inspected for leaks. The test shall be run for no less than one-half hour. Pump sets must be fully tested prior to shipment. Operation of pump set instrumentation shall be tested. A copy of the test procedures shall be sent to the consulting engineer and owner. The owners and or the consulting engineer, at their discretion, shall observe this and all other tests. A certificate of factory testing, together with a copy of the wiring and arrangement diagrams shall be placed in the control cabinet prior to shipment.



*Fuel Oil Transfer Pump and Day Tank Set Application Example*

## FUEL OIL ADDITIVES AND TREATMENTS

Used in conjunction with the Preferred PF series of automatic fuel oil filtration sets, these fuel oil additives can help break up water droplets and disperse sludge to improve filtration efficiency, increase boiler and engine performance, and increase overall reliability. Removing unwanted water from fuel tanks helps prevent corrosion, prevent leaks, and lengthen tank life. When ordered with the CA-1 option, Preferred filtration systems will store and automatically inject measured quantities of fuel additives to help keep tanks free of sludge and water buildup.

### Tank Protector

Our best all-in-one fuel oil treatment controls waxing and gelling, disperses water, cleans pumps and filter elements, prevents corrosion, and reduces boiler and engine smoke. A one pint can treats 275 gallons of oil.



*Tank Protector, Pint*

### Sludge Clean

Sludge solvent and fuel oil conditioner. Use for all grades of fuel oil to reduce soot formation. It keeps injector nozzles from clogging and disperses sludge and moisture so it is more easily removed by conventional filtration systems. One quart treats 1,000 gallons of fuel oil.



*Sludge Clean, Quart*

### Oil Dehydrator

Fuel tank water dispersant. Improves the efficiency of coalescing water filtration systems by breaking up large water particles. Water enters fuel oil tanks due to condensation, storm water leaks, or as part of the delivered fuel. Since sludge typically forms at the oil-water boundary, removing water from the tank greatly reduces bio-sludge formation. Removing water from fuel oil tanks also inhibits tank corrosion. One quart treats 275 gallons.



*Oil Dehydrator, Quart*

### Free Flo

Goes directly to the bottom of the tank and restores the flow of oil from tanks and oil trucks when the flow has been interrupted by ice formation. When an ice blockage is detected in a tank, use one quart per 100 gallons of fuel in the tank. When flow is restored, activate the Preferred filtration system to de-water the oil at the bottom of the tank.

### Petro-Cide

Fuel oil biocide. Kills bacteria and fungi that contribute to fuel oil tank sludge build-up and tank corrosion. Stops the growth of microorganisms in fuel oil that can plug and foul filters, transfer lines, burner nozzles, and fuel injectors. 1.25 to 2.5 fluid ounces per 100 gallons is recommended depending on severity of contamination.

### Odor-Kill Powder

A small quantity quickly neutralizes fuel oil odors caused by leaks, spills, tank overflows and oil burner drippings. Absorbs oil to allow for quicker, easier clean-up.

### Ordering Information

| Catalog Number | Description      | Size               | Weight (lbs) |
|----------------|------------------|--------------------|--------------|
| 011903         | Oil Dehydrator   | Quart              | 3            |
| 011905         | Petro-Cide       | 8 Ounce Container  | 2            |
| 011906         | Petro-Cide       | Gallon             | 10           |
| 011907         | Free Flo         | Quart              | 3            |
| 011908         | Free Flo         | Gallon             | 3            |
| 011909         | Tank Protector   | Pint               | 2            |
| 011910         | Odor-Kill Powder | 14 Ounce Container | 2            |





# Fuel Oil Specialties



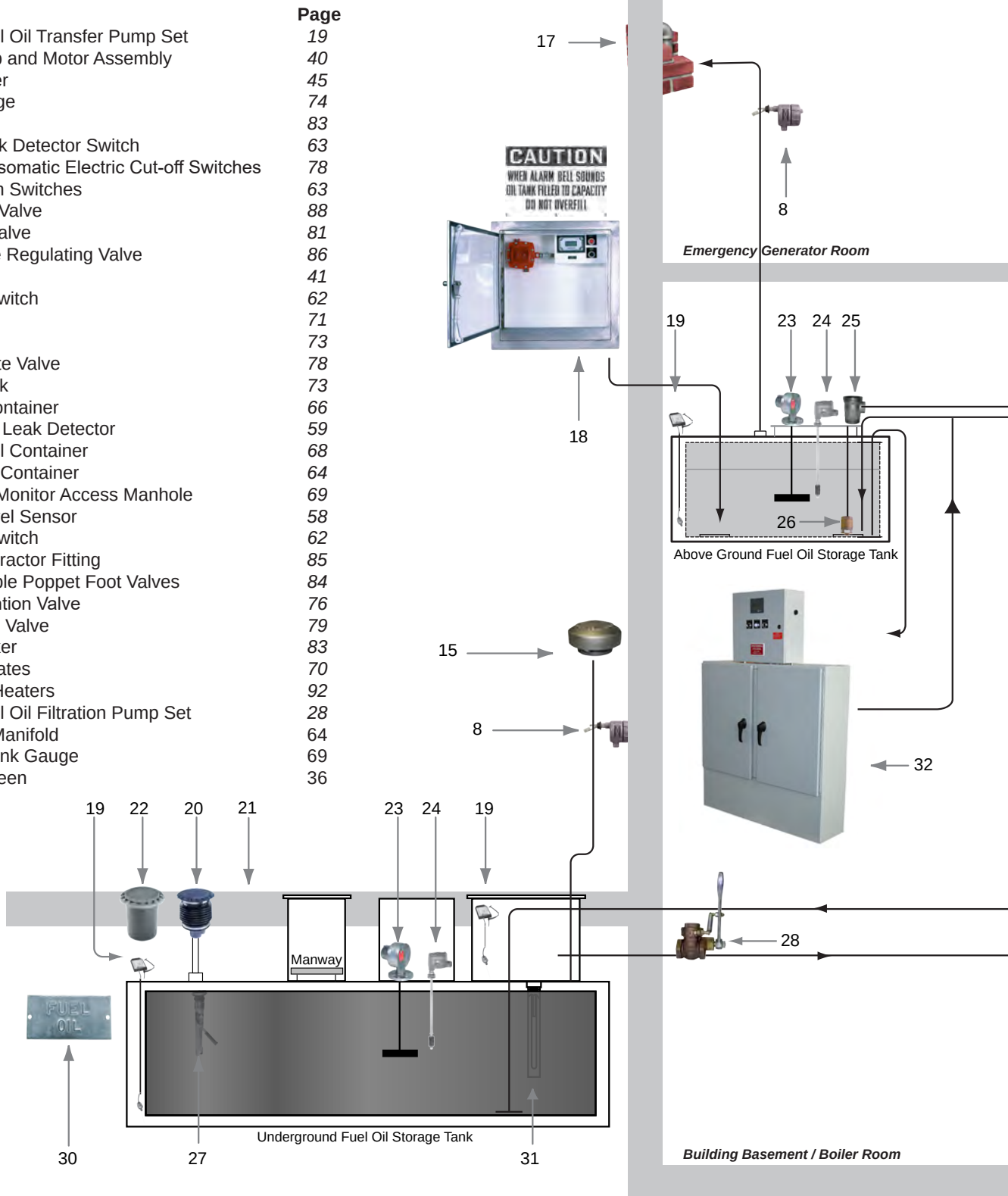
**PREFERRED**   
Utilities



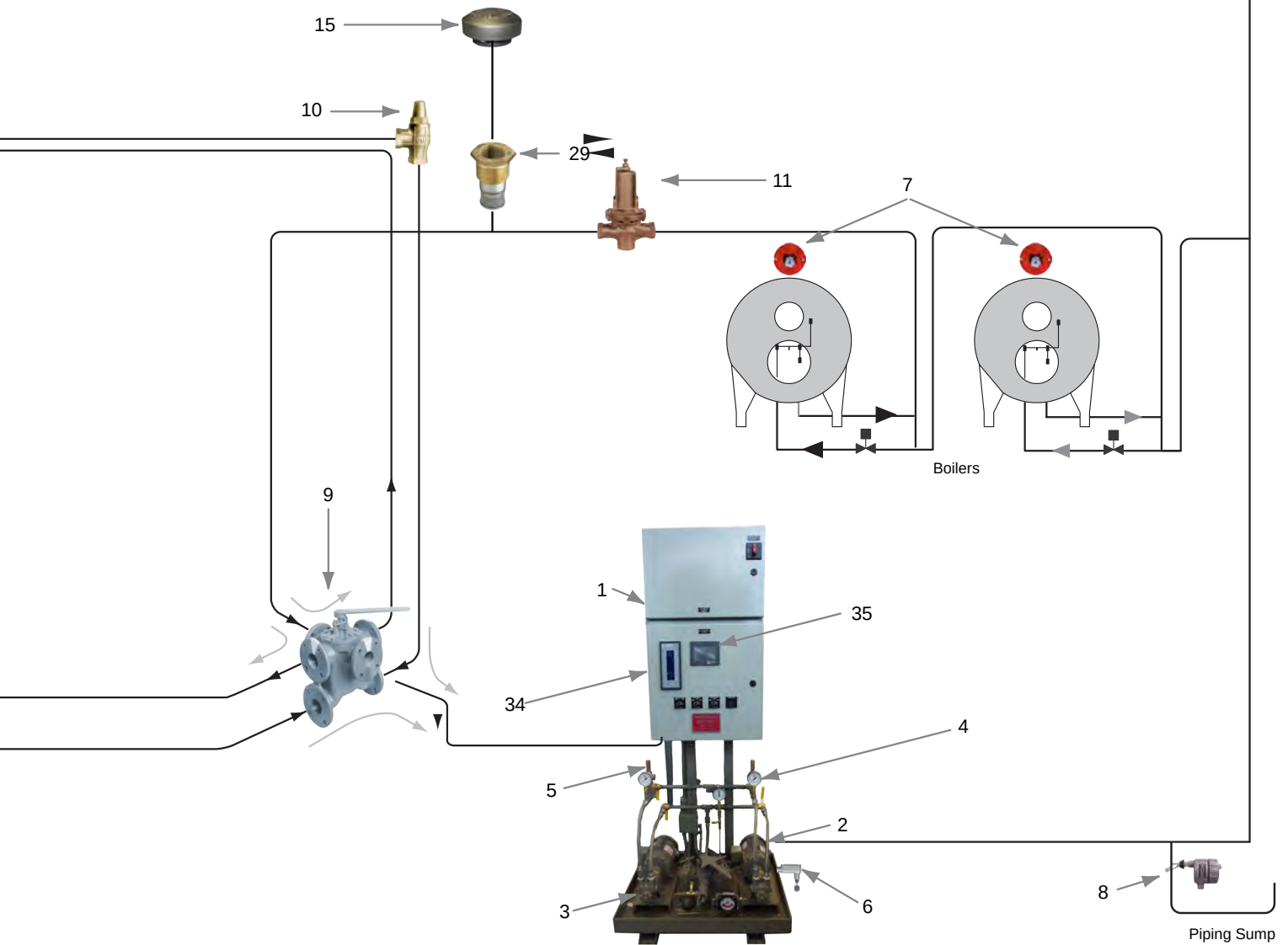
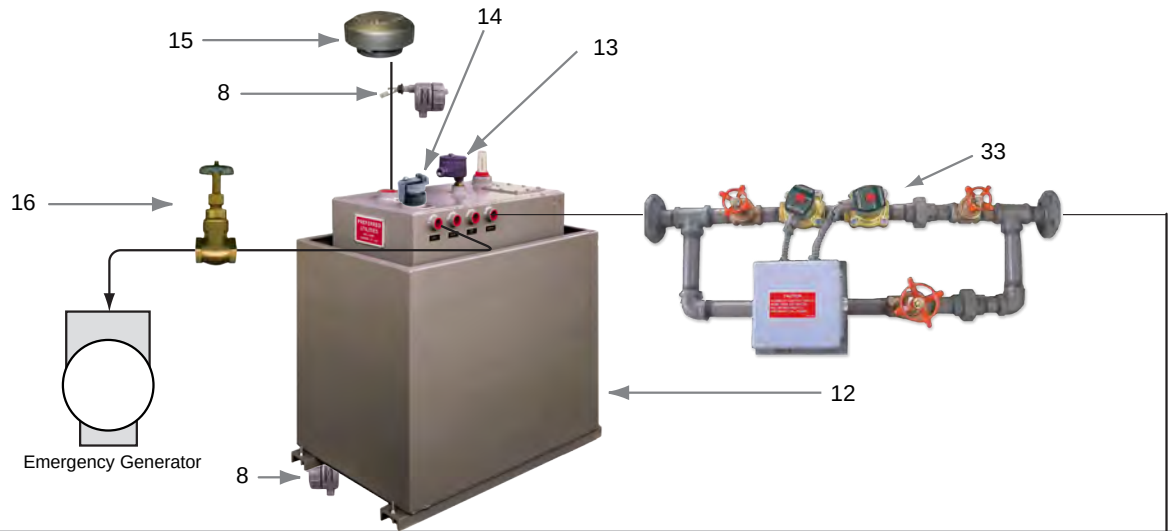
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# PRODUCT OVERVIEW





# LIGHT OIL PUMP & MOTOR ASSEMBLIES

Model LO-100 & 200

- 50 or 100 PSI Design Discharge Pressures
- From 20 to 2100 GPH Flow Rates
- Useful as a Replacement For Aged Assemblies

The Model LO-100 & 200 series light oil pump and motor assemblies are compact, direct drive units designed to meet the performance and reliability standards demanded in commercial, industrial and institutional applications. The pump and motor assemblies are for No. 2, No. 4, and diesel oils.

## Typical Applications

- Diesel Generators
- Fuel Transfer
- Oil Burners
- Fuel Oil Circulating Loops
- Day Tanks

## Construction

Built for maximum life, peak performance, and quiet operation, the pump and motor are precisely aligned on a one-piece, structural steel channel base. The shafts are directly connected with a flexible coupling; rotating parts are protected by a rigid, closely fitting, steel OSHA guard. For external protection the set is prime coated and finished with an oil, water and solvent resistant, polyurethane enamel. For easy access for inspection and service, components are through-bolted to the base and accessible from the top of the set.

The pumps are bi-rotational, positive displacement, internal gear types with cast iron housings and Buna-N self-adjusting mechanical seals. Being positive displacement pumps, the pumps require over-pressure relief valves for protection from an accidentally closed or plugged discharge line. Pumps are suitable for both continuous and intermittent duty. Standard motors are base-mounted, have standard N.E.M.A. frames and are Total Enclosed Fan Cooled (TEFC).

## Suggested Specifications

Oil pump and motor assemblies shall be factory assembled on a structural steel channel base and shall include a base mounted motor directly connected by a flexible coupling to a bi-rotational, internal gear pump, having self-adjusting mechanical seals and cast iron housing. Rotating parts shall have a steel OSHA guard. The sets shall be prime coated and finished with an oil, water and solvent resistant, polyurethane enamel. Pump and motor assemblies shall be Preferred Utilities Manufacturing Corp., Danbury, CT, LO-\_\_\_ rated at \_\_\_ GPH of (No. 2), (No. 4), (Diesel) oil against a discharge pressure of \_\_\_ PSI.



Model LO-203, Light Oil Pump and Motor Assembly

Approved by N.Y.C. Board of Standards and Appeals.  
LO-10\_ Pumps: Cal. No. 412-48-SA. U.L. 343  
LO-20\_ Pumps: Cal. No. 438-21-SA

## Ordering Information

Select model number from the table below.

| Catalog Number | GPH. Oil No. 2 / No. 4 | PSI | Motor |         | W  | L  | H  | Weight (lbs.) |
|----------------|------------------------|-----|-------|---------|----|----|----|---------------|
|                |                        |     | RPM.  | HP      |    |    |    |               |
| LO-101E        | 20 / 23                | 100 | 1725  | 1/3*    | 7  | 15 | 10 | 35.5          |
|                | 23 / 23                | 50  | 1725  | 1/3*    | 7  | 15 | 10 | 35.5          |
| LO-102E        | 27 / 33                | 100 | 1725  | 1/3*    | 7  | 15 | 10 | 36.5          |
|                | 32 / 33                | 50  | 1725  | 1/3*    | 7  | 15 | 10 | 36.5          |
| LO-103E        | 80 / 93                | 100 | 1725  | 1/3*    | 7  | 15 | 10 | 36.3          |
|                | 86 / 95                | 50  | 1725  | 1/3*    | 7  | 15 | 10 | 36.3          |
| LO-104E        | 145 / 155              | 100 | 1725  | 1/2**   | 7  | 15 | 9  | 36.6          |
|                | 155 / 164              | 50  | 1725  | 1/2**   | 7  | 15 | 9  | 36.6          |
| LO-105E        | 282 / 285              | 50  | 1725  | 3/4**   | 7  | 17 | 9  | 41.8          |
| LO-106E        | 277 / 285              | 100 | 1725  | 1**     | 7  | 19 | 9  | 46            |
| LO-201         | 340 / 415              | 50  | 1140  | 1/2**   | 7  | 18 | 12 | 58            |
| LO-202         | 300 / 410              | 100 | 1140  | 3/4**   | 8  | 18 | 12 | 77            |
| LO-203         | 780 / 890              | 50  | 1140  | 3/4**   | 10 | 20 | 12 | 99            |
| LO-204         | 700 / 870              | 100 | 1140  | 1 1/2** | 10 | 21 | 12 | 120           |
| LO-205         | 1100/1300              | 50  | 1140  | 1 1/2** | 10 | 21 | 12 | 134           |
| LO-206         | 1000/1200              | 100 | 1140  | 2**     | 10 | 21 | 12 | 142           |
| LO-207         | 1900/2200              | 50  | 1140  | 2**     | 10 | 26 | 12 | 225           |
| LO-208         | 1800/2100              | 100 | 1140  | 5**     | 12 | 28 | 12 | 290           |

Specifications subject to change without notice.  
Pump & motor assemblies ratings are nominal at pressures shown with maximum 10" Hg vacuum at pump inlet.

\*115, 208 or 230V 60Hz 1 phase

\*\*208, 230 or 460V 60Hz 3 phase

For non-standard motors or heavy oil pump and motor assemblies, please consult the factory.

# WATERPROOF PUMP & MOTOR ASSEMBLIES

Model WP-100 & 200

Designed for applications where fuel oil pumps can't be installed above historic flood levels due to suction lift constraints, **Preferred's waterproof pumps** are designed to be installed below grade level, withstand seawater inundation, and continue supplying diesel fuel to critical generators and boilers. They are rated for 75 ft of water submersion.

Available in sizes from the NYC approved LO-101 (20 gph) to the LO-205 (1100 gph) pump sizes, they are protected by an epoxy-enamel painted carbon steel enclosure with flanged access door.

## Additional features include:

- Oil suction and discharge fittings on the exterior of the enclosure
- Preferred HD-A2C discriminating leak detector installed at the low point of the enclosure to alert operators to the presence of water or oil in the containment vessel.
- 30' high voltage conduit "pig tail" with motor leads for connection above historic flood levels
- 30' low voltage conduit "pig tail" for leak detector wiring
- Sealed conduit to stop water in the conduits from entering the pump enclosure
- Flanged access door and sliding tray for easy pump removal

These pumps have been tested under load and show only negligible temperature rise inside the enclosure.

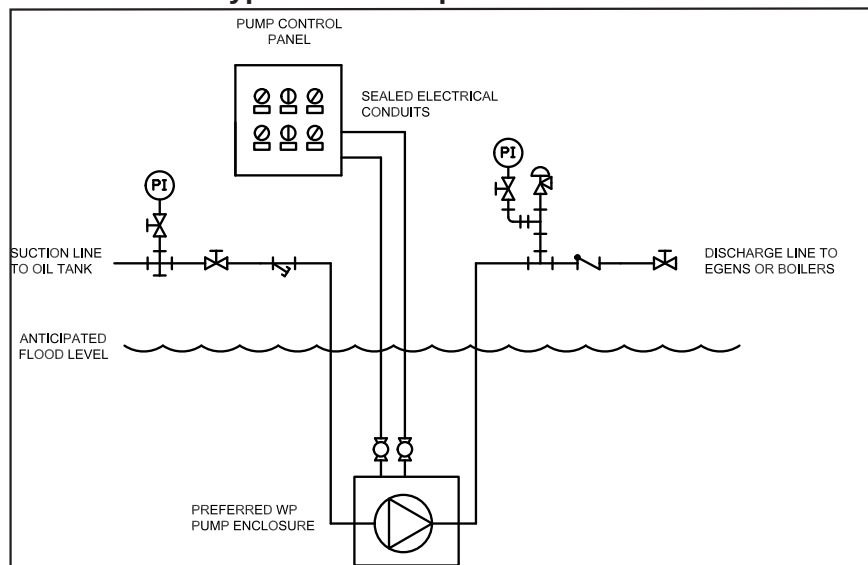


*Two Waterproof Pumps in a Duplex Pumpset configuration*

## Waterproof Light Oil Pump & Motor Assemblies

The WP line of pump enclosures is available stand-alone, or with Preferred ATPS or SATPS style pump accessories to be mounted above expected flood levels. Pump control panels, motor starters, strainers, gauges, and switch packages are available to integrate seamlessly with Preferred WP pumps. Product details subject to change.

## Typical WP Pump Installation



*Waterproof Pumps Prior to Shipment to New York City*

# WATERPROOF PUMP & MOTOR ASSEMBLIES

Model WP-100 & 200

## Suggested Specifications

Oil pump and motor assembly shall be factory assembled in an epoxy-enamel coated carbon steel waterproof enclosure with external threaded connections for pump suction and discharge. The base-mounted motor shall be directly connected by a flexible coupling to a bi-rotational, internal gear pump, having self-adjusting mechanical seals and cast iron housing. The pump and motor assembly shall be mounted on a sliding steel base for easy access. Stainless steel flex hoses shall connect pump suction and discharge to couplings welded to the pump enclosure. A Preferred HD-A2-C discriminating leak detector shall be installed at the low point of the pump enclosure to detect and annunciate the presence of oil or water. Electrical connections shall include sealed conduit and wire pigtails for termination above expected high water levels. Pump and motor assemblies shall be Preferred Utilities Manufacturing Corp., Danbury, CT. WT\_\_\_ rated at \_\_\_GPH (No.2), (No. 4), (Diesel) all or against a discharge pressure of \_\_\_PSI.



Internal View Waterproof Light Oil Pump & Motor Assembly

## Ordering Information

Select model number from the table below.

| Catalog Number | GPH. Oil No. 2 / No. 4 | PSI | Motor |         |
|----------------|------------------------|-----|-------|---------|
|                |                        |     | RPM.  | HP      |
| WP-101E        | 20 / 23                | 100 | 1725  | 1/3*    |
|                | 23 / 23                | 50  | 1725  | 1/3*    |
| WP-102E        | 27 / 33                | 100 | 1725  | 1/3*    |
|                | 32 / 33                | 50  | 1725  | 1/3*    |
| WP-103E        | 80 / 93                | 100 | 1725  | 1/3*    |
|                | 86 / 95                | 50  | 1725  | 1/3*    |
| WP-104E        | 145 / 155              | 100 | 1725  | 1/2**   |
|                | 155 / 164              | 50  | 1725  | 1/2**   |
| WP-105E        | 282 / 285              | 50  | 1725  | 3/4**   |
| WP-106E        | 277 / 285              | 100 | 1725  | 1**     |
| WP-201         | 340 / 415              | 50  | 1140  | 1/2**   |
| WP-202         | 300 / 410              | 100 | 1140  | 3/4**   |
| WP-203         | 780 / 890              | 50  | 1140  | 3/4**   |
| WP-204         | 700 / 870              | 100 | 1140  | 1 1/2** |
| WP-205         | 1100/1300              | 50  | 1140  | 1 1/2** |
| WP-206         | 1100/1200              | 100 | 1140  | 2*      |

Specifications subject to change without notice.

Pump & motor assemblies ratings are nominal at pressures shown with maximum 10" Hg vacuum at pump inlet.

\*115, 208 or 230V 60Hz 1 phase

\*\*208, 230 or 460V 60Hz 3 phase



## DAY TANKS

### Model DT

- Complete tank, rupture basin and instrumentation package
- Rectangular day tank and rupture basin assemblies of 290 gallons or less are doorway accessible
- Built to U.L. 142 or 2085 standards
- With its high strength & heavy duty construction, series DT day tanks cut manufacturing time and cost while maintaining Preferred's quality and customer service

Preferred day tanks provide a local supply of distillate or diesel fuel for boilers, emergency generators or other stationary engine driven or oil fired equipment. Available from 20 to 620 gallon capacities, a properly sized tank may be selected per individual job. For maximum fuel capacity in a minimum space, Preferred day tanks are rectangular in shape. Each day tank unit includes all necessary pipe connections, inspection port, manual fill port, and tank gauge, along with a variety of optional accessories.

#### Standard Equipment

- "UL" Day Tank Assembly
- "UL" Rupture Basin Assembly
- Level Gauge (top mounted & float operated)
- Three Drop Tubes (external device supply/return and day tank fill)
- Containment – 160% of Day Tank Capacity
- Plugged Drain Tapping
- Exterior Chemical Resistant Finish (gray enamel over rust-resistant primer)
- Structural Steel Channel Mounting Base

#### Optional Equipment

- PLS-2, PLS-4, or PLS-5 level switch assembly
- Model RBS leak detector
- Return pump(s)
- Supply pump(s)
- FSC-based control enclosure

#### Tank Specifications

|                                 |                                                                                            |
|---------------------------------|--------------------------------------------------------------------------------------------|
| <b>Mounting Base:</b>           | Structural steel channel                                                                   |
| <b>Metal Thickness:</b>         | 10 gauge                                                                                   |
| <b>Exterior Finish:</b>         | Chemical resistant gray enamel over rust resistant primer                                  |
| <b>Manual Fill Port:</b>        | 2" NPT                                                                                     |
| <b>Inspection Port:</b>         | 6" square gasketed plate                                                                   |
| <b>1" NPT Pipe Connections:</b> | Tank fill, engine fuel return, overflow to storage tank, engine fuel supply, plugged drain |



*Day Tank, Rupture Basin, Level Controller and Gauge, Inspection Port and Connections shown*

|                               |                                                                                         |
|-------------------------------|-----------------------------------------------------------------------------------------|
| <b>Vent Connections:</b>      | Top mounted<br>2" -- 20-60 gallon<br>3" -- 80-190 gallons<br>4" -- 220 gallons and over |
| <b>Approvals/ Compliance:</b> | UL approved, NFPA 30 compliant                                                          |

#### Rupture Basin Specifications

|                                          |                                                                              |
|------------------------------------------|------------------------------------------------------------------------------|
| <b>Mounting Base:</b>                    | Structural steel channel                                                     |
| <b>Containment:</b>                      | 160% of tank capacity standard (other capacities available, consult factory) |
| <b>Leak Detector:</b>                    | Preferred RBS float switch                                                   |
| <b>Metal Thickness:</b>                  | Same as companion tank                                                       |
| <b>Turned Edge Reinforcement Finish:</b> | Chemical resistant gray enamel finish over rust resistant primer             |
| <b>Drain:</b>                            | Plugged 1" NPT coupling                                                      |
| <b>Approvals/ Compliance:</b>            | UL approved                                                                  |

*Specifications subject to change without notice.*

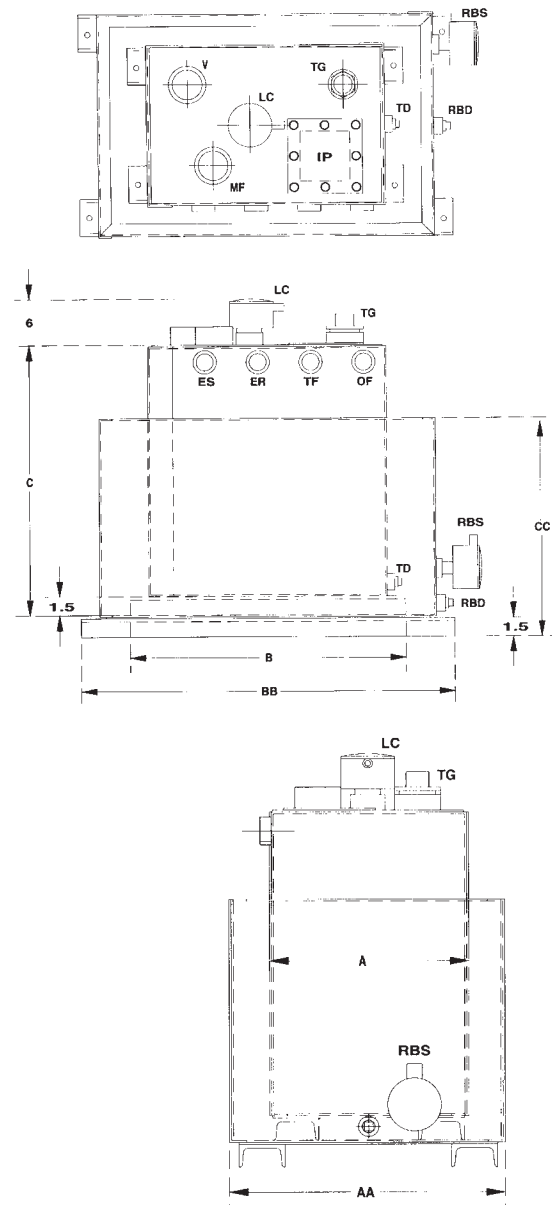
# DAY TANKS

## Specifications

Dimension Table

| Catalog Number | Tank Dimensions |     |       |      | Vent | Companion Rupture Basin |     |       |     |
|----------------|-----------------|-----|-------|------|------|-------------------------|-----|-------|-----|
|                | A               | B   | C     | WGT  |      | AA                      | BB  | CC    | WGT |
| DT-020         | 13"             | 22" | 21.5" | 79   | 2"   | 18"                     | 30" | 17.5" | 85  |
| DT-030         | 13"             | 31" | 21.5" | 136  | 2"   | 18"                     | 41" | 17.5" | 130 |
| DT-040         | 13"             | 26" | 33.5" | 166  | 2"   | 18"                     | 34" | 29.5" | 159 |
| DT-060         | 13"             | 37" | 33.5" | 245  | 2"   | 18"                     | 47" | 29.5" | 205 |
| DT-080         | 24"             | 22" | 45.5" | 317  | 3"   | 29.5"                   | 30" | 41.5" | 276 |
| DT-100         | 24"             | 27" | 45.5" | 366  | 3"   | 29.5"                   | 35" | 41.5" | 343 |
| DT-130         | 24"             | 33" | 45.5" | 361  | 3"   | 29.5"                   | 45" | 41.5" | 420 |
| DT-160         | 24"             | 40" | 45.5" | 405  | 3"   | 29.5"                   | 53" | 41.5" | 415 |
| DT-190         | 24"             | 47" | 45.5" | 483  | 3"   | 29.5"                   | 63" | 41.5" | 466 |
| DT-220         | 24"             | 53" | 45.5" | 524  | 4"   | 29.5"                   | 72" | 41.5" | 557 |
| DT-260         | 24"             | 61" | 45.5" | 584  | 4"   | 29.5"                   | 85" | 41.5" | 661 |
| DT-275         | 24"             | 64" | 45.5" | 620  | 4"   | 29.5"                   | 89" | 41.5" | 668 |
| DT-290         | 24"             | 68" | 45.5" | 656  | 4"   | 29.5"                   | 94" | 41.5" | 674 |
| DT-360         | 45"             | 45" | 45.5" | 689  | 4"   | 50"                     | 73" | 41.5" | 676 |
| DT-460         | 45"             | 57" | 45.5" | 805  | 4"   | 51"                     | 87" | 41.5" | 784 |
| DT-560         | 45"             | 69" | 45.5" | 964  | 4"   | 57"                     | 94" | 41.5" | 880 |
| DT-620         | 45"             | 76" | 45.5" | 1041 | 4"   | 60"                     | 99" | 41.5" | 932 |

Weights listed are approximate dry weights



|                                 |                               |
|---------------------------------|-------------------------------|
| ES Engine Supply 1"             | V Vent Tapping                |
| ER Engine Return 1"             | IP Inspection Port 6"x6"      |
| TF Tank Fill 1"                 | LC Level Controller Switch    |
| OF Overflow 1"                  | RBS Rupture Basin Leak Switch |
| TD Tank Drain 1"                | TG Tank Gauge                 |
| RBD Rupture Basin Drain 1"      |                               |
| MF Manual Fill Port 2" (capped) |                               |

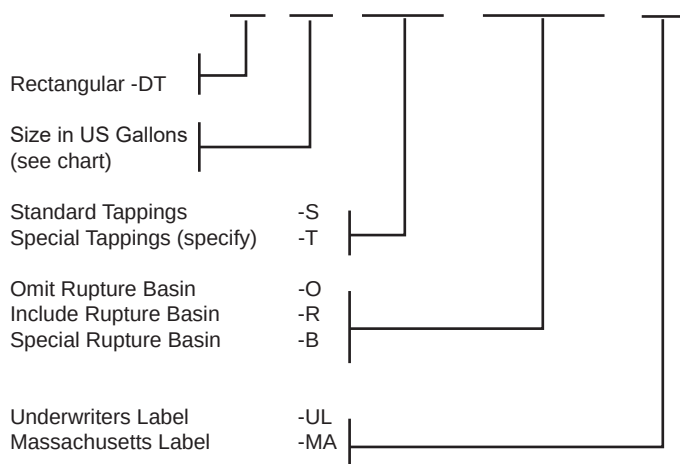
# DAY TANKS

## Suggested Specifications

### Ordering Information

Specify the Day Tank Catalog Number as follows:

DT - 060 - [S or T] - [O, R, or B] - [UL]



| Optional Features | Catalog Number   |
|-------------------|------------------|
| 50 PSI Test       | add "-EQ" suffix |
| NYC Certified     | add "-NY" suffix |
| Other Specs.      | add "-XX" suffix |

Consult factory for other special requirements.

### Suggested Specification

#### 1. Day Tank System Construction

Provide one (1) \_\_\_\_ gallon, UL 142 labeled Day Tank constructed of reinforced 10 gauge steel with channel side supports, 1" drain, removable gasketed 6" square inspection plate, fuel level gauge, level control probe, vent cap (shipped loose), and a 2" gasketed manual fill cap. Exterior shall be finished in an oil resistant, textured gray enamel. Day tank(s) shall be as supplied and coordinated by the pump set manufacturer. The fuel oil day tank shall be manufactured by Preferred Utilities Mfg. Corp. Danbury, CT, Model DT-S-R-UL.

#### 2. Tank Connections

Tank connections shall include fuel inlet, required vent openings, manual fill, overflow to main tank, engine supply, and engine return. All connections shall be piped with reinforced, welded pipe adapters. Fuel fill, inlet and return must be supplied with factory installed drop tubes to prevent surging and foaming in the day tank.

#### 3. Rupture Basin

Rupture basin (indoor applications only): the rupture basin shall consist of an open-top, welded heavy gauge steel structure sized a minimum of 160% capacity of tank capacity. Rupture basin (outdoor applications): the rupture basin shall consist of a welded steel top, welded heavy gauge steel structure sized a minimum of 160% capacity of tank capacity. Exterior shall be finished in an oil resistant, textured gray enamel. Provide and factory install a rupture basin leak detector for alarming and fuel supply pump shut down. Electrical connections shall be contained in a weatherproof junction box. Switch shall be a Preferred Model RBS.

### Optional Accessories

#### Custom Arrangements

Double-wall construction, non-standard shapes, sizes, metal gauges, connections, level detectors etc. are available. Please consult factory for details.

#### Preferred Fusomatic Fire-Safety Valve:

Thermally actuated, 1" gate valve. Automatically shuts off engine fuel supply when ambient temperature rises to 165° F.

#### Preferred Fusomatic Electric Cut-Off Switch:

Automatically stops remote transfer pump operation when ambient temperature rises to 165° F.

#### Solenoid Operated Valves:

One per tank required on fill line for multiple tank systems. Consult Factory.

#### Flow Control Manifolds:

Includes solenoid valves, filters, flow indicators etc. as required. Consult Factory.

#### Preferred Liquid Level Switch:

It is used to control the addition or removal of oil from remote pumps, and to alarm high and low levels.

#### Preferred Vent Protector:

It is made of cast aluminum and is threaded for standard pipe.

#### Preferred Fill Caps:

Prevent unauthorized fuel storage tank access to day tanks.

#### 4. Level Controls

Level controls shall have four (4) float-operated switches rated at 100 watts and factory installed in the day tank. Levels of control: emergency high-level alarm and total pump shutdown (90% capacity), pump off (80% capacity), pump on (50% capacity), and emergency low-level secondary pump on and annunciation (40% capacity). Unit shall be suitable for pressures to 150 PSI, and shall be made entirely of non-ferrous material. Electrical connections shall be contained in a weatherproof junction box. Level control shall be Preferred Model PLS-xx-4.

#### 5. Factory Testing

Fuel oil storage tank and day tank hydrostatic testing is required to ensure tightness prior to shipment. The minimum pressure for testing the tank shall be five (5) PSI. The hydrostatic pressure shall be maintained until all joints and connections have been visually inspected for leaks, but in no case for less than one-half hour. The tank shall not show any permanent deformation as a result of the test. The Rupture basin (open top) shall be hydrostatic tested prior to shipment. The basin shall maintain a full water level while all joints and connections are visually inspected for leaks. The test shall be run for no less than one-half hour. A copy of the test procedures shall be sent to the consulting engineer and owner. The owners and or the consulting engineer, at their discretion, shall observe this and all other tests.



## FLOW CONTROL MANIFOLDS

### Description

When two or more day tanks are being filled by one set of transfer pumps, a flow control manifold is required to direct oil only to the day tanks calling for fuel.

#### Factory Assembled Flow Control Manifolds Are:

- Pre-assembled in Preferred's factory
- Factory prepped and painted
- Pre-wired to a NEMA 12 junction box
- Pressure tested to 50 PSIG



Model FCM-15-S2-0-0-0-0 Flow Control Manifold

NFPA codes do not dictate the components of a flow control manifold. Preferred flow control manifolds always consist of an automatic shutoff valve, two manual shutoff valves, and a manual bypass valve. Additional components may be supplied depending on the application.

- Manual shutoff valves are required to isolate a day tank for maintenance or other reasons. A manual bypass valve is provided to ensure a day tank can be filled manually if a shutoff valve fails closed.
- One or two solenoid valves are most common. However, motorized valves are sometimes used and provide the benefit of valve proof-of-closure and valve proof-of-open switches.
- A strainer is recommended to protect the shutoff valves and optional flow meter.
- A sight flow indicator helps technicians and operators determine when oil is flowing into a day tank.
- A flow restrictor is used when a large number of day tanks are connected to one pump set. The flow restrictor allows the return pump to be sized according to the flow restrictor flow rather than the supply pump flow.
- A flow meter can be used to remotely determine when oil is flowing to a particular day tank, and can be used to totalize flow to a day tank.

| Flow Control Manifold Description |                                                                                          | Catalog Number          |                      |                      |        |         |          |         |
|-----------------------------------|------------------------------------------------------------------------------------------|-------------------------|----------------------|----------------------|--------|---------|----------|---------|
|                                   |                                                                                          | FCM - _ - _ - _ - _ - _ |                      |                      |        |         |          |         |
| Manifold Pipe Size                | 3/4" NPT<br>1" NPT<br>1.5" NPT<br>2" NPT                                                 |                         | 75<br>10<br>15<br>20 |                      |        |         |          |         |
| Shutoff Valves                    | One Solenoid Valve<br>Two Solenoid Valves<br>One Motorized Valve<br>Two Motorized Valves |                         |                      | S1<br>S2<br>M1<br>M2 |        |         |          |         |
| Strainer Option                   | No Strainer<br>Simplex Strainer                                                          |                         |                      |                      | 0<br>S |         |          |         |
| Sight Flow Indicator Option       | No Sight Flow Indicator<br>Sight Flow Indicator                                          |                         |                      |                      |        | 0<br>FI |          |         |
| Flow Restrictor Option            | 0= No Flow Restrictor<br>XXX= Flow Restrictor GPM                                        |                         |                      |                      |        |         | 0<br>XXX |         |
| Flow Meter Option                 | No Flow Meter<br>Flow Meter                                                              |                         |                      |                      |        |         |          | 0<br>FM |

## FLOW CONTROL MANIFOLDS

### Suggested Specifications

#### 1. Application

Provide and install for each day tank a factory assembled flow control manifold consisting of two 120 VAC solenoid valves, two manual shutoff and isolation valves, manual bypass valve, 40 mesh strainer, sight flow indicator, and flow restrictor sized for \_\_\_\_ GPM. The flow control manifold shall be factory assembled, painted, and fully wired into a NEMA 12 junction box. The entire assembly shall be pressure tested to 50 PSIG. The flow control manifold shall be Preferred Utilities Mfg Corp., Danbury, CT, Model FCM - \_\_\_\_ - \_\_\_\_ - \_\_\_\_ - \_\_\_\_ - \_\_\_\_ - \_\_\_\_.

# SIMPLEX OIL STRAINERS

## Model 125

The Model 125 simplex oil strainer is a heavy-duty single basket strainer for general use. It is suitable for installation in either the suction or discharge line, provided a temporary shut down for cleaning is possible.

- **Special yoke design for quick cleaning**
- **Large basket**

These strainers have been designed for applications where easy maintenance and large capacity straining are required. Service time is minimal because the cover is secured with quick-opening, non-yoke type knobs. Both the cover and basket use O-ring seals, eliminating the need to replace gaskets each time the strainer is serviced. This, combined with the machined basket seat, eliminates particle bypass. With the appropriate wire mesh, these strainers can be used to strain particles as small as 5 microns. Strainer bodies and covers are made of cast iron. All sizes feature an O-ring cover seal. Baskets are O-ring sealed in machined seats. Quick release knobs are ductile iron. Studs and nuts are alloy steel. A plugged NPT connection is provided at location "D". The standard basket is 304 stainless steel with .0625" perforation with minimum 6 to 1 open area ratio. Bronze, carbon steel, and stainless steel bodies are also available. Preferred Model 125 Simplex oil strainers are available from stock in the sizes listed in the table below. Larger sizes, flanged models, strainers for working pressures over 200 PSIG and a wide selection of special baskets are available on special order. Refer to Engineering Data Section for flow and pressure loss data.

### Ordering Information

The catalog numbers listed in the table below come standard with 1/16" perforated baskets. Add "M" for 40 mesh baskets or "-100M" for 100 mesh baskets.

Example:

|            |                                  |
|------------|----------------------------------|
| 13389      | —½" pipe with .0625" perf basket |
| 13389M     | —½" pipe with 40 mesh basket     |
| 13389-100M | —½" pipe with 100 mesh basket    |

| Catalog Number | Pipe Size | A    | B    | C    | D      | E     | Weight (lbs) |
|----------------|-----------|------|------|------|--------|-------|--------------|
| 13389          | ½"        | 4.56 | 4.00 | 2.50 | ¾" NPT | 4.82  | 5.5          |
| 13390          | ¾"        | 4.56 | 4.00 | 2.50 | ¾" NPT | 4.82  | 5.5          |
| 13391          | 1"        | 5.31 | 4.68 | 2.75 | ¾" NPT | 5.88  | 8.0          |
| 13392          | 1 ¼"      | 6.31 | 6.50 | 3.00 | ½" NPT | 8.13  | 15.0         |
| 13393          | 1 ½"      | 6.31 | 6.50 | 3.00 | ½" NPT | 8.13  | 14.0         |
| 13394          | 2"        | 8.25 | 7.88 | 3.63 | ¾" NPT | 10.13 | 27.0         |
| 13395          | 2 ½"      | 9.63 | 8.75 | 4.00 | 1" NPT | 11.88 | 36.0         |

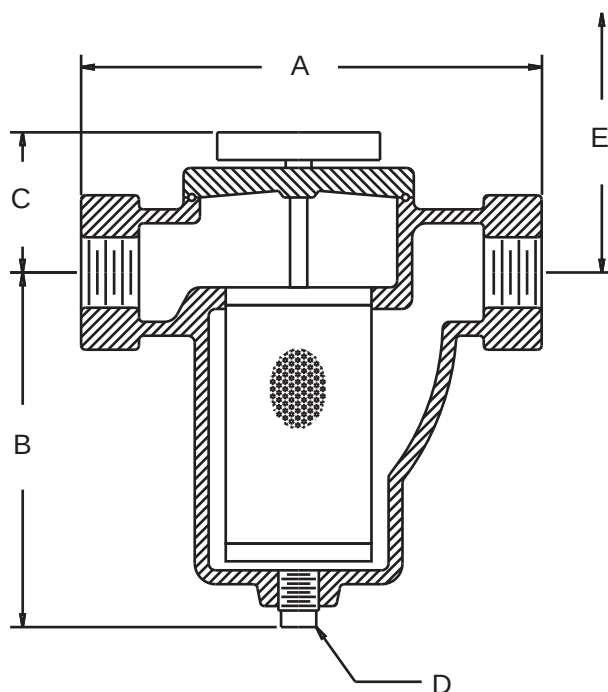
For larger sizes - consult factory.



Model 125 Simplex Oil Strainer

### Suggested Specifications

Oil strainers shall have a cast iron body, with threaded connections, sized as shown on the drawings and suitable for working pressures to 200 PSIG. Clamped cover and handle shall permit easy removal of the basket. Basket shall be constructed of (1/16" perforated) (40 mesh) (100 mesh) stainless steel. Strainer shall be Preferred Utilities Mfg. Corp., Danbury, CT, Model 125.



Clearance Dimensions, Simplex Strainers  
"E" Dimension is for basket removal.



## DUPLEX OIL STRAINERS

### Model 72

The Model 72 Duplex Oil Strainers are ideal for duplex fuel oil handling systems and for those applications where the requirement for a continuous supply of oil does not permit interruption of the flow for the routine cleaning of strainer baskets.

- **No flow interruption for routine cleaning**
- **90° handle movement switches baskets**
- **Handle blocks inadvertent opening of the active side**
- **U.L. listed**

In the Model 72 strainer, oil flows through only one basket at a time. The inactive basket is completely sealed off and may be readily removed. Switching from one basket to the other is accomplished by moving the handle through a 90° arc. There is no obstruction to the flow even when the handle is in the intermediate position. At the end of its travel the handle prevents inadvertent opening of the active side.

Covers are gasketed to assure an air tight seal and are secured with quick-opening clamps for easy basket access. These strainers are suitable for use on the suction side of the oil pumps or for discharge pressures up to 200 PSIG. They are available in the sizes shown in the table with the indicated threaded or flanged connections. All sizes have one-piece cast iron bodies, (ASTM A-126) and are hydrostatically tested to U.L. quality control specifications.

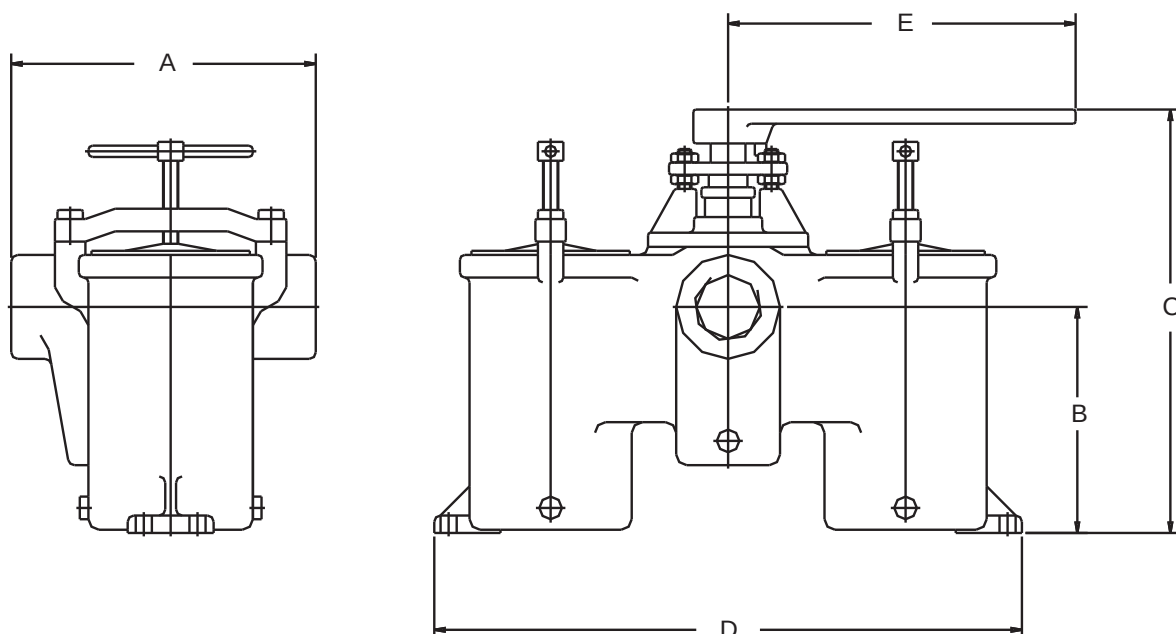
Standard baskets have 1/16" perforations. Mesh lined baskets for smaller particle filtration are available in 40, 60, 100, and 200 mesh construction. Refer to Engineering Data Section for flow and pressure loss data.



Model 72 Duplex Oil Strainer

### Suggested Specifications

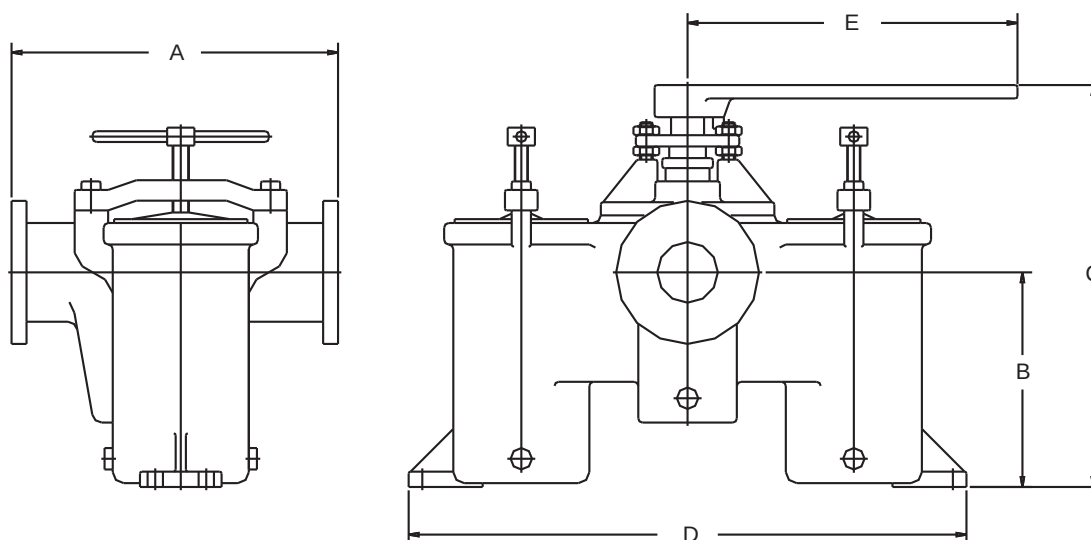
Furnish and install where shown one \_\_\_\_\_" (flanged) (threaded) duplex fuel oil strainer. Strainer shall have a one piece cast iron body (ASTM A-126), and shall be hydrostatically tested to U.L. quality control specifications. The strainer baskets shall be constructed of 1/16" perforated, 40, 60, or 100 mesh stainless steel. Strainer shall be Preferred Utilities Mfg. Corp., Danbury, CT, Model 72.



Clearance Dimensions, Threaded Strainers

# DUPLEX OIL STRAINERS

Model 72



Clearance Dimensions, Flanged Strainers

## Threaded Strainer Dimensions & Shipping Weight

| Catalog Number | Pipe Size | A     | B    | C     | D     | E     | Weight (lbs) |
|----------------|-----------|-------|------|-------|-------|-------|--------------|
| 13133          | 1"        | 5.25  | 5.88 | 10.13 | 10.88 | 8.00  | 28           |
| 13134          | 1 ¼"      | 7.75  | 7.94 | 14.13 | 14.00 | 12.00 | 46           |
| 13135          | 1 ½"      | 7.75  | 7.94 | 14.13 | 14.00 | 12.00 | 46           |
| 13136          | 2"        | 10.38 | 7.50 | 14.50 | 20.50 | 12.00 | 97           |
| 13137          | 2 ½"      | 10.38 | 7.50 | 14.50 | 20.50 | 12.00 | 104          |

(Dimensions in inches) Larger sizes available - consult factory.

## Flanged Strainer Dimensions & Shipping Weight

| Catalog Number | Pipe Size | A     | B     | C     | D     | E     | Weight (lbs) |
|----------------|-----------|-------|-------|-------|-------|-------|--------------|
| 13143          | 1 ½"      | 8.25  | 7.94  | 14.13 | 14.00 | 12.00 | 51           |
| 13144          | 2"        | 10.38 | 7.50  | 14.50 | 20.50 | 12.00 | 101          |
| 13145          | 2 ½"      | 10.38 | 7.50  | 14.50 | 20.50 | 12.00 | 104          |
| 13138          | 3"        | 10.88 | 10.75 | 17.75 | 20.50 | 12.00 | 124          |
| 13139          | 4"        | 14.75 | 12.75 | 20.06 | 25.25 | 12.00 | 262          |

## Ordering Information

Select model number from the table above. The model numbers listed in the table above come standard with 1/16" perforated baskets. Add "M" for 40 mesh baskets or "-100M" for 100 mesh baskets. Sixty mesh and 200 mesh are also available. Consult the factory for part numbers.

## Example:

13133 —¾" pipe with 1/16 perf basket  
 13133M —¾" pipe with 40 mesh basket  
 13133-60M —¾" pipe with 60 mesh basket  
 13133-100M —¾" pipe with 100 mesh basket  
 13133-200M —¾" pipe with 200 mesh basket

# FUEL SENTRY TANK GAUGE

Model TG-EL-D4A

The **Fuel Sentry Model TG-EL-D4A Tank Gauge and Leak Detection System** is a remote reading, microprocessor based tank gauge, with six intrinsically safe sensor inputs that can monitor one or two tanks. The leak detection system is designed for use with double wall tanks, vaulted tanks, single wall tanks with spill basins, and double wall piping. The TG-EL-D4A is designed for use with all fuel oils (No. 2 through No. 6), diesel, kerosene, jet, and most other petroleum products.

Tank gauges are required by NFPA 30 Flammable and Combustible Liquids Code and NFPA 31 Standard for the Installation of Oil-Burning Equipment, and NFPA 110 Standard for Emergency and Standby Power Systems.

## Features Include

- Automatic delivery detection
- Oil delivery verification / shortage detection
- Idle tank theft alarm
- Overfill alarm
- Auto-Stik stick chart generation
- Easy to read bar graph display
- Six intrinsically safe sensor inputs
- Daily HD-A2-C automatic leak sensor testing
- Sensor wiring fault detection
- Printer with delivery, consumption, status, and alarm reports
- RS-485 Modbus standard, Ethernet optional
- Fully field configurable

## Monitors one or two tank volumes via any combination of sensors

- TG-EL-WF-(7 or 12)-C wire float level sensor
- TG-EL-HLT-(7 or 15)-C drop-in head level sensor
- TG-EL-ULT-18-C ultrasonic level sensor
- Most other 4-20 mA level, head, bubbler, ultrasonic, or magnetostrictive sensors

## Leak Detection Sensor Inputs

- HD-A2-C discriminating leak sensor
- RBS or PS-LDS float leak switch
- Most other contact closure leak sensors
- Leak sensor wiring fault detection

The TG-EL-D4A system consists of the indicator/monitor, optional printer, level sensor(s), leak sensor(s), and optional delivery flow meter. The TG-EL-D4A accepts up to 6 sensors in any combination. For example:

|              |                                          |
|--------------|------------------------------------------|
| Single tank: | (1) level, (1) head level, (4) leak      |
| Single tank: | (1) head level, (1) flow meter, (4) leak |
| Dual tank:   | (2) level, (4) leak (2 per tank)         |



Model TG-EL-D4A Tank Gauge

## Capabilities

### Leak Sensor Testing

All leak detection systems must be tested periodically over the 20-30 year life of the tank. The Fuel Sentry can automatically test each HD-A2-C discriminating leak sensor every day and print the result. Inspectors can remotely initiate HD-A2-C testing from the Fuel Sentry at any time. Non-discriminating (wet/ dry) leak sensor wiring faults (opens or shorts) can be monitored, and alarmed, by the TG-EL-D4A if a model WFTN-1 network is installed at each sensor.

### Oil Delivery Verification

With the high price of oil, it is important to pay only for the oil that is actually delivered. With a single level (or head) sensor, the TG-EL-D4A can automatically detect a delivery and print a time/ date stamped 'gallons delivered' report which is used to verify the invoice before payment.

The TG-EL-D4A can also accept a flow meter signal, in addition to a level sensor, for higher accuracy delivery reporting.

Delivery 'shorting' by air injection, or waste fluid blending, changes oil density which makes the oil truck delivery meter reading inaccurate. With two sensors per tank: head plus either level or delivery flow, the TG-EL-D4A can note suspicious oil density changes on the 'gallons delivered' printed report.



# FUEL SENTRY TANK GAUGE

Model TG-EL-D4A

## Idle Tank Theft Alarm

If the gallons in an idle tank drop excessively, the TG-EL-D4A can activate a time/ date stamped "theft alarm." An external "tank is idle" contact closure (from an emergency generator, pump set, or...) input detects small, slow volume changes. If this input is not available, the Fuel Sentry can trigger a theft alarm based on a higher than normal fuel consumption rate.

## Overfill Alarm

The TG-EL-D4A can activate an FA-AV-x-D3 audible/ visual overfill alarm located near the tank fill pipe to warn the driver to stop filling the tank. The audible alarm self-silences.

## Data Logging, Printer, Communications

For a single tank configuration, the TG-EL-D4A automatically logs the following data into non-volatile memory:

- Last 2 inventories at midnight
- Last 14 deliveries with time/ date
- Last 14 daily consumptions (midnight to midnight)
- Last 10 weekly consumptions (Sunday midnight to Sunday midnight)

For dual tank configurations, the data quantities are half of the above for each tank. The last 10 alarm (or status) messages are displayed with time/ date stamp. Reports based on the above data can be automatically printed after every delivery, at midnight, after an alarm, or manually on demand. The data can also be read via RS485 Modbus (standard) or Ethernet Modbus TCP/ IP (optional).

## Fully Field Configurable

The TG-EL-D4A can be completely field configured from it's LCD menus and keypad, or with the TG-EL-D4A\_Edit PC-based software via the TG-EL-D4A USB port.

Sensor type, function, channel, and calibration data can be configured. Relay functions can be assigned (high, overfill alarm, low, leak, theft, pump start, system error, ..., common alarm).

The 51-point stick chart (volume versus level) can be generated in three ways:

1. Based on tank dimensions for standard shapes.
2. Manually entered values from the tank manufacturer's stick chart.
3. 'Auto-Stick' based on TG-EL-D4A data logging of flow meter and level sensor signals during a reduced rate tank fill. The flow meter can be temporary or permanent.

The resulting stick chart can be printed on the optional printer.



Model TG-EL-D4A Tank Gauge Control Panel



Model TG-EL-D4A Tank Gauge  
Optional Panel Mounted Printer

# FUEL SENTRY TANK GAUGE

Model TG-EL-D4A

## Instrument

**Input Power:** 120 VAC +/-15%, 50/60 Hz, 21 VA

## Case Size:

**TG-EL-D4A-00-x:** 8" H x 3.5" W x 7.7" D

**TG-EL-D4A-Ex-x:** 16.5" H x 14.75" W x 9" D

**Enclosure:** NEMA 4 faceplate

**Ambient Temp:** 32° F to 122° F

**Display:** High contrast LCD  
4" high, 0.5% resolution  
bargraph

## Inputs (9 total)

**Multi-purpose (6):** 6 channels, I.S. Class I, Division 2, Group D

**Contact Closure (3):** 28.4 VDC, 26 mA

**2 wire 4-20 mA:** 13 VDC @ 21 mA for each transmitter + wiring.  
0.006% resolution,  
0.1% accuracy

**Contact Closure (3):** 3 channels, non-I.S., non WFTN-1

**1 channel:** 120 VAC, 10 mA

**2 channel:** 15 VDC, 30 mA

## Ordering Information

## Outputs

### Relays (8 total):

2 channels SPDT, 10 A res., ½ HP, 120 VAC

4 channels SPST NO, 1.5 A pilot, 120 VAC

### 4-20 mA:

2 channels 650 ohms max, volume or depth

## Communications

### USB:

TG-EL-D4A\_Edit PC software

### RS485:

Modbus, ASCII or RTU

1200-38400 baud

### Ethernet:

Optional, Modbus TCP/IP

### Telephone Modem:

Optional, Custom Protocol

## Printer Specifications

**Input Power:** 120 VAC +/-15%, 50/60 Hz, 20 VA

**Case Size:** 4.6" H x 4" W x 2.8" D

**Enclosure:** NEMA 1

**Ambient Temperature:** 32° to 122° F

**Paper:** 2.3" W, thermal, 30 columns

| Description                                                                                                                         | Catalog Number   |
|-------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Tank Gauge Chassis Options:                                                                                                         |                  |
| Tank Gauge, no enclosure, no printer                                                                                                | TG-EL-D4A-00-x-0 |
| Tank Gauge, with wall mount enclosure, no printer                                                                                   | TG-EL-D4A-E0-x-0 |
| Tank Gauge, with wall mount enclosure, with printer                                                                                 | TG-EL-D4A-EP-x-0 |
| Communication Options:                                                                                                              |                  |
| RS485 Modbus                                                                                                                        | replace X with 0 |
| RS485 + Ethernet Modbus                                                                                                             | replace X with E |
| RS485 + telephone modem                                                                                                             | replace X with T |
| Level Sensors:                                                                                                                      |                  |
| Wire Float level sensor, 4-20 mA output, 7 ft maximum depth                                                                         | TG-EL-WF-7-C     |
| Wire Float level sensor, 4-20 mA output, 12 ft maximum depth                                                                        | TG-EL-WF-12-C    |
| Submersible Head Level sensor, 4-20 mA, 7 ft depth                                                                                  | TG-EL-HLT-7-C    |
| Submersible Head Level sensor, 4-20 mA, 15 ft depth                                                                                 | TG-EL-HLT-15-C   |
| Ultrasonic level sensor, 4-20 mA, 18 ft maximum depth                                                                               | TG-EL-ULT-18-C   |
| Leak Sensors:                                                                                                                       |                  |
| Discriminating Leak Sensor, Dry-H <sub>2</sub> O - Oil, 4-20 mA                                                                     | HD-A2-C          |
| Additional Options:                                                                                                                 |                  |
| Ship loose printer for panel mounting (for use only with JC-TGD-00-X-0 tank gauge)                                                  | JC-TGD-PRINTER   |
| Two wire direct burial cable (for use with TG-EL-WF, TG-EL-ULT, RBS, and HLS devices)                                               | 26302            |
| Detector Guard for HD-A2-C for sumps, vault floors, bright areas                                                                    | HD-HSG           |
| Wiring Fault Test Network (field-mounted at RBS, HLS, and other non-discriminating (wet/dry) contact closure leak or level sensors) | WFTN-1           |
| Four wire vented direct burial cable (for use with TG-EL-HLT-X-C)                                                                   | 26000            |

## FUEL SENTRY TANK GAUGE

### Suggested Specifications

#### Suggested Specifications

Provide a microprocessor-based tank gauging, leak detection, and overfill prevention system per NFPA 30 Flammable and Combustible Liquids Code, NFPA 31 Standard for the Installation of Oil-Burning Equipment, and NFPA 110 Standard for Emergency and Standby Power Systems. The tank gauge shall be provided complete with printer and RS-485 Modbus interface to the BAS for each storage tank indicated on the drawings. The indicator, printer, level sensors, leak sensors, and overfill alarm station shall be supplied by one manufacturer. The indicator and sensors shall be intrinsically safe for Class 1, Division 1, Group D hazardous locations as defined by the National Electric Code. The system shall be a Preferred Utilities Mfg Corp Model TG-EL-D4A with printer, HD-A2-C leak sensors, FA-AV-x-D3 Fil-A-Larm, and TG-EL-WF-x-C, or TG-EL-HLT-x-C, or TG-EL-ULT-x-C level sensor, as appropriate.

The indicator shall have a bright 4" bargraph display that is clearly visible from 20 foot viewing distance and shall be able to monitor either 1 or 2 tanks. All sensor signals shall be either 4-20 mA or contact closure for easy interchangeability of field devices. All leak sensors shall be automatically tested by the indicator on a daily basis with the result shown on the printed reports. Continuous sensor wiring fault detection (open or shorted) shall be provided. Automatic delivery detection logic shall trigger a printed, and data logged, report displaying the time, date, and amount delivered for delivery verification. The system shall be field upgradeable to dual sensors for higher accuracy delivery reporting and/or density shift detection in the event that delivery 'shorting' is suspected. Provide idle tank theft alarming capability for standby tanks or emergency generator tanks as required.

The printer shall automatically, or manually, print:

- Current inventory
- Time/ date
- Gallons of the last 7 deliveries
- Last 7 daily consumptions
- Last 5 weekly consumptions
- Last 10 time/ date stamped alarms

The tank gauge system shall be fully field configurable. It shall be able to automatically generate a stick chart based on measured delivery flow and measured level if an accurate stick chart is not available for the tank.

# MULTI-TANK GAUGE and LEAK DETECTION SYSTEM

Model TG-EL-D5

- **Multi-Tank Gauge and Leak-Detection System**
  - Accepts Model TG-EL-WF Wire Float, ultrasonic or differential pressure level sensors
  - Accepts up to 4 level sensors
  - Accepts up to 12 HD-A1 Leak Detectors
  - Consult factory for larger quantities
- **Major Capabilities**
  - 16 line by 40 character LCD Display
  - Overfill alarm leak detector and level sensor test capability
  - Alarm horn
  - Building Automation System (BAS) RS485 Modbus communication port
  - BAS relay outputs
  - Volumetric 4-20 mA DC outputs
  - Automatic Fuel Oil Transfer Pump Set, Model ATPS integration

## Description

The Model TG-EL-D5 Multi-Tank Gauge and Leak-Detection System is a comprehensive system that can simultaneously monitor product levels and leaks. The Model TG-EL-D5 combines digital monitoring and control technology with Preferred's line of tank gauging and monitoring equipment. The system provides the best solution for a variety of gauging and leak-detection applications. Intuitive displays operate on a simple menu system providing quick and easy navigation for all of the Model TG-EL-D5's features. The 16-line by 40 character LCD display is backlit to provide easy visibility of tank contents, leak sensor status and alarms. The Model TG-EL-D5 is applicable to a wide range of tank gauging applications. It accepts the wire float, Model TG-EL-WF for applications with liquid depths of 12 feet or less, and may accept ultrasonic or differential pressure sensors for larger depth liquids. Using the discriminating leak sensor, Model HD-A-C the Model TG-EL-D5 monitors both steel and fiberglass double wall tanks, double wall piping, tank manholes and/ or vaulted tank containment areas. The Model HD-A2-C sensor provides both local and remote oil and water leak detection.

## Major Capabilities

### Inventory Management

The Model TG-EL-D5 provides product level and volumetric data for each tank and maintains a delivery log with time/ date stamp, product quantity and tank number.

### Annunciation

The Model TG-EL-D5 provides high level and leak alarm monitoring. Alarms are visible on the tank status display, activate the integral alarm horn and are logged with time/ date stamp and English language description on an alarm summary display. Monitored alarms include: overfill alarm (high level), low level alarm (time to refill), and leak alarm.

California OSP-0361-10



Model TG-EL-D5 Multi-Tank Gauge and Leak-Detection System



Status Display Screen

## Fuel Transfer System Integration

The TG-EL-D5 may be fully integrated into Preferred's Automatic Fuel Oil Transfer Pump Set. Both pump set and tank gauge status is available on a common LCD display and RS-485 communication port. Up to a two (2) tank, a Model TG-EL-D5-2 may be integrated into the Automatic Fuel Oil Transfer Pump Set. Consult the factory for larger systems.



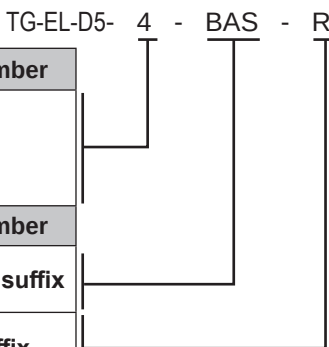
# MULTI-TANK GAUGE and LEAK DETECTION SYSTEM

## Specifications

|                                     |                                                                                                                      |                                                                                                                        |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Input Power:</b>                 | 120 VAC +/- 15%, 50/60 Hz                                                                                            | 120 VAC                                                                                                                |
| <b>Ambient Temperature:</b>         | 32° to 122° F                                                                                                        |                                                                                                                        |
| <b>Weight:</b>                      | 55 lb.                                                                                                               |                                                                                                                        |
| <b>Instrument Housing:</b>          | 16.5"W x 14.5"H x 6.75"D, wall mounted                                                                               | Overfill Alarm Station: High alarm relay output (for each tank), SPST, 8A, ½ HP, 120 VAC, remote alarm silencing input |
| <b>Display:</b>                     | 16 line by 40 character, 2.9" H X 5.1" W backlit LCD                                                                 | Common Alarm: Relay output, SPST, 8A, ½ HP, 120 VAC                                                                    |
| <b>Audible Alarm:</b>               | Integral                                                                                                             | BAS Outputs: Up to eight (8) relay outputs, SPST, 8A, ½ HP, 120 VAC (optional)                                         |
| <b>Keypad:</b>                      | Membrane, tactile feedback                                                                                           | Analog Output: Volumetric output for each tank, 4-20 mADC (optional)                                                   |
| <b>Level Sensor:</b>                | Up to four (4) wire float, Model TG-EL-WF, consult factory for other sensors or additional tank quantities           | <b>Modem:</b> Internal baud; RJ-11 jack and data (optional)                                                            |
| <b>Leak Sensor:</b>                 | Up to twelve (12) leak detectors Model HD-A1, consult factory for additional quantities                              | <b>Communication:</b> Modbus (ASCII or RTU modes), 1200 to 38,400 baud, RS485, optically isolated                      |
| <b>Intrinsic Safety: (optional)</b> | External intrinsically safe barriers allow sensors to be located in Class I, Div. I, Group C & D hazardous locations |                                                                                                                        |
| <b>Outputs:</b>                     | Common alarms PDT, 8A, ½ HP,                                                                                         |                                                                                                                        |

## Ordering Information

| Description                                                  | Catalog Number    |
|--------------------------------------------------------------|-------------------|
| Tank Quantity, Up to 4 Tanks                                 | 1<br>2<br>3<br>4  |
| Optional Features                                            | Catalog Number    |
| Building Automation System Discrete Output Contacts          | add "-BAS" suffix |
| Remote Volumetric Display Outputs (one output for each tank) | add "-R" suffix   |



## Additional Ordering Information

- Specify level sensor Model TG-EL-WF wire float, up to 4 sensors. Consult factory when using other level sensors or when larger quantities are required
- Specify leak detector model HD-A1, up to 12 leak detectors
- Caution sign (catalog number FA-S)
- Monitor access manhole (catalog number TG-MH-18)
- Specify FA-AV-[1,2, or 3 (number of tanks)]-D3 audible/visual overfill alarm
- Remote weatherproof bell 10" (catalog number 16276), or 6" (catalog number SDA-B6)
- Specify extra splice kits (catalog number 190271)
- Specify connecting cable: (catalog number 21655), three wire shielded cable for each leak or level sensor in 10' increments (800' maximum wire run per sensor)
- Specify number of tanks
- Provide tank print or description. It should include:
  - Type of construction (single or double wall, fiberglass or steel)
  - Manufacturer name and model number
  - Fluid capacity
  - Inside dimensions of tank including diameter and length (if dished heads, show length of both shell and overall)
  - Important dimension: from the inside bottom of tank to the top of the tank entrance fitting, and the type and pipe size of fitting
- Provide fluid description:
  - Grade of fuel oil
  - Other fluids type and specific gravity
  - For corrosive fluids, buyer must approve wetted parts material
- Specify destination: to satisfy local codes, specify destination so that the proper local governing authority information packages are included.

## Tank Information Required When Ordering

**Please Note:** Tank gauges are manufactured in accordance with specifications furnished with the order and are not suitable for operation with different tank configurations or installation plans. Complete specifications must be provided and should include a tank print.

# MULTI-TANK GAUGE and LEAK DETECTION SYSTEM

## Suggested Specifications

### Suggested Specifications

#### 1. Application

Supply a fully integrated remote reading microprocessor-based multiple tank monitoring system for one (1) (select up to 4) fuel oil storage tanks per the requirements of NFPA 30 Flammable and Combustible Liquids Code, NFPA 31 Standard for the Installation of Oil-Burning Equipment, and NFPA 110 Standard for Emergency and Standby Power Systems. The monitor shall contain a real time clock and provide real time monitoring of each tank, identifying fuel oil levels as well as leaks. Up to three (3) leak detection sensors must be available per tank for monitoring interstitial spaces, piping sumps, double wall piping and tank vaults. All wiring between the monitor and sensors shall be low voltage. System shall be Preferred Instruments, Danbury, CT multi-tank gauge and leak-detection system, Model TG-EL-D5.

#### 2. Operator Indications and Alarms

The system shall have a 16 line by 40 character back lit LCD display for tank inventory and alarm status and setup menus for easy operation and troubleshooting. Alarms shall be logged with time/ date stamp and English language description. The tank gauge shall include a minimum of 200 point memory. The following alarm conditions shall activate a local visual and audible alarms; high product level (higher than warning level), warning level (remote overfill alarm only), low product level, high water level and leak alarm. An over-fill visual and audible alarm circuit shall be provided for each tank to activate the remote alarm at the fill station on a high level condition. This circuit shall have remote alarm silencing capabilities. In addition, two (2) independently programmable relays shall be provided for each tank for user defined alarms.

#### 3. Inventory Management

The tank management system shall be able to detect an inventory increase when a fuel delivery is being made. This feature shall be automatically activated when the system detects an increase in volume that is in excess of a pre-programmed value. Upon activation, the system shall wait until the contents have settled and then display the amount of fuel delivered. The monitor will have the capability to store up to (32) deliveries. Deliveries in excess of 32 will automatically delete the oldest delivery to allow storage of the newest delivery.

#### 4. Testing

The system shall include a "manual leak test" feature that when activated via a magnet on the leak sensor shall test various elements of the system including: leak sensor, LCD, LED (controller and remote annunciator) and alarm horn (controller and remote annunciator).

#### 5. Communication

The tank monitoring system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS-485 Modbus protocol. Tank inventory and alarm status shall be available through the communications ports.

#### 6. Quality Assurance

The tank monitoring system shall be manufactured and labeled in accordance with UL 508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The tank monitoring system shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model TG-EL-D5-x-M ('x' = tank quantity from 2 to 4).

## OVERFILL ALARM STATION

Model FA-AV Fil-A-Larm System

For Overfill Prevention of Fuel Oil Storage Tanks per NFPA 30 and NFPA 31

The Model Fil-A-Larm system is designed to be located near the tank fill terminal to notify of a potential overfill condition. It triggers a high level alarm that alerts the filling operator that the tank is filled to its predetermined capacity. When an overfill alarm occurs, the alarm bell sounds and the corresponding alarm light flashes. The bell is automatically silenced in 90 seconds or instantly silenced when the operator selects the "alarm silence" pushbutton. The visual alarm is highly visible even in direct sunlight. The enclosure top mounted flashing lamp is visible from 180°. A "test" pushbutton is provided to verify the operation of the flashing alarm light(s) and bell. The alarm automatically resets when liquid level goes below the overfill alarm setpoint. A digital display of tank volume is available.

The Model Fil-A-Larm system is surface-mounted, NEMA 4 rated, moisture-proof enclosure. The box material is carbon steel. The interior is prime coated and painted with a durable white enamel.

### Specifications

|                              |                                                 |
|------------------------------|-------------------------------------------------|
| <b>Enclosure:</b>            | 12" W x 12" H x 6" D, NEMA 4                    |
| <b>Audible Alarm:</b>        | 4" 92 db bell                                   |
| <b>Visual Alarm:</b>         | Lens 3 1/4" H, 4 3/8" Dia.<br>with 40 Watt bulb |
| <b>Alarm Silence button:</b> | Silences bell (auto time-out also)              |
| <b>Alarm Test:</b>           | Verifies flashing alarm light(s)<br>and bell    |

### Ordering Information

Standard Unit FA-AV: Available for 1, 2, or 3 tanks  
Order FA-AV-[1, 2, or 3 (*number of tanks*)]-D3  
Example: FA-AV-2-D3 would be for two tanks  
To add gallons display unit:  
order FA-AV-[1, 2, or 3]-R-D3



FIL-A-LARM System Model FA-AV-2 shown

### Suggested Specifications

Provide and install where shown on the drawings an Audible/Visual Overfill Alarm Station for (1, 2, or 3) tanks to be activated by Preferred Utilities HLS high level switch, TG-EL-D3 or TG-EL-D5 Tank Gauges. The system shall consist of a Preferred FA-S caution sign and NEMA 4 weather-proof cabinet to include a 4" weather-proof bell with automatic silencing, 180° visible flashing lamp, bell silencing pushbutton, and alarm test pushbutton. Overfill alarm station shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model FA-AV. **To add gallons display** to FA-AV add: "to include a digital display of tank content, reading directly in gallons without multiplier."

\*Gallons Display Unit - Without "sticking" the tank, the gallons display unit allows the filling operator to read tank contents prior to filling. A digital display reads directly in gallons (0-150,000 gallons without multiplier). Display unit is available for up to three tanks.

## FIL-A-LARM CAUTION SIGN

Model FA-S

Installed near the FA-AV Alarm System or Model 2 In-Wall Spill Container, the sign reduces the possibility of tank overfilling by alerting the operator to the presence of the Fil-A-Larm System and Model 2 In-Wall Spill Container. The sign is 20" W x 14" H, 18 gauge steel with porcelain enameled bright yellow background and 2" black lettering.

### Suggested Specifications

Provide and install an "overfill caution sign" near the overfill alarm station. The sign shall be 20"W by 14"H of 18 gauge steel with porcelain baked enamel finished bright yellow background and minimum 2" H black lettering. The caution sign shall read: **CAUTION WHEN ALARM BELL SOUNDS OIL TANK FILLED TO CAPACITY DO NOT OVERFILL.** Sign shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Fil-A-Larm Sign Model FA-S.



### Ordering Information

Model: FA-S

## LEAK DETECTOR

Model HD-A2-C (for use with TG-EL-D4A or TG-EL-D5 Tank Gauges)

The Model HD-A2-C leak detector uses a combination electro-optic technology, which reliably distinguishes between water and oil. The horizontal detector contains an infrared optical liquid detector and a set of stainless steel conductivity rings. Oils are detected by the optical liquid detector and water is detected by both the optical liquid detector and the conductivity rings.

Ruggedly constructed, with no moving parts, the solid-state HD-A2-C leak detector provides reliable and cost-effective performance. The system is suitable for all grades of oil, including No. 6 and gasoline.

Up to six HD-A2-C leak detectors can be connected to a single TG-EL-D4A tank gauge, up to 8 HD-A2-C connect to an FSC, and up to 12 leak detectors can be connected to a single TG-EL-D5 tank gauge. The detectors monitor for leaks through the inner-wall (oil) or outer-wall (groundwater) of double walled tanks; oil or water leakage into the piping annular space; ground water leakage into a sump. Typical installation areas include:

- Fiberglass or steel tank annular space
- Piping or containment sump
- Vault spaces

### Water/ Oil Leak Discrimination

Upon the detection of oil or water in a monitored space, the HD-A2-C indicating transmitter will show an oil or water light and send a signal to the TG-EL-D4A or TG-EL-D5 tank gauges, or FSC.

### Continuously Checked

The integrity of the leak monitoring control loop is continuously checked electronically. In normal standby operation, the loop is continuously powered with the light sensor seeing the light from the source. An open or short in the field wiring or failure of the light source or sensor will alert the plant operator by activating the visual/ audible leak alarm at the tank gauge.

### Periodic Manual Testing

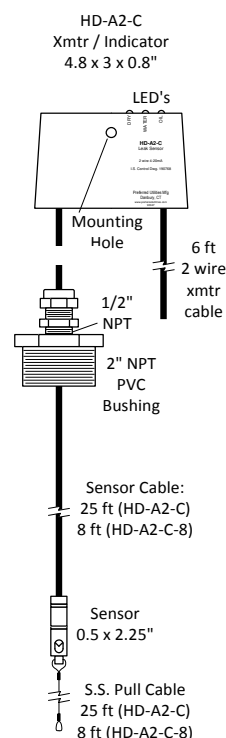
Recognizing that the HD-A2-C leak detector may not be required to automatically alarm for years, the HD-A2-C can be checked periodically by disconnecting power for 2-3 seconds. The sensor self-checks on restoration of power. The Fuel Sentry (TG-EL-D4A) tank gauge or FSC controller perform this self-test every 24 hours. The HD-A2 connecting wires, XMTR, and detector are fully tested.



HD-A2-C Leak Detector Transmitter



HD-A2-C Leak Detector Probe and Pull Cable



HD-A2-C Assembly Expanded View



## LEAK DETECTOR

Model HD-A2-C

### Specifications

|                           |                                                                                                                                |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Solid State:</b>       | No moving parts, fail safe                                                                                                     |
| <b>Leak Indications:</b>  | Red for oil, Yellow for water,<br>Green for dry                                                                                |
| <b>Detector Test:</b>     | Continuous self test                                                                                                           |
| <b>Sensor Cable:</b>      | 2 wire, shielded, suitable for<br>direct burial or conduit<br>installation,<br>Max. length 800 feet                            |
| <b>Splice Kit:</b>        | Waterproof                                                                                                                     |
| <b>Water Detection:</b>   | Conductivity                                                                                                                   |
| <b>Oil Detection:</b>     | Electro-optics                                                                                                                 |
| <b>Wetted Parts:</b>      | Stainless Steel, Epoxy Resin or<br>Polypropylene                                                                               |
| <b>Fluid Temperature:</b> | 135° F maximum                                                                                                                 |
| <b>Transmitter</b>        |                                                                                                                                |
| <b>Temperature:</b>       | -5° F to 122° F                                                                                                                |
| <b>Tank Mounting:</b>     | 2" tank opening minimum.<br>Other areas such as steel tank<br>sumps, double wall pipe or tank<br>vaults require ¾" NPT minimum |

Catalog Number: HD-A2-C

Order with TG-EL-D4A, TG-EL-D5 or FSC-based  
tank gauge systems.

### Ordering Information

### Suggested Specifications

Provide and install leak detectors in the annular space within the double wall tank (the piping sump and double wall containment piping, etc., as shown on the drawing). The leak detectors shall be solid state and discriminate between oil and water, display the leak with (3) LED's on its indicating transmitter, and send an appropriate alarm signal to the tank gauge. All leak detectors shall be intrinsically safe, have continuous self checking, fail safe to an alarm condition, and have indicating transmitters with local indicators at grade level. The leak detectors shall be Preferred Utilities Mfg Corp., Danbury, CT, Model HD-A2-C.

When the leak detector is to be mounted in manways, piping sumps, steel tanks, floor or vault containment areas, include a leak detector guard. The HD-HSG leak detector guard shall protect the leak detector from mechanical damage and exposure to high ambient infrared light. Leak detector guard shall be Preferred Utilities Mfg Corp., Danbury, CT, Model HD-HSG.

# TANK HIGH ALARM SWITCH

Model HLS, Fil-A-Larm Switch



The Model HLS Tank Fil-A-Larm Switch is used on light fuel oil storage tanks to reliably activate an overfill warning signal. This alerts the transfer operator to stop filling the tank. Federal codes for overfill prevention may be satisfied by an overfill alarm that sounds when the tank contents reach 90% of the tank capacity or one minute prior to overflow if the rate of fill is constant.

The control consists of a sealed brass probe that screws into a 1 1/4" NPT tapped opening in the top of the tank. A magnetic reed switch is factory encapsulated inside the probe where it is protected from liquid vapors. The closed cell Buna-N magnetic float is the only moving part.

## Applications

The Model HLS level switch may be used with any light fuel oil or clean low viscosity fluid compatible with the brass probe and Buna-N float materials. The Model HLS is not intended for installation where a portion of the control outside the tank might be submerged. Provide a suitable protective enclosure for access when installing underground. The Preferred sidewalk fill box is suitable for this purpose.

## Suggested Specifications

Tank high level alarm switch shall be Model HLS-X (where X is the distance between the bottom of the 1 1/4" mounting boss and the desired liquid level alarm point in inches) as manufactured by Preferred Utilities Mfg. Corp., Danbury, CT. It shall be float-operated, installed through a single 1 1/4" NPT tapping on the top of the tank, suitable for pressures up to 150 PSIG, manufactured entirely of nonferrous material, and complete with a switch rated at 100 watts. Electrical connections shall be made external to the tank in an explosion-proof head assembly approved by Underwriters Laboratories for Class I, Groups C & D applications.

**Approvals:** Meets the requirements of NFPA 30 Section 2-10.3, and 40CFR Subpart B, part 280.20c for overfill prevention on underground storage tanks when used with the Preferred Utilities Model FA-AV and an alarm bell.

| Tank Diameter | 80% Warning | 85% Warning | 90% Warning | 95% Warning |
|---------------|-------------|-------------|-------------|-------------|
| 4'            | 12"         | 10"         | 8"          | 5"          |
| 6'            | 18"         | 15"         | 12"         | 7"          |
| 8'            | 24"         | 20"         | 15"         | 10"         |
| 10'           | 30"         | 25"         | 19"         | 12"         |
| 12'           | 36"         | 30"         | 23"         | 15"         |

Distance between fluid and top of tank inner wall for various "percentage of full" warnings.



Fil-A-Larm Switch, Model HLS

## Specifications:

|                                |                                                                                                    |
|--------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Mounting:</b>               | 1 1/4" NPT coupling                                                                                |
| <b>Fluid Temperature:</b>      | 180° F maximum                                                                                     |
| <b>Fluid Specific Gravity:</b> | 0.5 minimum                                                                                        |
| <b>Fluid Pressure:</b>         | 150 PSIG maximum                                                                                   |
| <b>Electrical*:</b>            | SPST, 100W at 120 VAC<br>resistive, 20 mADC 24 VDC<br>resistive, 8 VA (holding) AC relay coil duty |
| <b>Switch Action:</b>          | Can be N.O. or N.C.**                                                                              |
| <b>Electrical Housing:</b>     | Cast aluminum, weather-proof, explosion-proof                                                      |
| <b>Wetted Parts:</b>           | Brass probe and Buna-N float                                                                       |
| <b>UL Listed:</b>              | Class I Groups C & D                                                                               |

\* Do not operate tungsten lamps directly from the contacts of the Model HLS as the cold filament inrush current will damage the contacts

\*\* When the HLS is used with a Preferred Model FA-AV-1, 2, or 3, please specify that switch is to be "normally closed" (N.C.).

## Ordering Information

Order Model HLS-\_\_" (NO or NC). Use the table to find the distance from the fluid surface to the top of the tank at the desired "percentage of full" warning level and enter that value into the model ordering description. If the Model HLS mounting boss will be mounted above the tank inner wall due to a riser, bushings, double-wall construction, etc., add this amount to the effective length of the probe when ordering.

## LIQUID LEVEL SWITCH

### Model PLS

The Model PLS Level Switch provides up to six independent liquid level switches on one sealed probe up to 72" in length. Magnetic reed switches are encapsulated in the sealed brass probe where they are protected from liquids and vapors. Buna-N floats, containing magnets, slide on the outside of the brass probe. A rising liquid level causes each float to rise to its upper travel stop position where it actuates a switch. For integration into a Preferred fuel oil handling system the PLS switches are supplied with the switch contacts "closed" when the float is in the down position, but either orientation can be ordered.

#### Application

The Model PLS level switch may be used with any clean, low viscosity, non-adhering fluid compatible with brass, solder, epoxy and Buna-N. It is commonly used on fuel oil day tanks to control the addition of oil from remote pumps, and to alarm high and low levels. Other applications include pressurized or vented tanks for water, hydraulic fluid, lubricating oils or distillate fuels. Insert the unit vertically and then thread it into a 1¼" NPT half coupling on the tank shell. The wiring enclosure is not designed to be submerged. A suitable protective enclosure for access, such as the Preferred sidewalk fill box, should be provided when installing underground. (See page 83.)

#### Suggested Specifications

The tank level control shall be Model PLS-XX-Y (XX" long with Y switches) as manufactured by Preferred Utilities Mfg. Corp. Danbury, CT. Control shall be float operated, installed through and threaded into a single 1¼" tapping on the top of the tank. Control shall be suitable for pressures up to 150 PSIG and temperatures up to 180°F and shall be entirely of nonferrous material with \_\_\_ switches each rated at 100 watts.

#### Specifications:

|                                |                                                           |
|--------------------------------|-----------------------------------------------------------|
| <b>Mounting:</b>               | 1¼" NPT coupling                                          |
| <b>Fluid Temperature:</b>      | 180° F maximum                                            |
| <b>Fluid Specific Gravity:</b> | 0.5 minimum                                               |
| <b>Fluid Pressure:</b>         | 150 PSI maximum                                           |
| <b>Electrical*:</b>            | 100 W at 120 VAC resistive 8<br>VAC relay coil pilot duty |
| <b>Switch Action:</b>          | Can be N.O. or N.C.                                       |
| <b>Housing:</b>                | Cast aluminum, UL listed                                  |
| <b>Wetted Parts:</b>           | Brass probe and Buna-N float                              |

\* Do not operate tungsten lamps directly from the contacts of the Model PLS as the cold filament inrush current will damage the contacts



Liquid Level Switch  
Model PLS

#### Ordering Information

Model PLS-[length in inches]-[# of switches]

Preferred Level Switches are custom fabricated. The probe can be up to 72" long with up to 6 switching points that may be specified to be either "open" or "closed" at any point along the probe length. At least 3" must be provided between adjacent operating points, 2" between the lower end of the probe and the lowest operating point, and 2" between the highest operating point and the bottom of the mounting plug. Please contact the factory and request Form 344 which details the information required for each assembly.

Specifications subject to change without notice.

## HORIZONTAL SPILL CONTAINER

### Model 2 For Horizontal Fill Applications

The Model 2 Horizontal Spill Container provides a building outside wall termination point for fuel oil storage tank fill lines that contains any oil spilled when disconnecting the delivery fitting. Spill containment precautions are required by NFPA 31 Standard for the Installation of Oil Burning Equipment. The spill container includes a three point latch locking handle that protects fill lines from damage, vandalism, or unauthorized access. When the container is flush-mounted, filling operations do not infringe upon property lines. The container is fitted with a ½" NPT drain plug to facilitate draining of the fill area should a spill occur. Included is a 1½", 2", or 3" dry disconnect coupling assembly for supply delivery and a disconnect dust cover to protect the mechanized coupling from a potentially harmful buildup of dirt and debris. A Preferred P-LDS leak detector switch is mounted at the bottom of the containment basin.

#### Construction

The Model 2 Horizontal Spill Container is housed in a NEMA 4 or NEMA 4X rated moisture-proof enclosure. The box material is continuously seam welded stainless steel (or carbon steel). The door is fully gasketed, utilizing a three point latch and locking handle. The interior is prime coated and painted with a durable white enamel to aid in visual product leak inspection. Total leak containment is 5 U.S. gallons. The Model 2 Spill Container is available in flush-mounting, surface-mounting and free-standing arrangements. Flush-mounted units are equipped with a 2" x 2" x ¼" mounting flange to facilitate installation. Surface mounted units are provided with mounted tabs in lieu of the flange and free standing units are provided with two (2) 2" NPT couplings welded to the cabinet bottom to be mounted on pipe stands (pipe stands not included with unit).

The Model 2 Spill Container is often mounted in direct sunlight. Fuel oil vapors can be generated from the sun heating the spill container. All components mounted inside the container are explosion-proof rated to be suitable for this environment.

#### Options

The Model 2 Horizontal Spill Container may be ordered with an electronic package that features an overfill alarm station. When an overfill alarm occurs, the alarm bell (or horn) sounds and the alarm light flashes. The bell is automatically silenced in 90 seconds (when used in conjunction with a Preferred tank gauge) or instantly silenced when the operator depresses the "alarm silence" pushbutton. The alarm automatically resets when the liquid level goes below the overfill alarm setpoint. Electronic package No. 4 adds a local tank volumetric display based on a signal from a Preferred tank gauge.

A Model FA-S Fil-A-Larm sign is mounted on the interior of the door to alert fuel transfer personnel of the presence of the Fil-A-Larm System.



*Model 2 In Wall Spill Container shown with Electronic Package No. 4 that includes an explosion proof alarm horn, alarm light, silence pushbutton, leak switch, and digital display. Standard unit is designed for single tank applications. Consult factory for other configurations.*



*Interior view of an installed Model 2 fill box with Electronics Package No. 4 and a solenoid overfill prevention valve.*





# HORIZONTAL SPILL CONTAINER

Model 2 For Horizontal Fill Applications

| Horizontal Spill Container Description |                                                                                                                                                                                                                                                                       | Catalog Number          |          |                  |               |         |
|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------|------------------|---------------|---------|
|                                        |                                                                                                                                                                                                                                                                       | Model 2 - _ - _ - _ - _ |          |                  |               |         |
| Enclosure Material                     | Carbon Steel<br>Stainless Steel                                                                                                                                                                                                                                       |                         | CS<br>SS |                  |               |         |
| Electronics Package                    | 1. Enclosure Only. No Electronics<br>2. Alarm Bell, Alarm Light, Alarm Silence PB, P-LDS Leak Switch, FA-S Sign<br>3. NEMA 7 Horn, Alarm Light, Alarm Silence PB, P-LDS Leak Switch, FA-S<br>4. Electronics Package 3 Plus Tank Volumetric Display, P-LDS Leak Switch |                         |          | 1<br>2<br>3<br>4 |               |         |
| Coupling Size                          | 1 1/2"<br>2"<br>3"                                                                                                                                                                                                                                                    |                         |          |                  | 1.5<br>2<br>3 |         |
| Mounting Style                         | Flush-Mount<br>Surface-Mount<br>Free-Standing                                                                                                                                                                                                                         |                         |          |                  |               | SM<br>F |

## Suggested Specifications

Storage tank fill lines shall terminate at the building wall in a Model 2 Horizontal Spill Container fill box per NFPA 31 Standard for the Installation of Oil Burning Equipment. The fill box shall have a total of 5 U.S. gallon holding capacity, NEMA 4 rated construction with a neoprene gasket door seal, three point latch locking handle, (1.5", 2" or 3") oil fill connection, dry disconnect and dust cover (shipped loose). The cabinet shall be 304 stainless steel (or carbon steel), 12 gauge construction, and be equipped with ½" NPT drain connection. The enclosure shall be equipped with "stitch" weld 2" x 2" x ¼" angle steel flanges for flush mounting, with 2 pre-drilled holes per side. The entire interior shall be prime coated and painted with white enamel. (If the In-wall spill container is carbon steel material, the exterior is to be primed and painted with compatible enamel paint.)

Provide an overfill Alarm Station integral to the Model 2 Horizontal Spill Container. The station shall consist of an explosion proof "overfill alarm" light(s), alarm horn and "alarm silence" pushbutton. (Provide a separate explosion proof digital tank content display.) The light and bell shall be automatically silenced in 90 seconds or instantly silenced when the operator depresses the "alarm silence" button. Explosion proof components are required to prevent the ignition of the fuel oil vapors generated from the sun heating the spill container. A Preferred model P-LDS leak detector switch shall be installed in the bottom of the spill container to alert the plant to the presence of oil in the spill container. The Horizontal Spill Container shall be a Preferred Utilities Mfg Corp., Danbury CT, Model 2-4, flush-mounted with (1.5", 2" or 3") fill connection size and a (stainless steel or carbon steel) enclosure.

## SIDEWALK SPILL CONTAINER

### Model 3 for In-Ground Applications

The Model 3 Sidewalk Spill Container provides an in-ground termination point for fuel oil storage tank fill lines that will contain any oil spilled when disconnecting the delivery fitting. Spill containment is required by NFPA 31 Standard for the Installation of Oil Burning Equipment. A fill pipe flexible entry boot accommodates several size fill pipes, and provides a waterproof barrier that will not transmit stress due to vehicle traffic, pavement tilt or frost heave to the fill pipe.

The sidewalk spill container interfaces with any Preferred Utilities tank gauge and activates a horn to notify the delivery truck operator when the tank reaches 90% full. An optional digital display indicates the current tank volume in gallons. An alarm light is provided and an alarm silence pushbutton. Fill box electronics are suitable for this environment and constructed in accordance with U.L. 508A.

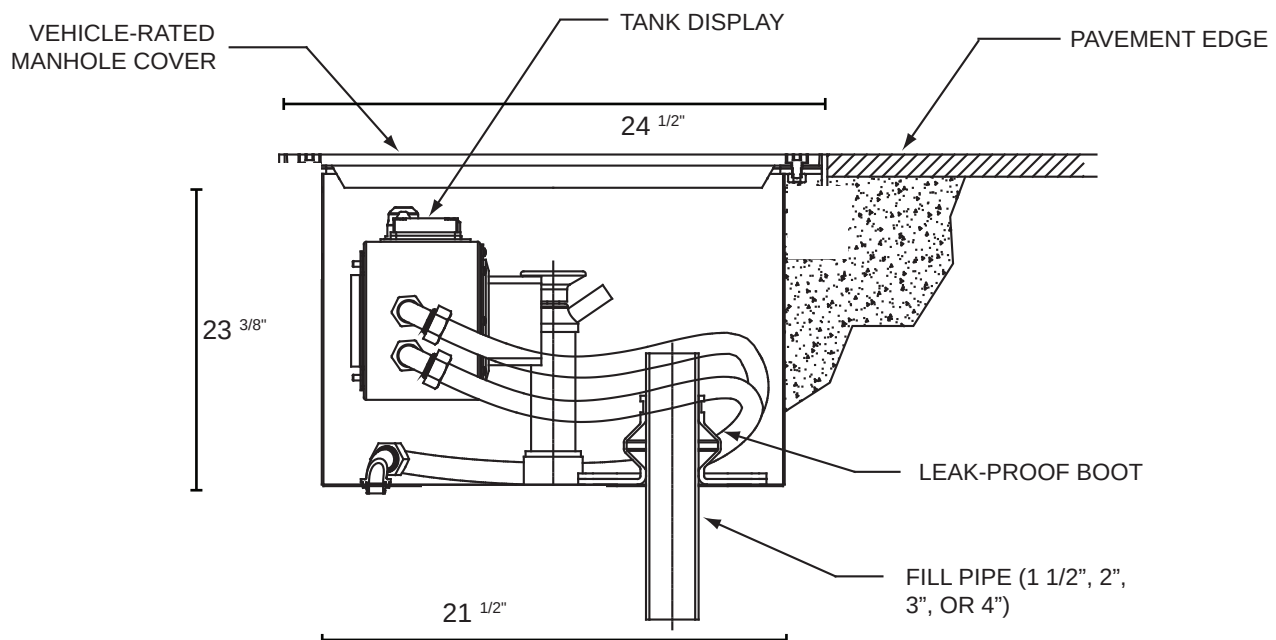
#### Construction

The Model 3 Sidewalk Spill Container is constructed of 14 gauge welded steel. The cover is made of diamond plate heavy gauge steel and is H-20 truck rated and secured by stainless steel tamper-proof hold down bolts to protect fill lines from damage, vandalism, or theft. A 1/8" gasket seals the enclosure against water, snow, and other contaminants. 1 1/2", 2", 3", and 4" fill pipe connections are standard. Other sizes can be special ordered. Any oil spilled is contained within the fill box. Models are available for fifteen gallon containment vessels. A hand pump is included to transfer any spilled fuel to the fill pipe.

The Model 3 Sidewalk Spill Container flush-mounts into any horizontal sidewalk or pavement and is held in place with four concrete anchor bolts.



*Model 3 Sidewalk Spill Container with overfill alarm horn and optional digital tank volume display*



*Model 3 Sidewalk Spill Container cutaway showing internal components.*

# SIDEWALK SPILL CONTAINER

Model 3 for In-Ground Applications

## Ordering Information

| Catalog Number | Description                                                                                                                               | Fill Pipe Size |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 3-3-1.5        | Model 3 Spill Container with alarm silence pushbutton, overfill light, and FA-S "Fil-A-Larm" sign                                         | 1.5"           |
| 3-3-2          |                                                                                                                                           | 2"             |
| 3-3-3          |                                                                                                                                           | 3"             |
| 3-3-4          |                                                                                                                                           | 4"             |
| 3-4-1.5        | Model 3 Spill Container with alarm silence pushbutton, overfill light, and FA-S "Fil-A-Larm" sign <b>plus digital tank volume display</b> | 1.5"           |
| 3-4-2          |                                                                                                                                           | 2"             |
| 3-4-3          |                                                                                                                                           | 3"             |
| 3-4-4          |                                                                                                                                           | 4"             |



Model 3 Sidewalk Spill Container Hand Pump

## Suggested Specification

Provide and install where shown on the drawings a Preferred Utilities Mfg. Corp., Danbury, CT, Model 3 sidewalk spill container per NFPA 31 Standard for the Installation of Oil Burning Equipment. The spill container is designed for below grade installation with flush mounting on horizontal surfaces.

The Model 3 sidewalk spill container body shall be made from heavy-duty carbon steel with welded body and painted for corrosion resistance. The sidewalk spill container shall include a gasket-equipped water-tight carbon steel Highway-20 rated cover held down with recessed screw heads. It will also include an integral recessed handle for easy cover removal. The steel cover has a Buna-N gasket and recessed head bolts.

The fill line shall enter the spill container through a boot connection. Boot connection shall be flexible for extreme temperature conditions that may effect piping expansion. Integral to the fill station shall be a hand pump for evacuation of spilled media. The spill container holds a minimum of 15 gallons of spilled fuel. A hose is provided so that clean oil can be pumped into the fill pipe. Contaminated oil or water can be pumped into a bucket for safe removal.

Internally mounted in the sidewalk spill container shall be an audible/visual overfill alarm system for single tank installations to be activated by a Preferred Utilities HLS high level switch when used in conjunction with a 190126 junction box or Preferred tank gauge system. The station shall consist of an "overfill alarm" light, alarm horn, "alarm silence" pushbutton and a digital readout of tank contents in US Gallons. All wiring shall be in Liquid-Tite waterproof flexible conduit.

The alarm light and horn shall be automatically silenced in 90 seconds or instantly silenced when the operator

depresses the "alarm silence" button. The digital display shall flash during a high level condition.

Inside the sidewalk spill container, provide a permanently mounted and prominently displayed nameplate showing the main oil storage tanks inventory capacity in US gallons. For the fill line connection, include a composite top-seal, tight fill adapter and lockable fill cap. The system shall include a Preferred FA-S caution sign.

The caution sign shall read as follows:

CAUTION WHEN ALARM BELL SOUNDS  
OIL TANK FILLED TO CAPACITY  
DO NOT OVERFILL.

The Sidewalk Spill Container shall be a Preferred Utilities Mfg Corp., Danbury CT, Model 3.

## FLEXFILL PUMP

### Pumped Fill Enclosure

#### Overview

The Preferred FlexFill Pump package is designed for pumped filling of single or multiple tank systems. It includes the Preferred FSC controller that can communicate to other controllers in a fuel system via the two channel redundant NodeNet system, and communicate to building automation systems via Ethernet or BacNet IP.

FlexFill Pump packages include:

- Fuel pump
- Lockable NEMA 4 enclosure available in carbon steel or stainless steel.
- Alarm horn
- Integral spill containment
- Containment basin leak detector
- Preferred FSC microprocessor controller

The integral FSC controller includes hard-wire interfaces to typical fuel system devices including:

- Tank level gauges
- Leak detectors
- Flow switches
- Tank selector valves

In addition, the FSC controller within the FlexFill Pump enclosure can be put on the redundant NodeNet digital network to interface with transfer pump controllers, day tank controllers, and filtration controllers. All information on the NodeNet network is accessible by all controllers on the network.

#### Operation

The FlexFill Pump allows for filling ground level or elevated fuel oil tanks from a gravity truck. It interfaces with tank gauges and leak detectors to close fill valves and energize an alarm horn when the tank reaches high level or a leak is detected. Using tank selector valves, one FlexFill Pump fill box can fill up to four separate tanks. In jurisdictions that require a "dry" fill pipe, the containment basin can be sized to be greater than the volume of the fill pipe.

#### Color Touchscreen HMI

The FlexFill Pump can be provided with a 4" color touchscreen Operator Interface Terminal. (OIT) If the FlexFill Pump is supplied stand-alone, the OIT will display tank levels for connected tanks, and status of leak detectors and flow switches. If supplied as part of a larger Preferred system, the FlexFill Pump OIT can provide information on the entire fuel system.

#### Building Automation System Interface

The 4" color touchscreen OIT acts as a gateway and provides Modbus RS-485, Ethernet, or BacNet IP communication of all Modbus register addresses in all the connected FSC controllers to an external building automation system or distributed control system.



*FlexFill Pump Enclosure for high-rise applications with an additional spill containment enclosure*

#### Ordering Information

When ordering FlexFill Pump packages, please specify:

- Pump flow and pressure required.
- Containment volume required.
- Number of tanks.
- Color touchscreen interface required.

#### Suggested Specifications

Provide, as detailed in the contract drawings, a pumped fill cabinet that includes a positive displacement pump with locking NEMA 4 cabinet suitable for flush-mounting, or mounting on a structural steel stand. The cabinet shall include a three point latch and locking handle, leak detector switch, and alarm horn.

The enclosure shall include a Preferred FSC microprocessor controller for connection to local tank gauges, leak detectors, and flow switches. The controller shall be capable of communicating with other FSC controllers in the fuel system via digital redundant NodeNet network. An optional 4" color touchscreen HMI shall be available for operations, diagnostics, and communication via Ethernet or BacNet IP. Pumped fill cabinet shall be Preferred FlexFill Pump with flow of \_\_\_\_\_ gallons at \_\_\_\_\_ discharge pressure of No. 2 oil. \_\_\_\_\_ gallon spill integral spill containment shall be included.



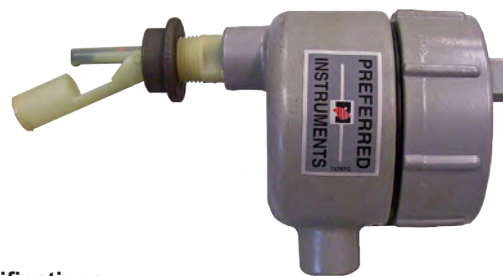
## LEAK DETECTOR SWITCH

### Model RBS

The Model RBS Leak Detection Switch detects leakage into day tank rupture basins and double wall piping leak containment systems containing diesel or distillate fuel oils. For easy installation, the Model RBS is designed for side-wall mounting. For reliability, the switch has redundant vapor and fluid sealing provisions, is lever float operated and magnetically actuated. External to the containment vessel, the Model RBS is protected with a heavy duty cast aluminum NEMA 4 watertight wiring enclosure.

#### Suggested Specifications

Provide where shown on the drawings a switch for leak sensing on all containment piping within the building. There shall be a switch at the end of each pitched horizontal run. Switches shall integrate with fuel oil management control center. The leak detection switch shall be Preferred Utilities Mfg. Corp., Danbury, CT, Model RBS.



#### Specifications:

|                                |                                                                            |
|--------------------------------|----------------------------------------------------------------------------|
| <b>Mounting:</b>               | 1/2" NPT                                                                   |
| <b>Insertion Depth:</b>        | 3 1/2" Nominal                                                             |
| <b>Fluids:</b>                 | Water, light fuel oils                                                     |
| <b>Fluid Temperature:</b>      | 150° F maximum                                                             |
| <b>Fluid Specific Gravity:</b> | 0.65 minimum                                                               |
| <b>Fluid Pressure:</b>         | 25 PSIG maximum                                                            |
| <b>Electrical:</b>             | 8 VA Pilot Duty @ 120 VAC                                                  |
| <b>Switch Action Can Be:</b>   | SPST-N.C./N.O. (depending on installation orientation - switch shown N.O.) |
| <b>Electrical Housing:</b>     | Cast aluminum, NEMA 4                                                      |
| <b>Wetted Parts:</b>           | Steel and nylon 66                                                         |

#### Ordering Information

Model RBS

*Specifications subject to change without notice.*

## PUMP SET LEAK DETECTOR SWITCH

### Model PS-LDS

The Model PS-LDS pump set leak detection switch detects leakage into the base pan of a pump set. The switch installs easily into a mounting bracket (included) which welds to the side of the pump set base. The switch is activated by a magnetic float.

#### Suggested Specifications

Provide in the pump set containment base a leak sensor to shut off pumps and energize an audible and visual alarm should a leak occur. Switch shall be plasma welded stainless steel float operated and fully contained within the pump set containment base pan for maximum protection from impact damage. Float shall be suitable for temperatures up to 250° F and pressures up to 300 PSIG. Pump set leak detector shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model PS-LDS.

#### Specifications:

|                                |                     |
|--------------------------------|---------------------|
| <b>Switch Action:</b>          | SPST, N.C.          |
| <b>Fluid Temperature:</b>      | 250° F maximum      |
| <b>Fluid Specific Gravity:</b> | 0.75 minimum        |
| <b>Fluid Pressure:</b>         | 300 PSIG maximum    |
| <b>Electrical:</b>             | 50 VA maximum       |
| <b>Electrical Housing:</b>     | Cast aluminum       |
| <b>Wetted Parts:</b>           | All stainless steel |



#### Ordering Information

Model PS-LDS

*Specifications subject to change without notice.*

# GROUND LEVEL SPILL CONTAINER

## Model 1

The Model 1 ground level spill containers are designed to catch any oil which can be spilled when disconnecting the delivery fitting during normal tank filling operations. The spill is prevented from entering the soil near the fill terminal and is allowed to drain directly into the tank. The optional suction hand pump allows removal of the unwanted overflow completely. Each spill container is complete, ready for installation and easily retrofits onto an existing 4" riser pipe. It includes a 4" fill nipple, corrosion resistant lockable fill cap and composite top-seal tight fill adapter. The fill cap meets tamper-proof and liquid-tight regulations. The Model 1 ground level spill container is protected from heavy driveway traffic and surface water by a ramped, drain slotted, cast iron body ring. A flexible bellows construction permits height alignment to grade. The design prevents the transmission of traffic weight to the fill terminal, and accommodates normal tank, concrete or grade settling. The durable heavy duty plastic construction of the assembly below grade section assures years of maintenance free protection. Should the need for soil testing arise, the removable bellows and lower body provide access without costly concrete excavation.



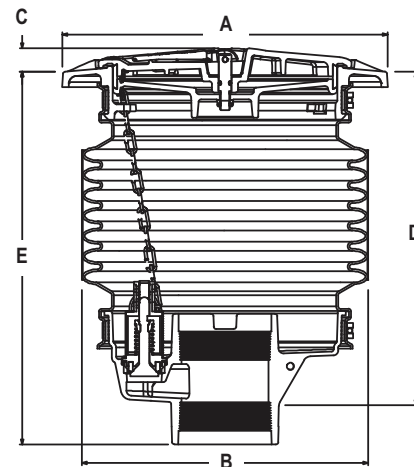
Thread-On Models

|   | 1-05A                           |    | 1-15A                           |    |
|---|---------------------------------|----|---------------------------------|----|
|   | in.                             | cm | in.                             | cm |
| A | 16                              | 40 | 16 <sup>7</sup> / <sub>32</sub> | 41 |
| B | 14 <sup>1</sup> / <sub>16</sub> | 36 | 22                              | 56 |
| C | 1 <sup>5</sup> / <sub>32</sub>  | 3  | 1 <sup>5</sup> / <sub>32</sub>  | 3  |
| D | 16 <sup>3</sup> / <sub>8</sub>  | 42 | 22                              | 56 |
| E | 18 <sup>5</sup> / <sub>16</sub> | 47 |                                 |    |

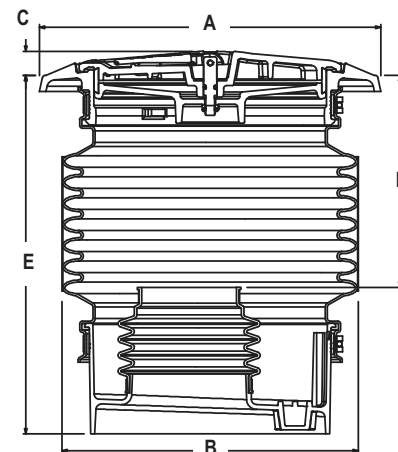
Slip-On Models

|    | 1-05                            |    | 1-15                            |    |
|----|---------------------------------|----|---------------------------------|----|
|    | in.                             | cm | in.                             | cm |
| A  | 16                              | 41 | 16 <sup>7</sup> / <sub>32</sub> | 41 |
| B  | 14                              | 36 | 22                              | 56 |
| C  | 1 <sup>5</sup> / <sub>32</sub>  | 3  | 1 <sup>5</sup> / <sub>32</sub>  | 3  |
| D* | 10 <sup>1</sup> / <sub>16</sub> | 26 | 22                              | 56 |
| E* | 17                              | 43 | 22                              | 56 |

Thread-On Models



Slip-On Models



## GROUND LEVEL SPILL CONTAINER

### Model 1

#### Suggested Specifications

Storage tank fill lines shall terminate in a Preferred Utilities Mfg. Corp., Danbury, CT, Model 1 ground level (\_\_\_ gallon) spill container. The spill container shall include a composite top-seal, tight fill adapter and locking fill cap. To prevent damage from frost heave, normal settling, or roadway traffic, the spill compartment shall incorporate a flexible bellows protected by a ribbed gravel shroud. The noncorrosive resin spill compartment shall be readily removable to allow soil testing directly through the spill container without breaking the concrete. The drain valve shall close with tank pressure to help prevent leakage during tank testing or filling.

#### Specifications:

|                       |                           |
|-----------------------|---------------------------|
| <b>Cover:</b>         | Aluminum                  |
| <b>Body Ring:</b>     | Cast iron, epoxy coated   |
| <b>Bellows:</b>       | Low density polyethylene  |
| <b>Gravel Shroud:</b> | High density polyethylene |
| <b>Lower Body:</b>    | High impact composite     |
| <b>Drain Valve:</b>   | Acetal, polypropylene     |
| <b>Clamps:</b>        | Stainless steel           |
| <b>Seals:</b>         | Buna-N                    |

*Specifications subject to change without notice.*

#### Ordering Information

| Description                                  | Catalog Number |
|----------------------------------------------|----------------|
| 5 gallon, slip on                            | <b>1-05</b>    |
| 5 gallon, thread on with drain               | <b>1-05A</b>   |
| 15 gallon, slip on (NYC Fire Dept. Approved) | <b>1-15</b>    |
| 15 gallon, thread on with drain              | <b>1-15A</b>   |
| Optional hand pump                           | <b>11280</b>   |

## STORAGE TANK MONITOR ACCESS MANHOLE

Model TG-MH-18

The Model TG-MH-18 18" manhole is designed to sit flush on a concrete pad at grade and provide access as required to equipment installed on an underground tank, such as tank gauging and leak detection equipment. Because the manhole is not attached to the tank, it eliminates the possibility that the weight of a vehicle might be transferred to the shell of the tank.

The assembly consists of cast iron body ring, 3/8" steel cover, and a 12" skirt. The bottom is open, allowing water to run off and away from tank monitors or other delicate components. NOTE: The manhole is not designed for access to tank fill pipes.

### Suggested Specifications

Provide a manhole for access to storage tank gauge assembly and leak detection probes. The manhole shall have a 3/8" steel cover, 18" diameter cast iron body ring and a 12" skirt. The box shall provide access to the storage tank monitoring instruments without being attached to the tank, thereby preventing the weight of a vehicle that might be transferred to the fill line or tank. The manhole shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model TG-MH-18.

### Ordering Information

Model: TG-MH-18





## TANK NAME PLATES

The **Preferred** tank name plates are durable 1/8" thick cast-bronze plates with polished 1/16" high raised letters. They are used to permanently identify fill, sounding and vent terminals for underground storage tanks. This is especially important when adjacent tanks contain different liquids. Standard plates are approximately 3" x 6" with 3/4" or 1" letters depending upon the markings used. (Special sizes and markings are available - contact us for information.) Two (2) 1/4" diameter holes are provided for permanent fastening to any flat surface.

### Suggested Specifications

Each storage tank fill, vent and test line terminal shall be suitably identified by a one piece cast bronze nameplate approximately 3" x 6" with polished raised letters as furnished by Preferred Utilities Mfg. Corp., Danbury, CT.



### Ordering Information

Select from the standard markings below:

|                                   |                     |                       |
|-----------------------------------|---------------------|-----------------------|
| Annulus Space                     | Fuel Oil Tank No. 2 | Test Well Tank 3      |
| Diesel                            | Fuel Oil Tank No. 3 | Turbine Oil           |
| Diesel Fill                       | Fuel Oil Tank No. 4 | Unleaded Gasoline     |
| Diesel Fuel                       | Gasoline            | Vapor Recovery        |
| Diesel Fuel Fill                  | Gasoline Fill       | Vapor Return          |
| Diesel Fuel Sounding              | Heating Fuel        | Vent                  |
| Diesel Oil                        | Heating Oil         | Vent #1               |
| Diesel Oil Fill                   | Heavy Oil           | Vent #2               |
| Diesel Oil Tank No. 1             | Kerosene            | Waste Oil             |
| Diesel Tank No. 1                 | Light Oil           | Waste Oil Do Not Fill |
| Diesel Tank No. 2                 | Manual Transmission | Water                 |
| Diesel Tank No. 3                 | No. 2 Oil           |                       |
| Diesel Tank No. 4                 | No. 2 Fuel Oil      |                       |
| Emergency Gen.                    | No. 6 Fuel Oil      |                       |
| Emergency Gen. Fuel Oil Fill      | Sounding Line       |                       |
| Emergency Gen. Fuel Oil Tank Fill | Tank Fill           |                       |
| Fill-Supply Tank                  | Telltale            |                       |
| Fuel                              | Test                |                       |
| Fuel Oil                          | Test Well           |                       |
| Fuel Oil Fill                     | Test Well Tank 1    |                       |
| Fuel Oil Tank No. 1               | Test Well Tank 2    |                       |

\*Contact factory for non-standard markings.

## WATERTIGHT FLUSH FILL CAPS

Model W

Approved by the New York City Board of Standards and Appeals (Cal. No. 213-35 SA)



The Model W watertight flush fill caps screw onto the threaded end of fill and/ or sounding lines to provide full diameter access to the tank through a watertight terminal. The assembly consists of a rust-resistant, galvanized cast iron body, with a gasket sealed solid bronze cover for a waterproof seal.

### Suggested Specifications

Each storage tank fill and sounding line shall terminate in a galvanized, cast iron fill body with threaded brass cap and oil-treated gasket to make it watertight. Assembly shall be the full size of the pipe and shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model W.

### Ordering Information

Select model number from the table below.

| Catalog Number | Threads | O.D. | Height | Weight   |
|----------------|---------|------|--------|----------|
| 11830          | 2"      | 3 ½" | 2 ¾"   | 2.2 lbs. |
| A-933          | 3"      | 4 ½" | 2 ¾"   | 3.2 lbs. |
| 11832          | 4"      | 6 ¼" | 2 ½"   | 5.2 lbs. |

*When ordering specify pipe size.*

## WATERTIGHT LOCKING FILL CAPS

Model FF

The Model FF watertight locking fill caps are heavy duty assemblies intended to prevent unauthorized fuel storage tank access when the fill or sounding lines of underground tanks extend above ground level or are under a manhole cover.

The assembly consists of a solid cast iron body with malleable iron hasp. The brass cover is gasketed to provide a waterproof seal. The body threads directly on to the line while the cap threads onto the body. For easy cap removal, with the padlock off, the hasp swings out to become a rugged lever handle.

### Suggested Specifications

Fill and sounding lines shall terminate using a rain-tight, locking fill cap arranged to accommodate a standard padlock. Body shall be cast malleable iron with gasketed, threaded, cast brass cap, equipped with a swing-away cast iron lever handle. Assembly shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model FF.



### Ordering Information

Select Model Number from the table below.

| Catalog Number | Threads | Weight   |
|----------------|---------|----------|
| 13112          | 2"      | 2.5 lbs. |

## BREATHER CAPS

Preferred breather caps provide rugged, maintenance-free terminal protection for breather lines from sumps, reservoirs, expansion tanks and a wide assortment of industrial applications.

The breather caps are made of cast aluminum construction and threaded for standard pipe (except the ¾" and 1" sizes which are supplied with set screws). They are furnished with brass mesh screens that prevent the entry of airborne seeds, dust, bugs, and other contaminants. The screens are removable for inspection and cleaning as they can eventually clog if exposed to an excessively oily or dirty environment. A routine inspection and maintenance program is recommended.

### Suggested Specifications

Sump, reservoir, expansion, or tank breather lines shall be protected by a one piece cast aluminum breather cap with brass mesh screen. Assembly shall be a Preferred Utilities Mfg. Corp., Danbury, CT, breather cap.

### Ordering Information

| Catalog Number | Sizes | Weight   |
|----------------|-------|----------|
| 11888          | ¾"    | 0.2 lbs. |
| 00334          | 1"    | 0.4 lbs. |
| 00333          | 1 ¼"  | 0.5 lbs. |
| 00332          | 2"    | 0.8 lbs. |



## TANK VENT PROTECTOR

Tank Vents Required by NFPA 30 and NFPA 31

The standard tank vent protectors (2" and larger) conform to Standards for the Installation of Oil Burning Equipment (NFPA 31) which governs the installation of fuel oil storage tanks.\*

The standard tank vent protectors are made of cast aluminum or iron and are threaded for standard pipe connection. A wire mesh screen is included. Vent protectors should be the full size of the vent line. NFPA 30 provides guidelines for sizing the vent line based on length of the line and the capacity of the pumps that fill and empty the tank.\*\*

### Suggested Specifications

Fuel oil storage tank vent protector shall be the full size of the vent pipe in accordance with NFPA 30 Flammable and Combustible Liquids Code and NFPA 31 Standard for the Installation of Oil-Burning Equipment. It shall be of cast iron or aluminum construction and provided with standard pipe threads. A standard tank vent protector must be furnished by Preferred Utilities Mfg. Corp., Danbury, CT.



### Ordering Information

Select catalog number from the table below.

| Catalog Number | Size Inches | O.D. Inches | Weight   | MAX. TANK Capacity* | Material |
|----------------|-------------|-------------|----------|---------------------|----------|
| 13115          | 1 ¼         | 2 ¾         | 0.5 lbs. | 500 gals.*          | Iron     |
| 13116          | 1 ½         | 4           | 0.8 lbs. | 3,000 gals.*        | Iron     |
| 11741          | 2           | 4           | 0.8 lbs. | 10,000 gals.**      | Aluminum |
| 11739          | 3           | 5 ¾         | 1.8 lbs. | 35,000 gals.**      | Aluminum |
| 11740          | 4           | 7           | 2.5 lbs. | -----               | Aluminum |

\*NFPA 31 if a tight connected pump is not used for filling.

\*\*NFPA 30 may require a larger vent size depending on pump capacity.

## TANK VENT BRICK

Approved by the New York City Board of Standards and Appeals (Cal. No. 15-36 SA)

The tank vent brick is designed as a terminal for vent lines from storage tanks when the line is run inside the building walls. Such lines are hidden from view and must be protected from damage or vandalism in a manner that does not infringe upon property lines. The face of the tank vent brick is the same 2 1/8" x 8" x 3" measurement as a standard masonry brick and blends into all types of wall construction.

Tank vent bricks are made of a one-piece aluminum casting, weighing three pounds and are available with screwed connections to accept either 2" or 3" pipe.

### Suggested Specifications

Fuel oil vent line, as required by NFPA 30 Flammable and Combustible Liquids Code and NFPA 31 Standard for the Installation of Oil-Burning Equipment, shall terminate in a one piece, cast aluminum tank vent brick, which is to be an integral part of the outer face of the building wall. Tank vent brick shall be furnished by Preferred Utilities Mfg. Corp., Danbury, CT.



### Ordering Information

| Catalog Number | Size | Weight |
|----------------|------|--------|
| 13079          | 2"   | 3 lbs. |
| 13080          | 3"   | 3 lbs. |



## 4" PRESSURE GAUGE

The 4" pressure gauges are bottom connected with sealed stainless steel case and shatter-proof, heat resistant polycarbonate lenses. The rugged Bourdon tube mechanism incorporates a unique spring suspended, brass movement that resists the effects of shock, pulsation and vibration. Additionally, the gauge is equipped with a pulsation dampening orifice and is filled with glycerine to further protect against the harmful effects of vibration and pulsation and to ensure a long and trouble-free life.

The gauges are furnished with bronze Bourdon tube, brass ¼" NPT connection socket, and matte white aluminum scale plate with easy to read black markings and pointer.



### Suggested Specifications

Provide and mount a dial pressure gauge on the discharge side of each pump. Gauges should be selected to provide mid-scale readings under normal operating pressures. Gauges shall be liquid filled to dampen pulsation, with bright finished stainless steel case, brass movement, bronze Bourdon tube, and shall be furnished with a pulsation dampening orifice. Gauges shall be mounted with isolation cocks. Each gauge shall be equipped with an isolation ball valve. Pressure Gauge shall be furnished by Preferred Utilities Mfg. Corp., Danbury, CT.

### Ordering Information

Select model number from the table below.

| Catalog Number | Range                    | Weight   |
|----------------|--------------------------|----------|
| 11131          | 30" mercury; 0 - 15 PSIG | 1.2 lbs. |
| 11135          | 0 - 100 PSIG             | 1.2 lbs. |
| 11136          | 0 - 160 PSIG             | 1.2 lbs. |
| 11137          | 0 - 200 PSIG             | 1.2 lbs. |
| 11138          | 0 - 300 PSIG             | 1.2 lbs. |

## 2.5" PRESSURE GAUGE

The 2.5" pressure gauges are bottom connected with satin black steel case and shatterproof, heat resistant polycarbonate lenses. The rugged Bourdon tube mechanism incorporates a unique spring suspended, brass movement that resists the effects of shock, pulsation and vibration.

The gauges are furnished with bronze Bourdon tube, brass ¼" NPT connection socket, and matte white aluminum scale plate with easy to read black markings and pointer.

### Suggested Specifications

Provide and mount a dial pressure gauge on the discharge side of each pump. Gauges should be selected to provide mid scale readings under normal operating pressures. Gauge mechanism shall be spring suspended to resist the effect of shocks and pulsations. Gauges shall be mounted with isolation cocks. Each gauge shall be equipped with an isolation ball valve. Pressure gauge shall be furnished by Preferred Utilities Mfg. Corp., Danbury, CT.



### Ordering Information

Select model number from the table below.

| Catalog Number | Range                    | Weight   |
|----------------|--------------------------|----------|
| 11754          | 30" mercury; 0 - 15 PSIG | 0.3 lbs. |
| 11755          | 0 - 100 PSIG             | 0.3 lbs. |
| 11756          | 0 - 200 PSIG             | 0.3 lbs. |
| 11877          | 0 - 300 PSIG             | 0.3 lbs. |

## OIL THERMOMETER

The oil thermometer has a white dial with highly visible black numbers and pointer. The case is of welded stainless steel construction and is hermetically sealed to prevent the entrance of damaging moisture. This virtually eliminates obscuring "fog" on the glass face.

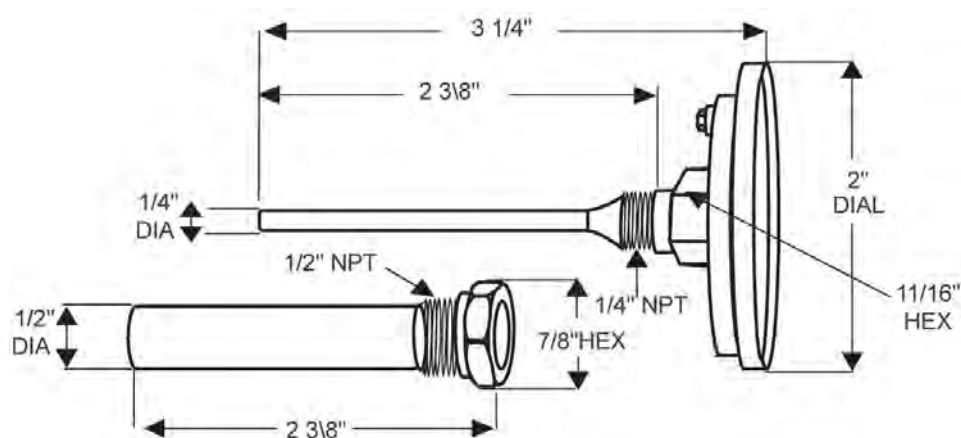
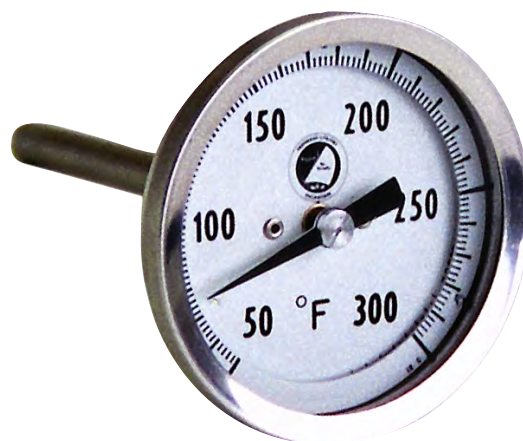
The bimetal overall construction of the Preferred oil thermometer provides a back mounted 2" stem with 1/2" NPT male threaded connection. The gauge is calibrated from +50° to +300° F with a 1% full span accuracy. Good practice requires the use of a thermowell on any application where temperature plays a role in overall operating performance. This includes pressurized applications where temperature can influence fluid expansion.

### Suggested Specifications

Provide and mount a dial thermometer at the inlet and outlet of each heater. Gauge shall have a 2" white dial with a stainless steel, hermetically sealed construction, and matching thermowell. Gauge shall be calibrated from 50° to 300° F and be furnished by Preferred Utilities Mfg. Corp., Danbury, CT.

### Ordering Information

| Description         | Catalog Number | Weight   |
|---------------------|----------------|----------|
| Oil Thermometer     | <b>11638</b>   | 0.3 lbs. |
| Matching Thermowell | <b>8187</b>    | 0.2 lbs. |



## OVERFILL PREVENTION VALVE

### Model 71 for Underground Gravity Filled Storage Tank

The Model 71 overfill prevention valve provides a mechanical method of automatic fuel oil shut-off to prevent overfilling of underground storage tanks during a gravity filled delivery as required by NFPA 30 Flammable and Combustible Liquid Code. It is designed to satisfy EPA regulations covering overfill protection, "a device that will automatically shut off the flow of oil into the tank when the tank is no more than 95% full."\* It is recommended to be installed with a Preferred Fil-A-Larm system, which provides a pre-alert audible/visual alarm and shut-off notification to the fill operator, prior to the actuation of the Model 71.

#### Application

The Model 71 is used for underground diesel or No. 2 fuel oil storage tanks where the tank is gravity filled (i.e. not applicable to "pumped-in fill" applications). The overfill prevention valve includes upper and lower drop tube sections. The upper section is flared, rests on the top of a 4" fill pipe, and is secured in place by the tight fill adaptor. The lower drop tube section extends into the tank and is cut off at either 6 inches from the tank bottom, or at the dimension required by local codes. The overfill prevention valve is installed between the drop tube sections. The valve can be installed from outside the tank without excavation (installation is as easy as changing drop tubes).

**Please Note:** On existing tanks, the drop tube may be held in the tank coupling below the riser pipe. On these installations, the existing drop tube must be removed to accommodate valve operation.

#### Operation

The overfill prevention valve is a float-operated, two-stage shut-off valve system. It is installed as an integral part of a 4" drop tube assembly. When the fuel oil level increases to approximately 95% of tank capacity, the main valve closes. A small bypass valve remains open to permit delivery hose draining at a rate of approximately 2-5 GPM. If the oil level reaches 98% of tank capacity, the bypass valve closes to prevent accidental or intentional overfilling.

**Please Note:** The overfill prevention valve is used with "gravity fill" systems only, and is not intended for "pumped-in fill" applications. It is for diesel or No. 2 fuel oil only.



Model 71, Overfill Prevention Valve

#### Suggested Specifications

Provide and install, in the tank fill pipe, a Preferred Utilities Mfg. Corp., Danbury, CT, Model 71 Overfill Prevention Valve system. The unit shall have a float-operated, two-stage valve system. The main valve shall shut-off at approximately 95% of the tank capacity leaving a small bypass valve open to permit the hose to drain. At approximately 98% of tank capacity, the bypass valve will close completely to shut off all flow.

#### Specifications

|                                    |                                     |
|------------------------------------|-------------------------------------|
| <b>Valve Body:</b>                 | Cast aluminum                       |
| <b>Float:</b>                      | Nitrile rubber,<br>Closed cell foam |
| <b>Valve:</b>                      | Aluminum                            |
| <b>Seals:</b>                      | Viton                               |
| <b>Upper and Lower Drop Tubes:</b> | Aluminum                            |

#### Ordering Information

Preferred overfill prevention valve:  
Model 71 for tanks buried to 5' of depth, with a maximum inside tank diameter of 8'  
Model 71-L for tanks buried to 9' of depth, with a maximum inside tank diameter of 10'

(EPA, Fed. Reg. 9/23/88.)

*Specifications subject to change without notice.*

## OVERFILL PREVENTION VALVE

### Model 61F-Stop for Aboveground Pumped-In Storage Tank

The Model 61F-Stop overflow prevention valve provides a mechanical method of positive fuel oil shut-off to prevent overfilling of above ground storage tanks during a pressurized fill (pump-in fill) delivery. "The stopper" threads into the fill opening and is an integral part of the fill tube. The Preferred 61F-Stop is fully adjustable to allow for easy installation in new or existing aboveground tanks of various heights and storage capacities.

#### Operation

The stopper is a single-action, complete shut-off valve. When the liquid level rises to the specified tank capacity, the valve mechanism is released and automatically stops the flow of the product. Any excess product left between the valve and the fuel delivery coupler is drained into the tank through internal drain vents. The drain vents on the 61F-Stop act as an anti-siphon device, by introducing air/vapor into the fill line and thereby preventing the tank from being exposed to a siphon condition, resulting from a broken or leaking fill pipe. Minimum flow of 25 GPM is required for valve to function properly.

#### Suggested Specifications

Provide and install in the tank fill pipe a Preferred Utilities Mfg. Corp., Danbury, CT, Model 61F-Stop overflow prevention valve system. The unit shall have a float-operated, two-stage valve system. The main valve shall shut-off at approximately 95% of the tank capacity, leaving a small bypass valve open to permit the hose to drain. At 5" above main valve shut-off, the bypass valve will close completely to shut off all flow.

#### Specifications

|                    |                            |
|--------------------|----------------------------|
| <b>Valve Body:</b> | Cast aluminum              |
| <b>Float:</b>      | Closed-cell Buna-N         |
| <b>Poppet:</b>     | Cast aluminum, hard coated |
| <b>Cam:</b>        | Stainless steel            |
| <b>Follower:</b>   | Brass                      |
| <b>Shaft:</b>      | CRS zinc plated            |
| <b>Bearing:</b>    | Sintered bronze            |

#### Ordering Information

Model 61F-Stop for above ground "pumped in" storage tanks.



Model 61F-Stop, Overflow Prevention Valve

*Specifications subject to change without notice.*



## FUSOMATIC GLOBE / GATE VALVE

Approved by the Massachusetts Department of Public Safety

Preferred Fusomatic globe and gate valves are designed to meet NFPA 31 Standard for the Installation of Oil Burning Equipment for automatic closing of oil supply lines in case of fire. The valve includes a spring and a replaceable fusible element that melts at 165° F allowing the valve to close tightly. It may also be manually opened and closed. The ½" and ¾" sizes are **globe** valves, suitable for lighter grades of fuel oil. The 1" size is a **gate** valve, suitable for heavier grades of oil.

### Application

The Fusomatic valve is designed to be located in a horizontal pipe run at each point of use or where dictated by code.

The Preferred Fusomatic valve is designed not to restrict the capacity of the oil suction line. This feature is especially important when applied to the heavier grades of fuel oil on larger installations. The UL listed ½" and ¾" sizes are globe valves suitable for lighter grades of fuel oil. For lines larger than 1" use the Model 110 lever gate valves.

### Suggested Specifications

Furnish and install, where shown on contract drawings a quick-closing, spring-loaded and thermally-actuated fusible element that melts at 165° F causing the valve to close tightly. The valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Fusomatic globe/gate valve.



*Fusomatic Gate Valve*

### Ordering Information

| Catalog Number | Size | Replacement Hand Wheel | Weight   |
|----------------|------|------------------------|----------|
| 13362          | ½"   | 13086                  | 0.6 lbs. |
| 13081          | ¾"   | 13086                  | 0.9 lbs. |
| 13082          | 1"   | 13087                  | 2.2 lbs  |

## FUSOMATIC ELECTRIC CUT-OFF SWITCH

Approved by Massachusetts Department of Public Safety & Underwriters Laboratories Inc.

The Fusomatic electric cut-off switch is a thermally actuated safety switch used in combustion installations. As required by many codes, it automatically breaks the burner control circuit in the event of a fire.

### Application

The Fusomatic electric cutoff switch is installed on a 3 ¼" or 4" round junction box located in the area(s) to be temperature monitored. Wired in series with the burner control circuit, a temperature rise to 165° F melts the fusible element to open the contacts and stop burner firing. The switch is rated 9.8 A, ½ HP @ 120 VAC.

### Suggested Specifications

Furnish and install where shown on contract drawings a thermally-actuated fusible element safety switch. Install the switch into a 3 ¼" or 4" round junction box and wire into the burner control circuit. In the event the ambient temperature rises above 165° F the fusible element melts to open the contact and stop the burner firing. The fusible element safety switch shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Fusomatic electric cut-off switch.



### Ordering Information

| Catalog Number | Weight   |
|----------------|----------|
| 13083          | 0.5 lbs. |

## OIL LEVER GATE VALVE

### Model 110 Fire Safety Fuel Shut-off Valve

The Model 110 Oil Lever Gate Valve is used in fuel oil piping systems to provide automatic shut-off of the fuel flow in the event of a fire. Valve operation is fully mechanical and is independent of the electrical power supply. The emergency fuel line shut-off is mandated by many local codes.

The assembly consists of a 125 lb. screwed, full-ported, bronze body and disc, lever-operated, quick-closing mechanism with zinc plated malleable iron lever, cadmium-plated steel spring, hand-lapped seats and discs, and an extra long stem packing to avoid suction line air leaks. Standard installation kit includes a 25' coil of wire and two (2) 165° F fusible links. Additional links and longer wire are available upon request. The valve can also be equipped with an automatic fuel shut-off limit switch assembly. This switch is then wired to the fuel oil management system to provide "fire" and "loss of fuel supply" alarms and interlock fuel oil pump set operation.

#### Application

The Model 110 oil lever gate valve is designed to be located in a horizontal pipe run where the oil supply enters the building, and/or at each point of use, or where dictated by code. Install the trip wire with the fusible link(s) in the area(s) to be monitored for excess temperature.

#### Operation

The precision ground metal gate is lever operated with a quarter turn required for opening or closing. The valve is held open by a stretched wire containing one or more fusible links. When the temperature at any fusible link rises above 165° F, the link will melt and the tension of the integral spring will close the valve. NOTE: on applications utilizing long wire runs with many fusible links, a weight should be added to ensure that the valve will close reliably and quickly.

#### Testing

As with any piece of safety equipment, the lever gate valve should be tested upon completion of installation and regularly thereafter to ensure that it will close in the event of excess temperatures. Ideally, the link furthest from the valve would be heated with a small flame until the link melts. If the valve does not snap closed properly, the wire should be checked for freedom of movement, and the mechanism of the valve should be checked for free operation. The valve may need to be cleaned and repacked with a Teflon packing or an additional weight may need to be added.

#### Suggested Specifications

Provide and install, where shown in the fuel oil supply line, a quick-closing, spring-loaded, lever gate valve held open by a wire with fusible link arranged so that the valve will automatically close if the link melts. The valve must be equipped with an automatic fuel shut-off limit switch assembly. Switch assembly shall be wired to the fuel oil management system to provide "fire" and "loss of fuel



Model 110 Lever Gate Valve

supply" alarms and interlock fuel oil pump set operation. The valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT, model 110 oil lever gate valve with an automatic fuel shut-off limit switch assembly.

#### Ordering Information

Includes 25' cable & two (2) fusible links

| Catalog Number | Size                  | Weight (lbs.) |
|----------------|-----------------------|---------------|
| 011892         | 1"                    | 3.4           |
| 011879         | 1 ¼"                  | 4.9           |
| 011880         | 1 ½"                  | 7.6           |
| 011881         | 2"                    | 9.4           |
| 011882         | 3"                    | 22.5          |
| add -S         | Limit Switch Assembly | 2             |
| 13088          | Extra Cable/Link Kit  | 1             |
| 13084          | Extra Link            | 0.5           |

## FIRE SAFETY OIL SHUT-OFF VALVE

Model 119-O

The Model 119-O fire safety oil shut-off valve combines an API rated oil shutoff valve with a fusible link for an FM approved fire safety valve assembly for fuel oil applications.

The assembly consists of an API 607 certified full port three-piece ball valve, ATEX approved spring pack, and 165° F fusible link

### Application

The Model 119-O may be used in any oil fueling system to ensure positive oil shutoff in the event of a fire. This includes boiler rooms, diesel generator rooms, tank farms, refineries, and chemical plants. It must be installed in a horizontal run of pipe with the spring pack pointed upward.

### Operation

Each valve is shipped with a red protective safety link that must be removed prior to putting the valve into operation. A hand lever or wheel is provided to manually close the valve regardless of the action of the spring pack. Once put into operation, the valve is held open against the torque of the spring pack by the fusible link. If subjected to temperatures greater than 165° F the fusible link melts and the valve slams closed.

### Suggested Specifications

Provide and install, where shown on the contract drawings, an FM approved oil fire safety valve. The assembly shall consist of an API 607 certified ball valve, spring pack and 165° F fusible line. The entire shutoff valve assembly shall be F.M. approved for oil service. The fire safety oil shutoff valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT Model 119-O.

### Specifications

|                         |                                                                |
|-------------------------|----------------------------------------------------------------|
| <b>Valve Body:</b>      | Carbon steel                                                   |
| <b>Ball &amp; Stem:</b> | 316 stainless steel                                            |
| <b>Seats:</b>           | RTFE/stainless                                                 |
| <b>Spring Pack:</b>     | Corrosion resistant<br>zinc alloy with epoxy<br>enamel coating |

Note: Stainless steel body valves and higher temperature fusible links are available upon request

### Ordering Information

Select catalog number from the table.

| Catalog Number | Pipe Size | H      | L     |
|----------------|-----------|--------|-------|
| 11964-.5       | ½" NPT    | 6.25"  | 2.95" |
| 11964-.75      | ¾" NPT    | 6.50"  | 3.14" |
| 11964-1        | 1" NPT    | 7.13"  | 3.54" |
| 11964-1.25     | 1 ¼" NPT  | 10.25" | 4.33" |
| 11964-1.5      | 1 ½" NPT  | 10.63" | 4.72" |
| 11964-2        | 2" NPT    | 11.69" | 5.51" |
| 11964-2.5F     | 2 ½" FLG  | 19.04" | 7.50" |
| 11964-3F       | 3" FLG    | 19.75" | 8.00" |



Model 119-O Oil Fire Safety Valve with manual fuel oil shut-off lever



Model 119-O Oil Fire Safety Valve with handwheel for manually closing the oil valve



# FIRE SAFETY GAS SHUT-OFF VALVE

## Model 110-G

The Model 110-G Fire Safety Gas Shut-off Valve is used in gas piping systems to provide automatic shut-off of gas flow in the event of a fire. The valve operates mechanically and independently. Many codes mandate emergency fuel line shut off.

The assembly consists of an aluminum bodied valve rated to 50 PSI with aluminum bonnet, zinc plated brass adapter and 303 stainless steel stem. Standard installation kit includes 25' coil of wire and two (2) 165° F fusible links. Additional links and longer wire are available upon request. Maximum pressure differential is 5 PSI.

### Application

The Model 110-G may be used in any gas flow application by locating the valve in a horizontal pipe run where the gas supply enters the building. Install the trip wire with the fusible link located in the area to be monitored for excessive temperature.

### Operation

The valve is held open by a stretched wire containing a fusible link. When the temperature rises above 165° F, the link will melt and the tension of the internal spring closes the valve.

### Testing

As with any piece of safety equipment, the gas shut-off valve should be tested upon completion of installation and regularly thereafter to ensure that the valve will close in the event of excessive temperature at the fusible link. Ideally, the link would be heated with a small flame until the link melts. The valve should snap closed immediately. If the valves not close properly, the wire should be checked for freedom of movement, and the mechanism of the valve should be checked for free operation.

### Suggested Specifications

Provide and install, where shown in the gas supply line, a quick-closing, spring-loaded, fire safety gas shut-off valve held open by a wire with a 165° F fusible link arranged so that the valve will automatically close if the link melts. The fire safety gas shutoff valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT Model 110-G

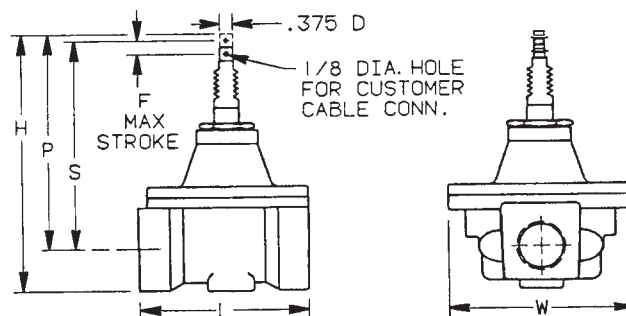
### Specifications

**Valve Body & Bonnet:** Aluminum  
**Adapter:** Zinc plated brass  
**Stem:** 303 stainless steel  
**Safe Working Pressure:** 50 PSI  
**Max Pressure Differential:** 5 PSI

*Specifications subject to change without notice.*



Model 110-G, Fire Safety Gas Shut-Off Valve



### Ordering Information

Select Catalog Number from the table.  
 Includes 25' cable & two (2) fusible links

| Catalog Number | NPT                  | F     | H       | L       | P       | S       | W       | CV  |
|----------------|----------------------|-------|---------|---------|---------|---------|---------|-----|
| 011745         | 1/2                  | 3/16  | 4 3/8   | 2 3/4   | 3 13/16 | 3 9/16  | 7 61/64 | 5.2 |
| 011746         | 3/4                  | 3/16  | 4 13/16 | 3 5/16  | 4       | 3 3/4   | 2 23/64 | 6.5 |
| 011747         | 1                    | 17/32 | 7 5/32  | 5       | 5 27/32 | 5 19/32 | 2 11/32 | 23  |
| 011748         | 1 1/4                | 17/32 | 7 5/32  | 5       | 5 27/32 | 5 19/32 | 5 3/8   | 34  |
| 011749         | 1 1/2                | 17/32 | 7 5/32  | 5       | 5 51/64 | 5 21/32 | 5 3/8   | 38  |
| 011750         | 2                    | 39/64 | 7 3/4   | 6 3/32  | 6 1/4   | 6       | 5 3/8   | 54  |
| 011751         | 2 1/2                | 29/32 | 9 61/64 | 7 51/64 | 7 5/8   | 7 3/8   | 6 5/16  | 110 |
| 011752         | 3                    | 29/32 | 9 61/64 | 7 25/32 | 7 5/8   | 3 9/16  | 7 61/64 | 138 |
| 13084          | Extra Link           |       |         |         |         |         |         | .5  |
| 13088          | Extra Cable/Link Kit |       |         |         |         |         |         | 1   |



## ANTI-SYPHON VALVE

Model A

UL Listed; Approved by the NYC Board of Standards and Appeals (Cal. No. 192-34-SA)

The Model A Anti-Syphon Valve reduces fire hazards and prevents oil spills caused by oil being siphoned from the storage tank onto the boiler room floor. The valve automatically shuts off the oil flow in case of a broken or inadvertently left open oil suction line as required by NFPA 30 Flammable and Combustible Liquids Code. This protection is required by many codes and is recommended on all installations where the highest level of oil in storage is above the boiler room floor.

The assembly consists of a heavy bronze body with oil-proof gasketing, spring-loaded poppet, composition seat and dashpot. Tight shutoff is assured by the resilient seat material. The dashpot provides smooth, quiet operation. For positive action, the valve is furnished for various hydrostatic heads: up to 5', 5-10', 10-15', and 15-20' (as measured vertically from the top of the tank to the pump inlet). Suction lines may be tested for tightness under reasonable pressure without damage to the seat. Maximum oil grades for these valves are as follows:  $\frac{3}{8}$ " and  $\frac{1}{2}$ " valves for No. 2 oil only,  $\frac{3}{4}$ " for No. 2 or No. 4 oil only and the 1" through 3" for all grades of fuel oil including No. 6.

### Application

The Anti-Syphon Valve is installed in a vertical position at the highest point in the suction line with no part of the line between the valve and the tank below the maximum oil storage level. Although suitable for outdoor installation, consideration should be given to the possibility that moisture entrained in the oil might freeze in the valve and immobilize the poppet. Complete instructions are furnished with each valve.

### Operation

In the nonflow mode, spring pressure holds the valve poppet closed against the hydrostatic head. When flow is required, an additional vacuum is created by the oil pump, lifting the poppet and opening the valve. Since the total downstream pressure of the hydrostatic head plus the pump suction is required to lift and hold open the poppet, an opening in the suction line will dissipate the vacuum, close the valve and prevent an oil siphoning effect. Valve closure will be positive regardless of whether or not the pump is in operation.

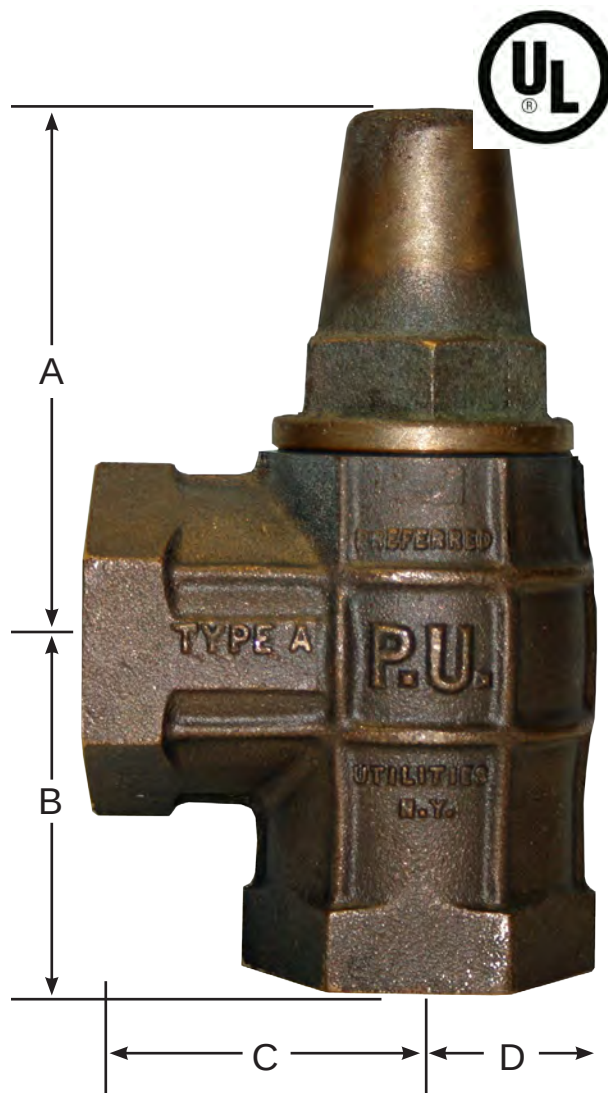
### Approvals

UL Listed

New York City Board of Standards and Appeals (Cal. No. 192-34-SA)

### Suggested Specifications

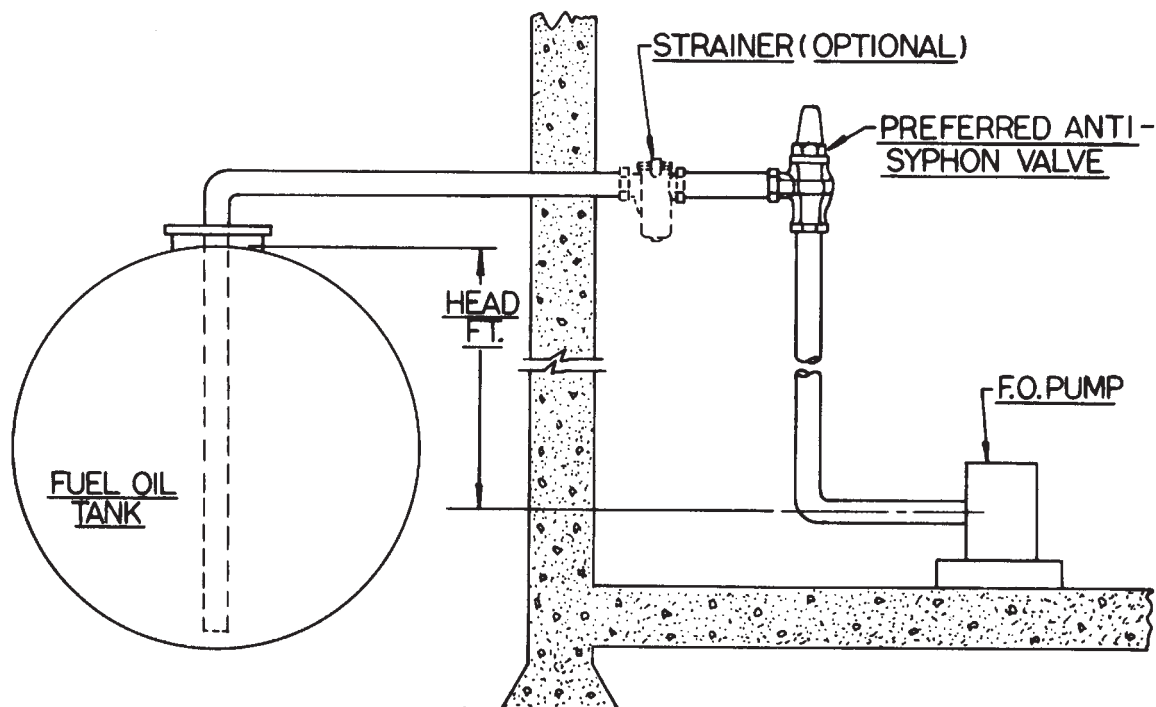
Furnish and install inside the building, at the high point of the oil suction line, from each fuel oil tank, a U.L. listed and labeled Anti-Syphon Valve per NFPA 30 Flammable



and Combustible Liquids Code. Valves that do not have a Underwriters Laboratory certification, listing and label and do not conform to local, state and federal fire codes shall not be acceptable. The installing contractor shall assume all liability for the installation of this valve and shall certify to the consulting engineer that a U.L. tested and labeled anti-syphon valve has been supplied and installed per manufacturer's instructions. Anti-Syphon valves supplied without a U.L. label shall be removed and a U.L. certified valve installed at the contractor's expense. The valve shall be sized to meet the flow requirements of the system and piping and shall be equipped with a spring to match the vertical distance between the highest oil storage level, of the main tank, and the inlet to the fuel oil pumps. Valve shall be as manufactured by Preferred Utilities Mfg. Corp. Danbury, CT, **Model A Anti-Syphon Valve.**

# ANTI-SYPHON VALVE

Model A



## Ordering Information

See table below.

| Model Numbers |       |       |       | Size | Grade Oil | Capacity<br>GPH | Weight<br>(lbs.) | Dimensions (inches) |     |     |     |
|---------------|-------|-------|-------|------|-----------|-----------------|------------------|---------------------|-----|-----|-----|
| Head Size     |       |       |       |      |           |                 |                  | A                   | B   | C   | D   |
| 5'            | 10'   | 15'   | 20'   |      |           |                 |                  |                     |     |     |     |
| A-270         | A-271 | A-272 | A-273 | ⅜"   | 2         | 30              | 2                | 2 ½                 | 1 ½ | 1 ⅞ | 1 ¼ |
| A-274         | A-275 | A-276 | A-277 | ½"   | 2         | 30              | 2                | 2 ½                 | 1 ½ | 1 ⅞ | 1 ¼ |
| A-278         | A-279 | A-280 | A-281 | ¾"   | 4         | 100             | 2.4              | 3 ⅜                 | 1 ¾ | 1 ¾ | 1 ½ |
| A-305         | A-306 | A-307 | A-308 | 1"   | 6         | 300             | 10               | 5                   | 3 ⅞ | 3 ⅞ | 1 ⅝ |
| A-302         | A-283 | A-284 | A-285 | 1 ¼" | 6         | 300             | 10               | 5                   | 3 ⅞ | 3 ⅞ | 1 ⅝ |
| A-303         | A-287 | A-288 | A-289 | 1 ½" | 6         | 300             | 9.5              | 5                   | 3 ⅞ | 3 ⅞ | 1 ⅝ |
| A-304         | A-291 | A-292 | A-293 | 2"   | 6         | 300             | 8.2              | 5                   | 3 ⅞ | 3 ⅞ | 1 ⅝ |
| A-294         | A-295 | A-296 | A-297 | 2 ½" | 6         | 1000            | 26.6             | 7 ½                 | 4 ¼ | 3 ⅞ | 2 ½ |
| A-298         | A-299 | A-300 | A-301 | 3"   | 6         | 1000            | 23.3             | 7 ½                 | 4 ¼ | 3 ⅞ | 2 ½ |

## RELIEF VALVE

### Model R

The Model R Relief Valve is designed to relieve excess pressure in lines containing any grade of fuel oil fulfilling the requirements of NFPA 31 Standard for the Installation of Oil-Burning Equipment. It is also suitable for use with water and air. It opens to relieve at the "set" pressure (adjustable) and closes tightly when the pressure drops. It should be used as a safety device to relieve excess pressure and not as a regulating valve to maintain a constant upstream pressure.

The assembly consists of a bronze body with threaded ends, stainless steel ball, bronze disc, and cadmium plated steel loading spring with bronze spring housing. An adjustment screw protection cap is provided. The valve is suitable for pressures up to 300 PSIG at 300° F maximum.

#### Suggested Specifications

All expansion and pressure relief valves shall be sized and located as shown on project drawings per NFPA 31 Standard for the Installation of Oil-Burning Equipment. Valve bodies shall be one piece bronze construction suitable for pressures up to 300 PSIG. Valves shall be Model R as furnished by Preferred Utilities Mfg. Corp., Danbury, CT, with an adjustable range from \_\_\_\_\_ to \_\_\_\_\_ PSIG.



#### Ordering Information

See table below.

| Catalog Numbers |             |             | Rated Capacity-GPM* |              |              |               |        |
|-----------------|-------------|-------------|---------------------|--------------|--------------|---------------|--------|
| 5-35 PSIG       | 25-100 PSIG | 75-300 PSIG | Size                | 50 PSI Inlet | 70 PSI Inlet | 115 PSI Inlet | Weight |
| 13040           | 13041       | 13042       | ½"                  | 10           | 12           | 15            | 1.5    |
| 13043           | 13044       | 13045       | ¾"                  | 13           | 16           | 21            | 2.0    |
| 11695           | 13046       | 13047       | 1"                  | 17           | 20           | 26            | 3.0    |
| 13048           | 13049       | 13050       | 1 ¼"                | 23           | 28           | 37            | 6.0    |
| 13051           | 13052       | 13053       | 1 ½"                | 30           | 36           | 47            | 8.0    |
| 13054           | 13055       | 13056       | 2"                  | 50           | 60           | 79            | 10     |
| 13057           | 13058       | 13059       | 2 ½"                | 67           | 80           | 105           | 18     |
| 13128           | 13129       | 13130       | 3"                  | 94           | 112          | 147           | 25     |

\*Flow based on water at a 5 PSIG outlet pressure. Oil flow correction factors: 50 SSU-flow x 0.86; 200 SSU-flow x 0.71; 2000 SSU-flow x 0.51

## VACUUM BREAKER

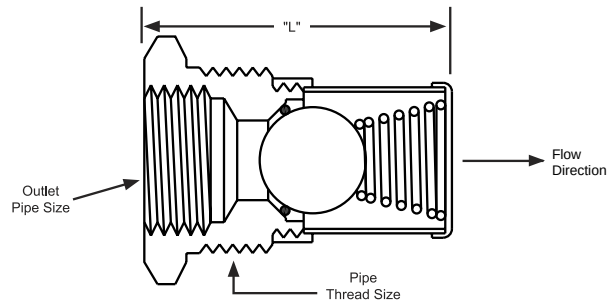
### Model VB

The Model VB Vacuum Breaker Valve provides a simple, dependable means to relieve unwanted vacuum that may develop in a closed piping system or vessel. Some fuel oil loop systems can develop a siphoning effect caused by fuel oil returning to a fuel oil storage tank from a non-vented fuel oil supply header. The valve installs directly into the riser line located at the lowest pressure point of the fuel oil return line and admits air before oil can begin to be siphoned.

The Model VB assembly consists of a brass body with threaded ends, stainless steel ball and EPN "O" ring seat. The successful combination of spring action, round ball and a soft resilient seat provides positive bubble-tight closing, even at very low differential pressure. And, of course, the higher the pressure the tighter the seal. The device is suitable for pressures up to 300 PSIG and 365° F and opens to relieve unwanted pressure with less than 2" Hg.

#### Suggested Specifications

Furnish and install a Vacuum Breaker Valve into a riser line as shown on the contract drawings. The valve shall prevent excessive vacuums that can disrupt fuel system operation or damage equipment. The valve shall automatically open to admit air when an unwanted vacuum develops. Provide and install a Preferred Standard Vent Protector to prevent water and debris from entering the riser. The valve shall be a Preferred Utilities Mfg. Corp. Danbury, CT, Model VB Vacuum Breaker Valve.



#### Ordering Information

See table below for model numbers and sizes

| Model Number | Pipe Thread Size | Outlet Pipe Size | "L" Length | Weight (lbs.) |
|--------------|------------------|------------------|------------|---------------|
| 11829        | ½"               | 3/8"             | 1 3/8"     | 0.2           |
| 11826        | ¾"               | ½"               | 2 1/8"     | 0.3           |
| 11827        | 1"               | ¾"               | 2 3/8"     | 0.5           |
| 11864        | 1 ¼"             | 1"               | 2 5/16"    | 0.8           |
| 11828        | 1 ½"             | 1 ¼"             | 3 1/16"    | 0.9           |

## SINGLE POPPET FOOT VALVE

Model 60

The Model 60 Single Poppet Foot Valve is designed to keep the suction line to the pump set primed by preventing the flow of oil back into the tank when the pumps are not in operation. Check valves mounted above the tank cannot provide an equal degree of protection against loss of prime. Pump life is shortened and reliable performance is lost if the suction piping drains during periods when pumps are inoperative.

All single poppet foot valves have unleaded bronze bodies and are designed to be capable of high flow rates with minimal head loss. All components are carefully manufactured to provide long dependable, maintenance free operation with light oils through No. 4 oil. Each foot valve includes a basket style inlet strainer. The ½" foot valve basket strainer is made of polyethylene while the ¾" through 3" basket strainers are made of stainless steel. For heavier oils it is recommended that a high quality angle check be installed at the top of the tank to help prevent loss of pump prime.

### Suggested Specifications

Provide and install at the bottom of the tank suction stub a fully automatic foot valve suited for service in which drip tight shutoff is required. The body shall be constructed of unleaded bronze with a spring loaded poppet assembly. The foot valve shall be complete with an inlet basket style strainer with a minimum open area ratio of 3 to 1 versus the nominal pipe size. The foot valve shall be rated for a minimum of 150 PSI and shall be a Preferred Utilities Mfg. Corp. Danbury, CT Model 60.



### Ordering Information

Select the catalog number from the table below

| Catalog Number | Size | O.D.                             | Height  | Weight   |
|----------------|------|----------------------------------|---------|----------|
| 13060          | ½"   | 1 <sup>3</sup> / <sub>16</sub> " | 2 1/2"  | 0.2 lbs. |
| 13061          | ¾"   | 1 1/2"                           | 3 1/2"  | 0.3 lbs. |
| 13062          | 1"   | 1 15/16"                         | 5"      | 0.8 lbs. |
| 13063          | 1 ¼" | 2 1/4"                           | 5 1/16" | 1.0 lbs. |
| 13064          | 1 ½" | 2 5/8"                           | 5 1/2"  | 1.6 lbs. |
| 13065          | 2"   | 3 1/16"                          | 5 5/8"  | 2.1 lbs. |
| 13066          | 3"   | 4 5/8"                           | 9 1/2"  | 11 lbs.  |

Fuel Specialties

## DOUBLE POPPET FOOT VALVE

Model 22

The Model 22 Double Poppet Foot Valve provides double protection against the loss of pump prime. The valves have long wearing metal to metal seating with flat poppets that close on sharp, raised seats. The poppets and seats are lapped-in for tight closure. The poppets are stem guided for positive alignment. To allow servicing of foot valves, refer to the 233-FV Foot Valve Extractor Fitting.

All Double Poppet Foot Valves have bronze body and poppet to provide long dependable service with light oils through #4 fuel oil. Each foot valve includes a 20 mesh monel screen and is rated for 34' maximum hydrostatic head pressure.

### Suggested Specifications

Provide and install at the bottom of the tank suction a double poppet foot valve of bronze construction, with lapped-in seats, flat poppets and 20 mesh monel screen. The valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model 22 (add -2 for 2" size) Double Poppet Foot Valves.



### Ordering Information

Select the catalog number from the table below

| Catalog Number | Size | O.D.     | Height | Weight   |
|----------------|------|----------|--------|----------|
| 22-.75         | ¾"   | 2"       | 2"     | 1.2 lbs  |
| 22-1           | 1"   | 2 1/8 "  | 4 3/8" | 1.9 lbs  |
| 22             | 1 ½" | 2 11/16" | 6"     | 4.3 lbs. |
| 22-2           | 2"   | 3 ¾"     | 6 5/8" | 6.3 lbs. |

*Specifications subject to change without notice.*



# FOOT VALVE EXTRACTOR FITTING

Model 233-FV

The Model 233-FV Foot Valve Extractor Fitting permits easy removal and reinstallation of the Model 22 Double Poppet Foot Valves or Model 900 Single Poppet Foot Valves sizes smaller than 1½". The removable access cap is gasket sealed to prevent loss of prime due to air leakage.

## Suggested Specifications

Furnish and install at the tank suction stub exit the Model 233-FV Foot Valve Extractor Fitting. If the riser pipe is extended to grade, protect the installation with a Preferred Utilities Mfg. Corp. 4" Model W Watertight Fill Box. The foot valve extractor fitting shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Model 233-FV.



## Specifications

- Bottom Thread:** 4" NPT for connection to tank entrance fitting
- Top Thread:** 4" for a riser pipe to grade (if required)
- Inlet:** 1½" NPT suction stub
- Outlet:** 1½" NPT
- Maximum clear I.D. through the valve:** 2 ⅞"

## Ordering Information

Foot Valve Extractor Fitting: 233-FV: (1 ½")  
Preferred Extractor Wrench: 89 (for 4 feet depth)  
Weight: 20.7 lbs.

# BACK PRESSURE REGULATING VALVE

Model BQ



The Model BQ Back Pressure Regulating Valve is a self-operated, spring-loaded back pressure regulating valve. Typically the Model BQ is installed at the far end of the oil supply line, downstream of the boiler fuel metering valves and passes unburned oil to the return line. Alternately, the Model BQ may be installed upstream of the boiler fuel metering valves. In both cases, the valve passes oil to the return line in order to maintain a constant supply pressure to the fuel metering valves.

The Model BQ is a ½" NPT valve with cast iron body, brass trim, composition disc and neoprene diaphragm. The diaphragm is suitable for use with fluid temperatures up to 200° F. The valve has capacities of 390 GPH for No. 2 or No. 4 oil and 275 GPH for No. 6 oil at a viscosity of 3500 SSU. The Model V Back Pressure Regulating Valve is recommended for higher flow rates.

## Suggested Specifications

Provide and install a Back Pressure Regulating Valve as shown on the contract drawings. The valve shall be a ½" NPT Preferred Utilities Mfg. Corp., Danbury, CT, Model BQ, with adjustable range from \_\_\_\_\_ to \_\_\_\_\_ PSIG, cast iron body, bronze trim and neoprene diaphragm.

## Ordering Information

| Catalog Number | Size | Spring Range PSI | Set Pressure PSI | Weight (lbs.) | Gallons Per Minute |       |       |
|----------------|------|------------------|------------------|---------------|--------------------|-------|-------|
|                |      |                  |                  |               | Oil Viscosity, SSU |       |       |
|                |      |                  |                  |               | 35                 | 300   | 750   |
| 11825          | ½"   | 2 to 30          | 3                | 18.2          | 1.03               | 0.89  | 0.72  |
| 11665          | ½"   | 5 to 15          | 5                | 18.2          | 4.05               | 3.61  | 3.17  |
| 11666          | ½"   | 10 to 25         | 10               | 18.2          | 6.16               | 5.41  | 4.75  |
| 11664          | ½"   | 20 to 75         | 20               | 18.2          | 10.09              | 9     | 8.53  |
| 11667          | ½"   | 65 to 150        | 65               | 18.2          | 14.81              | 13.2  | 11.6  |
| 11668          | ½"   | 140 to 300       | 150              | 18.2          | 21.9               | 19.52 | 17.14 |

## BACK PRESSURE REGULATING VALVE

### Model V

The Model V Back Pressure Regulating Valve is a self-operated, spring-loaded back pressure regulating valve. Typically the Model V is installed at the far end of the oil supply line, down stream of the boiler fuel metering valves and passes unburned oil to the return line. Alternately, the Model V may be installed upstream of the boiler fuel metering valves. In both cases the valve passes oil to the return line in order to maintain a constant supply pressure to the fuel metering valves.

The Model V is a 1" NPT, 250 lb. cast iron body, balanced-cage, hardened and polished stainless steel trim. The 30 to 150 PSI range valve has a Teflon seat and stainless steel diaphragm while other ranges have Viton seats and six (6) ply Teflon composition diaphragms for increased responsiveness. The valve capacities are shown in the table below.

#### Suggested Specifications

Provide and install a Back Pressure Regulating Valve as shown on the contract drawings. The valve shall be a 1" NPT Preferred Utilities Mfg. Corp., Danbury, CT, Model V. The valve shall be diaphragm-operated with 250 lb cast iron body, hardened stainless steel trim with an adjustable spring range from \_\_\_\_\_ to \_\_\_\_\_ PSIG.

#### Ordering Information

Select catalog number from the table below.

| Catalog Number | Size | Spring Range PSI | Set Pressure PSI | Weight (lbs.) | Gallons per hour   |      |          |
|----------------|------|------------------|------------------|---------------|--------------------|------|----------|
|                |      |                  |                  |               | Oil Viscosity, SSU |      |          |
|                |      |                  |                  |               | 35                 | 300  | 750      |
| 12784          | 1"   | 1 to 5           | 3                | 28.3          | 300                | 750  | not rec. |
| 12763          | 1"   | 5 to 20          | 15               | 28.3          | 1500               | 1250 | 1000     |
| 12764          | 1"   | 20 to 80         | 50               | 28.3          | 1350               | 1100 | 900      |
| 12765          | 1"   | 30 to 150        | 100              | 28.3          | 2500               | 2000 | 1750     |
| 12765          | 1"   | 30 to 150        | 125              | 28.3          | 2800               | 2200 | 1850     |



Model V, Back Pressure Regulating Valve

# PRESSURE REDUCING VALVE

## Model B

The Model B Pressure Reducing Valve is a self-operated spring-loaded pressure regulating valve used for reducing pressure in air, water and oil systems. These valves are commonly found in industrial plants, apartment buildings, water supply systems, schools and underground water distribution systems.

### Suggested Specifications

Provide and install a Pressure Reducing Valve as shown on the contract drawings. The valve shall be a 1" (½") NPT Preferred Utilities Mfg. Corp., Danbury, CT, Model B. The valve shall be diaphragm operated with 250 lb cast iron body, hardened stainless steel trim with an adjustable spring range from \_\_\_\_\_ to \_\_\_\_\_ PSIG.

### Flow Table

| Inlet Pressure (PSI) | Outlet Pressure (PSI) | Gallons per hour |      |
|----------------------|-----------------------|------------------|------|
|                      |                       | ½"               | 1"   |
| 10                   | 2                     | 379              | 896  |
| 10                   | 5                     | 379              | 896  |
| 30                   | 5                     | 862              | 2068 |
| 30                   | 10                    | 779              | 1862 |
| 30                   | 20                    | 551              | 1310 |
| 100                  | 30                    | 1448             | 3448 |
| 100                  | 50                    | 1206             | 2896 |
| 100                  | 70                    | 951              | 2275 |
| 150                  | 100                   | 1206             | 2896 |
| 150                  | 125                   | 862              | 2068 |

Capacities based on 50 SSU Liquids

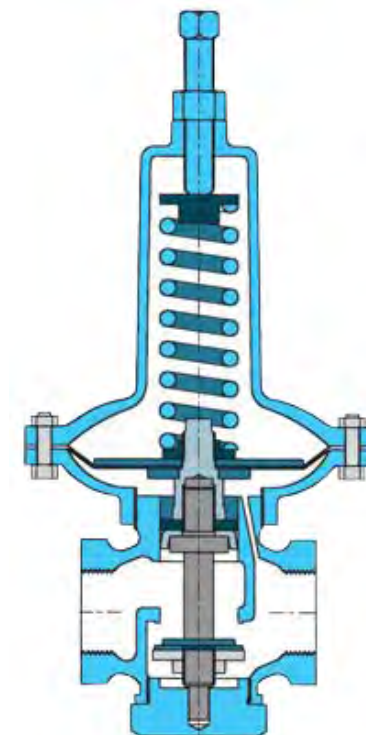
### Ordering Information

| Catalog Number | Size | Spring Range PSIG | Weight |
|----------------|------|-------------------|--------|
| 11925          | ½"   | 1-12              | 7      |
| 11926          | ½"   | 5-35              | 7      |
| 11927          | ½"   | 20-70             | 7      |
| 11928          | ½"   | 40-125            | 7      |
| 11929          | 1"   | 1-12              | 8      |
| 11930          | 1"   | 5-35              | 8      |
| 11931          | 1"   | 20-70             | 8      |
| 11932          | 1"   | 40-125            | 8      |

Large pressure reductions may require multiple pressure reducing valves - Contact factory for details



Model B, Pressure Reducing Valve



## TANK SELECTOR VALVES

Recommended by NFPA 31

Instead of a confusing array of hand valves, the Preferred Tank Selector Valve provides a simple and efficient way to select one of two fuel oil storage tanks. Movement of a single lever transfers both the supply and return lines from one tank to the other while providing an uninterrupted path for supply to the pump set and return from the loop. The Tank Selector Valve eliminates the potential overflow hazard inherent in pumping from one tank while returning to the other tank. It also eliminates the danger of blocking the return path from relief valves and positive displacement pumps while changing tanks.

### Operation

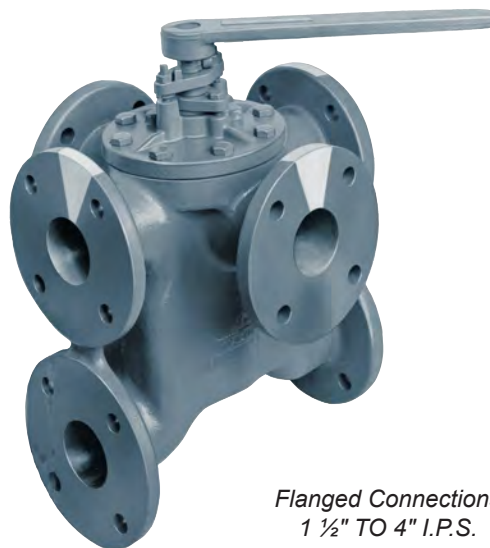
The Preferred Tank Selector Valve consists of a precision-ground tapered plug that rotates 90 degrees within a precision machined cast iron body. The valve is designed so that there is no "blind spot" between the two end positions that would block all flow to or from the tanks. To change tanks, the operator loosens the plug, swings the handle to the opposite position, and re-tightens the plug to ensure the tightest possible seal between the supply and return side of the valve.

**Optional:** An electric actuator can also be mounted on top of the valve to provide automatic lever movement (cannot be done on valves with lifting jacks).

### Construction

Standard valve construction consists of a cast iron plug within a cast iron body. Nuts running on threaded studs (see photo) are used to tighten the plug.

Optional plug materials include Sure-tite, Teflon coated cast iron, and bronze (Sure-tite and Teflon coated cast iron plugs are only available on 1¼" and larger valves). These plug



*Flanged Connections  
1 ½" TO 4" I.P.S.*

construction options include a lifting jack arrangement on 1¼" and larger valves which, simplifies adjustment of the plug to body fit. The lifting jack allows the valve plug to be loosened easily prior to rotating the tank selection lever, and to be tightened after the selection is made. These optional plug constructions allow a tighter seal between the supply and return lines, and between the two tank circuits.

**Caution:** The Tank Selector Valve should be applied on applications where slight leakage from the return piping to the suction piping is not objectionable. On applications utilizing intermittent pumps, care should be taken that the return connections at the valve remain flooded during the pump "off" cycle to prevent the inspiration of air into the suction line from the return side of the valve. If the return connections cannot remain flooded, it is recommended that the Sure-tite option with lifting jack be used. Valve stem packing prevents the inspiration of air into the piping from outside the valve.

### Suggested Specifications

Furnish and install a Tank Selector Valve for manifolding of fuel oil storage tanks per NFPA 31 Standard for the Installation of Oil-Burning Equipment. Valve shall incorporate six (6) valve connections in a common casting with a single operating lever for tank selection and visible indication of tank use. The selector valve for the transfer set shall be manually operated. A Sure-tite plug material shall be supplied to prevent loss of pump set prime. Refer to the mechanical drawings for piping arrangement. The valve shall be a Preferred Utilities Mfg. Corp., Danbury, CT, Tank Selector Valve.

### Ordering Information

Select catalog number from the tables on the next page. To add optional plug material, add the appropriate suffix:

- S Sure-tite (1¼" and larger valves only)
- T Teflon coated cast iron (1¼" and larger valves only)
- B Bronze



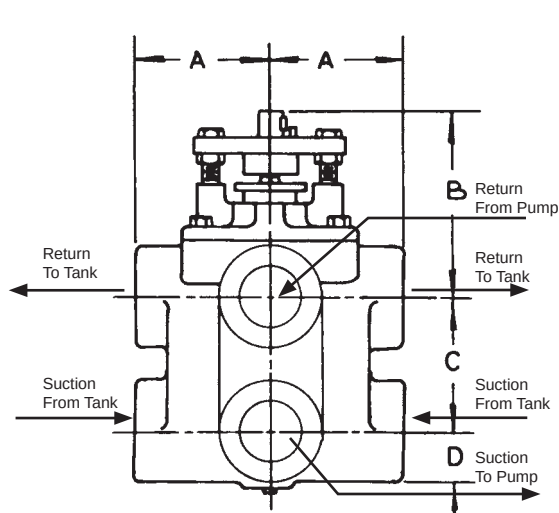
*Threaded Connections  
¾" TO 2 ½" I.P.S.*



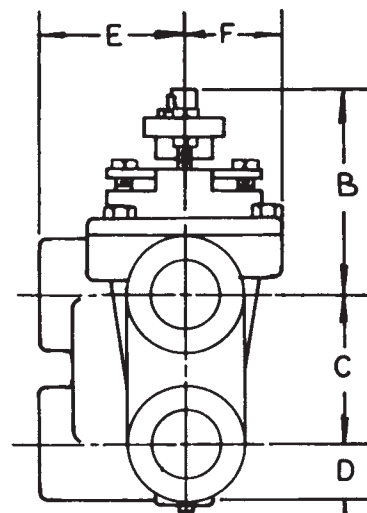
# TANK SELECTOR VALVE

## Ordering Information

### Tank Selector Valve with Threaded Connections



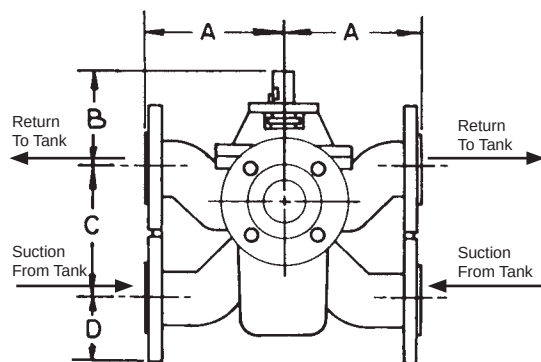
Valve Front View



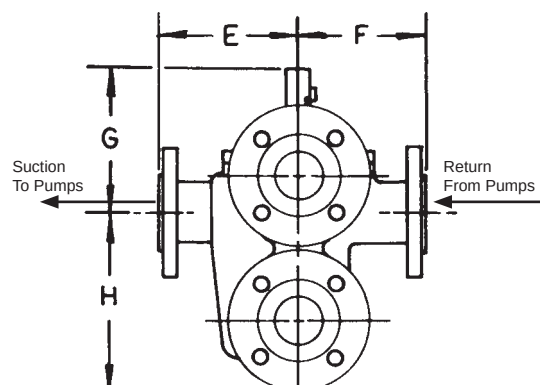
Valve Side View

| Catalog Number | Threaded Connections |       |       |         |         |       | Weight (lbs.) |
|----------------|----------------------|-------|-------|---------|---------|-------|---------------|
|                | SIZE                 | A     | B     | C       | D       | E     |               |
| 13030          | 3/4                  | 2 5/8 | 3 7/8 | 2 5/8   | 1 1/8   | 2 5/8 | 14            |
| 13031          | 1                    | 2 5/8 | 3 7/8 | 2 5/8   | 1 1/8   | 2 5/8 | 14            |
| 13032          | 1 1/4                | 3 3/4 | 6 3/4 | 2 3/4   | 1 11/16 | 3 3/4 | 35            |
| 13033          | 1 1/2                | 3 3/4 | 6 3/4 | 2 3/4   | 1 11/16 | 3 3/4 | 35            |
| 13034          | 2                    | 5 7/8 | 6 3/4 | 3 13/16 | 3       | 5 7/8 | 85            |
| 13127          | 2 1/2                | 5 7/8 | 6 3/4 | 3 13/16 | 3       | 5 7/8 | 85            |

### Tank Selector Valve with Flange Connections



Valve Front View



Valve Side View

| Catalog Number | Flanged Connections |        |         |        |       |         |        |         |          | Weight (lbs.) |
|----------------|---------------------|--------|---------|--------|-------|---------|--------|---------|----------|---------------|
|                | SIZE                | A      | B       | C      | D     | E       | F      | G       | H        |               |
| 13038          | 1 1/2               | 5      | 5 5/8   | 6 3/8  | 1 1/8 | 4 15/16 | 4 7/16 | 6 5/8   | 7 7/8    | 55            |
| 13126          | 2                   | 6      | 6 5/8   | 6 3/4  | 1 1/8 | 6 1/4   | 5 3/4  | 7 1/16  | 9 5/16   | 90            |
| 13035          | 2 1/2               | 6 1/2  | 6 5/8   | 7 3/4  | 3 1/2 | 6 1/2   | 6 1/8  | 7 1/16  | 10 13/16 | 120           |
| 13036          | 3                   | 7      | 6 15/16 | 7 3/4  | 3 3/4 | 6 7/8   | 5 5/8  | 7 1/16  | 11 3/8   | 141           |
| 13037          | 4                   | 10 1/2 | 4 15/16 | 10 1/4 | 4 1/2 | 9       | 6 5/8  | 7 11/16 | 12 1/16  | 250           |

(Additional Sizes Available-consult factory.)

All Dimensions are in inches.

Specifications subject to change without notice.

## SUCTION BELLS

Model SB (SB-20, SB-30, SB-40 and SB-60)

The Model SB Suction Bells are used on preheated heavy oil underground tank applications to provide a pool of warm oil without wasteful heating of the entire tank. Hot oil from the return line is confined within the suction bell where it blends with oil from storage to maintain a pumpable temperature at the bottom of the suction stub.

The Suction Bell also allows a loop system to be brought up to temperature with a small electric heater at the pump and heating set. By returning the warmed oil to the confines of the bell, it may be returned to the pump and recirculated through the start-up heater. The oil temperature in the loop will eventually rise to a point that allows the plant to be started, even though the capacity of the heater may not be sufficient to heat the entire flow of oil in one pass through the loop.

When the volume of oil returned from the electric heater does not provide sufficient heat, models with internal coils should be used. All models are fabricated of  $\frac{1}{8}$ " steel plate and are  $15\frac{3}{8}$ " diameter to permit passage through a standard tank manhole. Coils are fabricated of  $\frac{3}{4}$ " diameter seamless steel tube and are suitable for use with steam, hot water, or glycol.

The Preferred Suction Bell should not be used as the sole source of heat in an above-ground tank installation as it might not provide sufficient heat to keep the entire tank above the pour point of the fuel. Consult factory for further information.

### Suggested Specifications

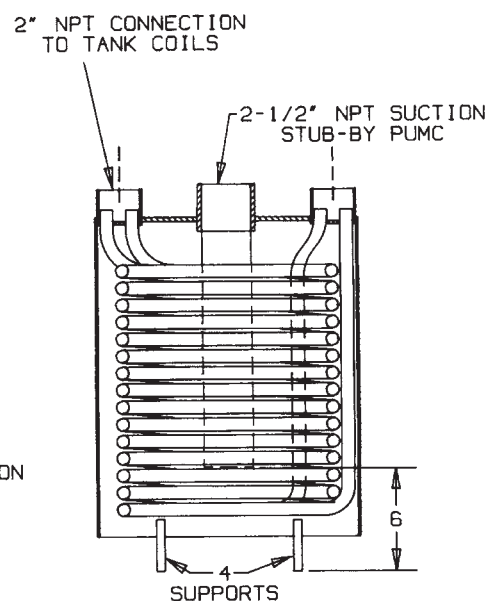
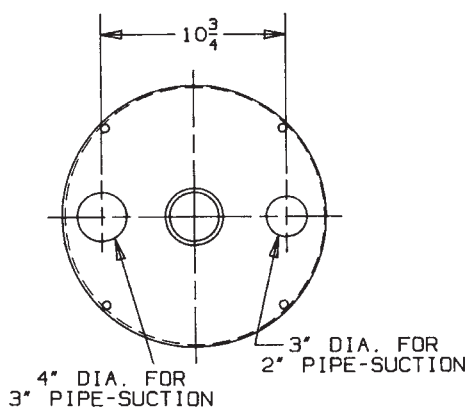
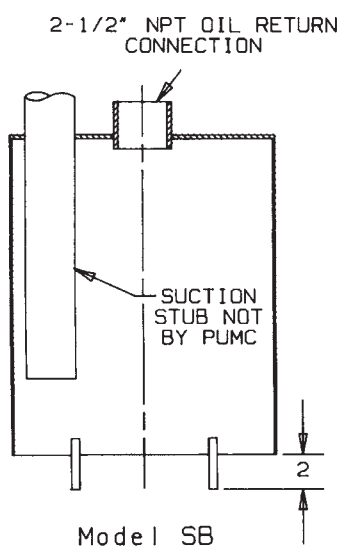
Provide and install one Preferred Utilities Mfg. Corp., Danbury CT, Model SB-20 Suction Bell and Heating Coil. The suction bell shall be fabricated out of  $\frac{1}{8}$ " steel plate and be  $15\frac{3}{8}$ " diameter to permit passage through a standard tank manhole. Provide a 20 square foot (up to 60) heating coil fabricated out of  $\frac{3}{4}$ " diameter seamless steel tubing.

### Ordering Information

Select catalog number from the table below.

| Model | Htg. surf. | Height             | Weight   | Capacity* | Catalog Number |
|-------|------------|--------------------|----------|-----------|----------------|
| SB    | No Coil    | 18 $\frac{1}{2}$ " | 30 lbs.  | N/A       | 03822          |
| SB-20 | 20 sq.ft.  | 18 $\frac{1}{2}$ " | 70 lbs.  | 160 GPH   | A-995          |
| SB-30 | 30 sq.ft.  | 25 $\frac{1}{2}$ " | 95 lbs.  | 240 GPH   | A-996          |
| SB-40 | 40 sq.ft.  | 40 $\frac{1}{2}$ " | 115 lbs. | 320 GPH   | A-1283         |
| SB-60 | 60 sq.ft.  | 46"                | 150 lbs. | 480 GPH   | A-1024         |

\*Heating capacity ratings are based on a 60°F oil temperature rise using low pressure steam or 190° F hot water. Note that NFPA 31 prohibits the use of steam at pressures over 15 PSIG in tank heating coil applications.



## TANK HEATING COILS

### Model B (B60, B70)

The Model B Tank Heating Coils are used on underground storage tank applications where excessive ground water, unusually cold ground conditions, or high pour point oils dictate the need for reserve heating capacity. They are also useful where there is a need for the radiated heat in the tank to promote the stored oil to flow towards the suction stub. The Tank Heating Coils produce a less localized heat than the coils within the Suction Bells.

The Model B-60 consists of two concentric coils connected in parallel. The coils are made of  $\frac{3}{4}$ " diameter carbon steel tubing, and have a total surface area of 60 square feet. The assembly weighs 150 lbs, 45" long and 15  $\frac{3}{8}$ " wide at the 1" NPT coupling connections.

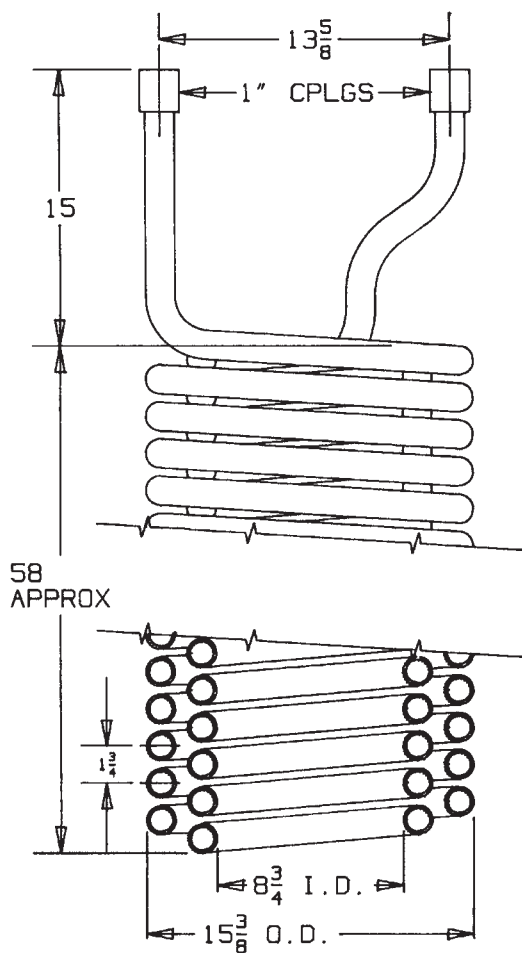
The Model B-70 consists of two concentric coils connected in series. The coils are made of 1" standard steel pipe, and have a total surface area of 70 square feet. The assembly weighs 375 lbs and is 73" high and 15  $\frac{3}{8}$ " in diameter. The 1" NPT couplings are on 13  $\frac{5}{8}$ " centers.

### Suggested Specifications

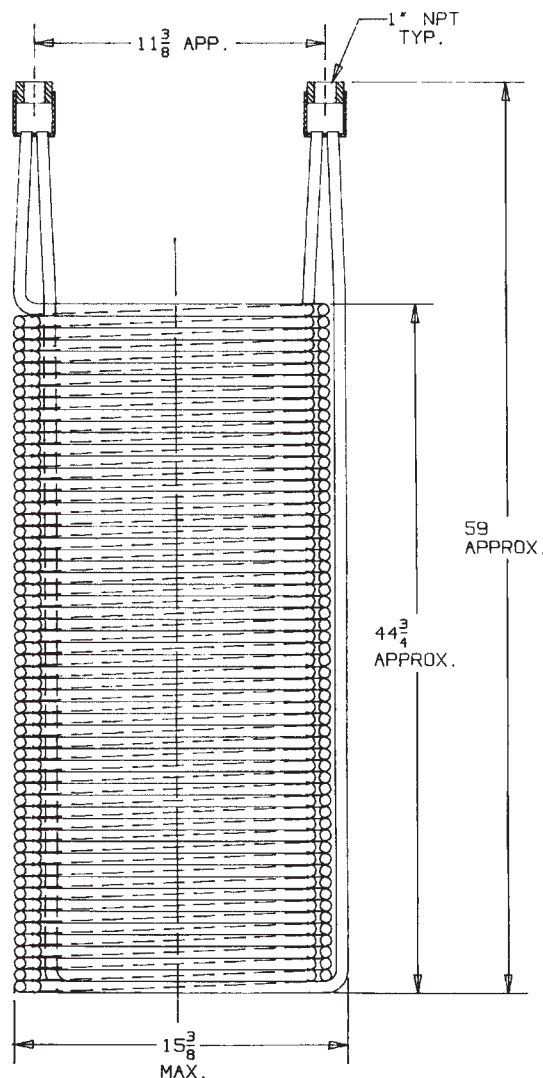
Provide and install one Preferred Utilities Mfg. Corp. Danbury, CT, Model B-70 (B-60) Tank Heating Coil. Coil shall be of 1" standard steel pipe ( $\frac{3}{4}$ " 16 gauge steel tubing), contain not less than 70 (60) square feet of heating surface and shall not be over 15  $\frac{3}{8}$ " in diameter for insertion through a 16" manhole.

### Ordering Information

|            |        |
|------------|--------|
| Model B-60 | A-1404 |
| Model B-70 | A-914  |



MODEL B-70



MODEL B-60

# SUCTION STUB HEATER

Model SS

Approved by New York City, Board of Standards and Appeals (Cal. No. 700-57 SA)

The Model SS Suction Stub Heater is a low watt density, thermostatically controlled, electric immersion type fuel oil heater specifically designed to maintain residual fuel oil in the tank suction stub at a pumpable temperature during times the oil is not flowing.

Care should be used in selecting heaters for installation in the suction line to avoid oversizing or a subsequent high watt density applied to the heater surface. These conditions will cause temperature overrides which in turn lead to vapor lock at the oil pump. The wattage on the Model SS heater is relatively low, but is adequate to maintain the oil in the safe range of 80° F to 120° F during shutdown.

As shown in the sketch below, the heater is installed through the straight run of a tee located at the top of the suction stub. It is suitable for installation in 2" or larger suction lines. The length "A", shown in the table, should exceed the tank diameter by six inches because of the required pipe fittings. The thermostat settings and all wiring connections are located in a heavy-duty cast iron, water and vapor-proof electrical junction box. A contactor is not required.

The Preferred Model SS Suction Stub Heater is stocked for 230/208 VAC single phase current in the sizes listed in the table. Heaters for 460 VAC single phase current and non-standard lengths are available on special order.

| Model | Rating in Watts |        | "A" Dimension Inches | Catalog Number |
|-------|-----------------|--------|----------------------|----------------|
|       | 230V            | 208V   |                      |                |
| SS 1  | 750             | 613.2  | 75                   | 13105          |
| SS 21 | 1000            | 818.6  | 99                   | 13090          |
| SS 22 | 2000            | 1637.6 | 99                   | 13091          |
| SS 31 | 1000            | 818.6  | 123                  | 13092          |
| SS 32 | 2000            | 1637.2 | 123                  | 13093          |
| SS 33 | 3000            | 2451.2 | 123                  | 13094          |

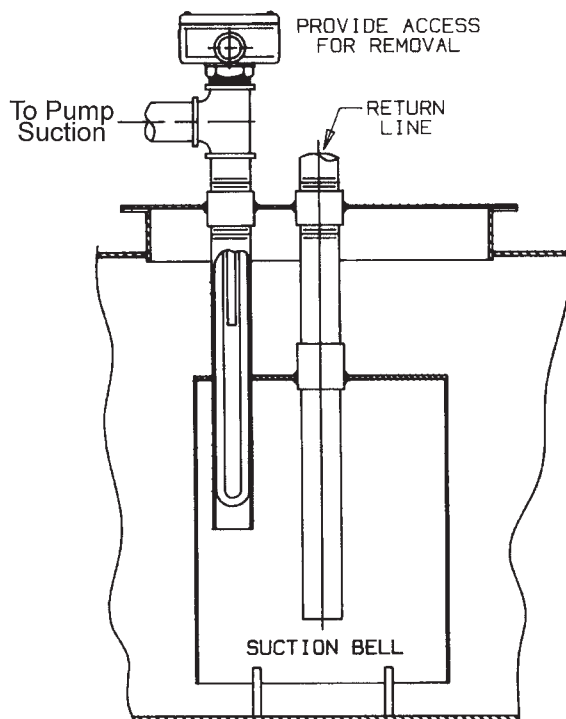
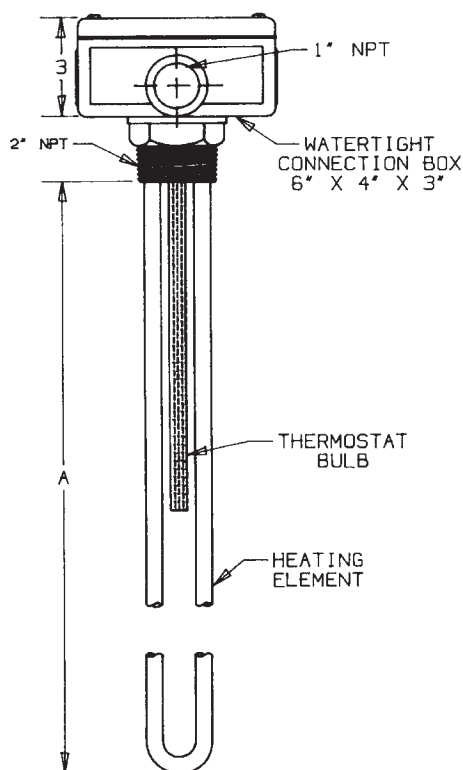
## Suggested Specifications

Provide and install in the oil suction stub, inside each tank, one (1) Model SS \_\_\_\_ Suction Stub Heater as manufactured by Preferred Utilities Mfg. Corp., Danbury, CT. Heater shall be of the low watt density type, thermostatically controlled and shall be complete with a cast iron water and vapor proof electrical junction box.

## Ordering Information

Select catalog number from table above. Add voltage to part number. Example: 13091-480

*Specifications subject to change without notice.*





## CROSS FLOW STEAM/OIL HEATER

### Heat Exchanger

The Cross Flow Heater is a steam-to-oil heat exchanger designed to provide a dependable and economical means for preheating fuel oil.

Steam flows through the tubes of these heaters. Oil is pumped through the shell and over and under a series of baffles that direct the oil across the tube bundle. The resultant turbulence assures maximum utilization of heat transfer surfaces. Installation should be on the discharge side of the oil pump. Continuous circulation of the oil must be assured whenever steam is being admitted to the heater. A Model R Relief valve must be installed on the oil side of each heater to protect against oil pressure buildup due to thermal expansion.

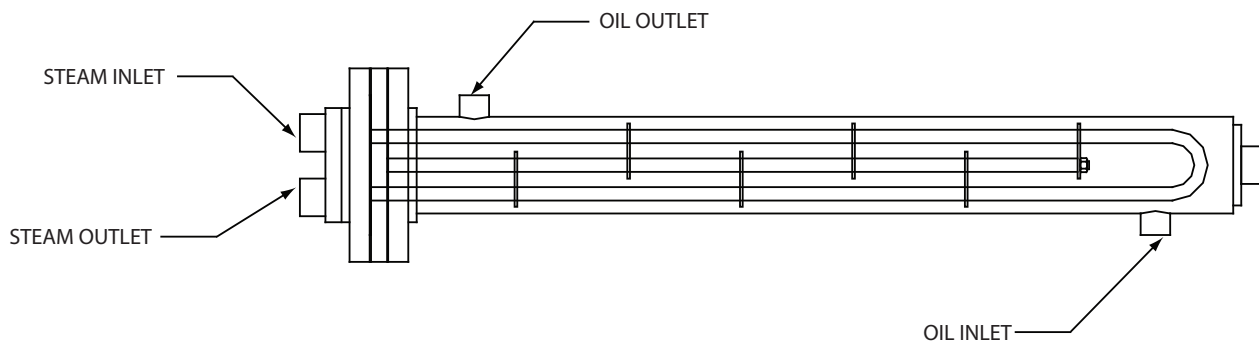
Standard construction includes carbon steel shell, cast iron heads, steel tubes and steel tube sheets. The U-type bundle is easily removed by disengaging a single set of flange bolts. Heaters are designed for a maximum 150 PSIG working pressure on the steam side and a maximum 250 PSIG pressure on the oil side.

### Suggested Specifications

Steam type oil heater shall be Model \_\_\_\_ Cross Flow steam/oil Heater, as furnished by Preferred Utilities Mfg. Corp., Danbury, CT. It shall be designed to raise \_\_\_\_ GPH of oil from \_\_\_\_ to \_\_\_\_ degrees F. when supplied with steam at \_\_\_\_ PSIG. Heater is to be constructed of a carbon steel shell and tubes with cast iron heads and shall be suitable for a 150 PSIG working pressure on the steam side and a 250 PSIG working pressure on the oil side.

### Ordering Information

Consult factory.



## ELECTRIC OIL HEATERS

Model L

Listed as standard by Underwriters' Laboratories, Inc.

Approved by New York City, Board of Standards and Appeals (Cal. No. 554-57 SA)



The Model L Electric Oil Heater is used for preheating fuel oil as it is pumped through the piping system. It is usually installed on the discharge side of oil heaters that use steam or hot water as the heating medium to maintain oil temperatures during standby and cold starting conditions. It is also frequently installed in the oil return line to warm the lighter oils when it is necessary to avoid accumulations of paraffin wax in the piping system. For the latter application, a Preferred Model SB Suction Bell should also be installed in the tank to assure that warm oil will be drawn back into the suction line.

The thermostatically controlled electric immersion heating element is housed in a welded steel manifold suitable for pressures to 150 PSIG. The element is flanged for easy removal during servicing or cleaning. The oil temperature thermostat is adjustable over a range of 100° F to 220° F.

Standard heaters are furnished with wattage ratings based on 208, 230, or 460 VAC. The actual wattage depends upon the exact voltage supplied to the heater.

These heaters are available with three different watt densities. The low watt density series should always be used when the heater is on the suction side of the pump.

Low Watt Density, Series E, have 12 watts per square inch of heating surface.

Medium Watt Density, Series M, have 18 watts per square inch of heating surface.

High Watt Density, Series S, have 24 watts per square inch of heating surface.

A fully enclosed, suitably rated contactor and enclosure with a 120 V/60Hz coil is furnished with each heater.

### Ordering Information

When ordering, specify size, watt density series and electrical characteristics. (Example: LS-18 240V/3/60) Consult factory for other voltages.

### Suggested Specifications

Electric Oil Heater shall be Preferred Utilities Mfg. Corp., Danbury, CT, Model L\_\_\_\_\_, designed for operation with \_\_\_\_\_ volt \_\_\_\_\_ phase power, rated at \_\_\_\_\_ KW and having a watt density not more than \_\_\_\_\_ watts per square inch. Heater shall be controlled by a line voltage thermostat with a range of 100° F to 220° F, that shall be wired in the pilot circuit of a contactor of ample rating for the heater current. Heater shall be U. L. approved and shall have a flanged manifold rated at 150 PSIG with 2" NPT oil connections.

*Specifications subject to change without notice.*

# ELECTRIC OIL HEATERS

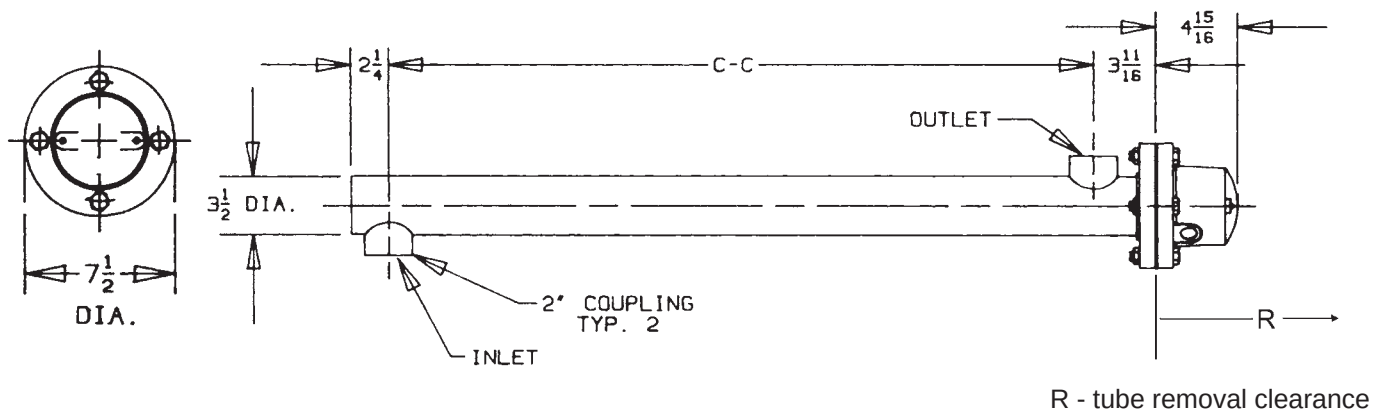
Model L

## Capacity & Load Ratings

Gallons per hour for 50° F temperature rise

| Catalog Number | 230 VAC, 1 phase |       |    | 208 VAC, 3 phase |       |    | 230 VAC, 3 phase |      |    | 460 VAC, 3 phase |      |    |
|----------------|------------------|-------|----|------------------|-------|----|------------------|------|----|------------------|------|----|
|                | GPH              | A     | KW | GPH              | A     | KW | GPH              | A    | KW | GPH              | A    | KW |
| L6             | 96               | 26.1  | 6  | 96               | 16.7  | 6  | 96               | 15.1 | 6  | 96               | 7.5  | 6  |
| L8             | 128              | 34.8  | 8  | 128              | 22.2  | 8  | 128              | 20.1 | 8  | 128              | 10.1 | 8  |
| L10            | 160              | 43.5  | 10 | 160              | 27.8  | 10 | 160              | 25.1 | 10 | 160              | 12.6 | 10 |
| L12            | 192              | 52.2  | 12 | 192              | 33.3  | 12 | 192              | 30.2 | 12 | 192              | 15.1 | 12 |
| L15            | 240              | 65.2  | 15 | 240              | 41.7  | 15 | 240              | 37.7 | 15 | 240              | 18.8 | 15 |
| L18            | 288              | 78.3  | 18 | 288              | 50.0  | 18 | 288              | 45.2 | 18 | 288              | 22.6 | 18 |
| L24            | 384              | 104.3 | 24 | 384              | 66.7  | 24 | 384              | 60.3 | 24 | 384              | 30.2 | 24 |
| L30            |                  |       |    | 480              | 83.4  | 30 | 480              | 75.4 | 30 | 480              | 37.7 | 30 |
| L36            |                  |       |    | 576              | 100.0 | 36 | 576              | 90.5 | 36 | 576              | 45.2 | 36 |

Outputs rated are based on 208, 230, and 460 VAC.

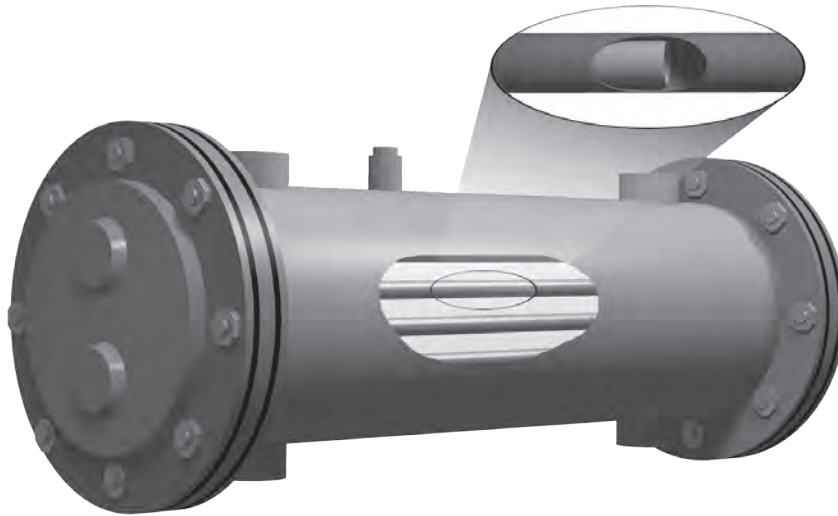


| Catalog Number | Series E<br>12 W/sq. in. |     | Series M<br>18 W/sq. in. |     | Series S<br>24 W/sq. in. |    |
|----------------|--------------------------|-----|--------------------------|-----|--------------------------|----|
|                | R                        | CC  | R                        | CC  | R                        | CC |
| L6             | 28                       | 25  | 19                       | 15  | 18                       | 13 |
| L8             | 37                       | 34  | 25                       | 22  | 18                       | 13 |
| L10            | 47                       | 44  | 31                       | 28  | 24                       | 19 |
| L12            | 55                       | 52  | 38                       | 35  | 30                       | 25 |
| L15            | 69                       | 66  | 46                       | 43  | 36                       | 31 |
| L18            | 83                       | 80  | 56                       | 53  | 40                       | 36 |
| L24            | 111                      | 108 | 75                       | 72  | 54                       | 50 |
| L30            | 123                      | 120 | 93                       | 90  | 66                       | 32 |
| L36            | ---                      | --- | 111                      | 108 | 78                       | 74 |

Dimensions in Inches

## SAFETY TYPE OIL HEATERS

### Double Tube Heat Exchanger



Safety Type Oil Heaters are water- or steam-to-oil double tube heat exchangers providing a reliable, efficient and safe method of heating oil for boiler plant operation. While used as a standard on hot water to oil heating applications, Safety Type Oil Heaters enhance steam to oil heating by permitting condensate to return to the boiler.

If there is a tube failure, the problems resulting from possible fuel oil contamination of the boiler and associated piping are minimized. On water to oil installations the high cost of providing pumps, expansion tanks, feeders, valves, etc. to provide an intermediate closed loop system is eliminated. On steam to oil installations the Safety Type Oil Heater avoids the substantial inefficiencies and problems involved with disposing of exchanger condensate that is prohibited by many environmental agencies because of the possibility of oil entering the disposal line system.

The Safety Type Oil Heater has a six pass design, and utilizes a tube within a tube construction. With oil in the inside tube and the heating medium in the shell and around the outside tube, as well as a highly efficient heat transfer fluid in the area between the tubes, double heat transfer is effected from the heating medium through the sealing fluid to the oil. Should a leak occur, the oil mixes only with the sealing fluid and is visually indicated at the rear of the safety chamber. Oil does not enter the boiler water.

Safety Type Oil Heaters are intended for installation on the discharge side of oil pumps. They have a steel shell and tube sheet, cast iron oil chamber, and 304 stainless steel oil tubes. The designed working pressure for both shell and tubes is 100 PSIG. Consult factory for higher capacities and pressures, and two (2) pass heaters for pump suction side installations or special configurations.

#### Suggested Specifications

Fuel oil heaters shall be of the Safety Type, six (6) pass, tube within a tube design with a capacity to heat \_\_\_\_ GPH of No. 6 fuel oil from \_\_\_\_°F to \_\_\_\_°F when supplied with (steam at \_\_\_\_ PSIG) (water at \_\_\_\_°F.) Heaters as furnished by Preferred Utilities Mfg. Corp., Danbury, CT, shall have 304 stainless steel tubes for oil, and shall comply with ASME requirements for 100 PSIG operation on both shell and tube sides.

#### Ordering Information

Safety Type Oil Heaters are custom made. Specify GPH capacity and heating capacity when ordering. Contact the factory for more information.

*Specifications subject to change without notice.*



## Instruments & Controls



## SCADA/FLEX DISTRIBUTED CONTROL

### Overview

#### Plant Data That Promotes Optimization

- Energy usage computed by degree day
- Efficiency of the plant and each boiler/furnace
- Total steam generated by the plant and each boiler
- Total fuel used by the plant and each unit
- Average cost of steam
- Equipment cycle times and operating hours
- Condensate Temperature to help identify "blown trap"
- Blowdown Monitoring
- Make-up water flow vs. total feedwater or steam flow
- Flue Gas Oxygen vs. Setpoint Monitoring, etc.

#### Boiler Diagnostics

- Boiler control and flame safeguard alarm and equipment status information are presented both graphically and on alarm and event summaries. This aids in troubleshooting the cause of trips and potential trips
- Remote equipment monitoring allows for preventative maintenance. Problems can be evaluated centrally, allowing technicians to come properly equipped to the remote site

#### Unsurpassed Availability

- Preferred PCC-III, PWC, FSC, and BMU controllers provide continued plant operation in the event of a Control Network and/or SCADA shutdown
- Multiple SCADA Servers provide continued operation in the Central Control Room in the event of a SCADA shutdown
- Dedicated boiler controllers provide continued remote and local operation of unaffected boilers in the event of a single controller shutdown

#### Lower Installation and Commissioning Cost

- Controller Tuning Screens and Historical Trending tools help speed commissioning
- Controllers and I/O wiring are located near the equipment to save installation cost

#### SCADA/Flex is a Robust Plant Optimizing Solution

The ability to monitor and control plant-wide processes from a single location, while also collecting and sharing real-time plant data, has become an invaluable tool for improving the operation of boiler plant equipment. Plant owners around the country have successfully turned to SCADA/Flex from Preferred Instruments. SCADA/Flex helps you turn plant operating data into information, and information into dramatically improved performance.

#### Overview Graphics

Overview graphics are provided to match the specifics of your plant. Each screen intuitively displays critical information for quick and easy operation. "Soft buttons" provide an intuitive "point and click" interface for navigating between screens, acknowledging alarms, and controlling equipment.

## SCADA/FLEX

### Distributed Control



SCADA/Flex Workstation

#### SCADA/Flex Offers:

- Process visualization (HMI)
- Supervisory Control And Data Acquisition (SCADA)
- Local or remote operating modes
- Historical Trending
- Alarming, alarm management and printing
- Report Generation and Printing (Option '-R')
- High performance networking (Ethernet & Fiber Optic optional)
- Interface to Fireye and Honeywell Flame Safeguards (optional) Quanta-Flame Flame Safeguards
- Development Software allows continued development on site (Option '-DS')

#### Open Architecture for Third Party Applications (optional)

SCADA/Flex can act as an OPC Server to any standard OPC Client. Alternatively, SCADA/Flex can act as an OPC Client to any standard OPC Server. SCADA/Flex leverages the ODBC Application Programming Interface (API), adding the capability to collect and write real-time secure electronic records to one or more relational databases. Data can easily be moved between a relational database and the SCADA/Flex process database.

#### Historical Trending

Multi-colored strip charts display of any group of eight variables for any length of time. The Zoom feature and a data cursor allow precise readout and comparison of any event. Data may be placed on a server or flash drive for long-term storage and can be reloaded at any time for analysis.

# SCADA/FLEX DISTRIBUTED CONTROL

## Overview

### Report Generation (Option '-R')

Intelligent reports tabulate and summarize to help identify trends in efficiency. Energy use can be compared with previous reports to spot potential waste or to verify the effectiveness of fuel saving strategies. Plant managers can easily run reports on key "performance indices" *such as cubic feet of fuel burned per degree day*. Careful data tracking coupled with the intelligent control of process systems helps produce significant energy cost savings. Shift, daily, weekly, monthly, and yearly summary reports are automatically generated and can be printed at any time.

### Centralized Plant Operation-Local Control

The SCADA/Flex System provides the ease and flexibility of centralized plant operation while ensuring the safety of local control. Workstations can fully operate an entire series of plants, on site or across the country, through dial-up or leased line. SCADA/Flex systems can even be outfitted with laptops so that monitoring and control can be administered while traveling. However, PCC-III and PWC controller local operator interfaces allow plant operation in the event of a workstation and/or data highway malfunction.

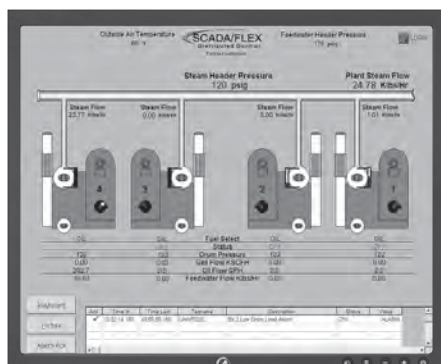
Microsoft Excel - Gates

File Edit View Format Window Help

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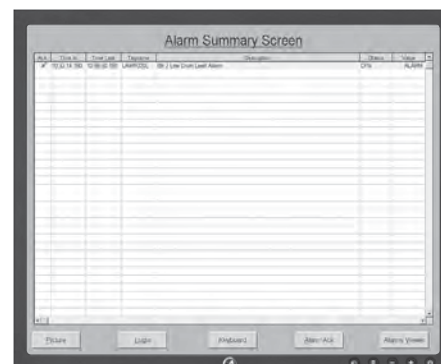
Intelligent Reports



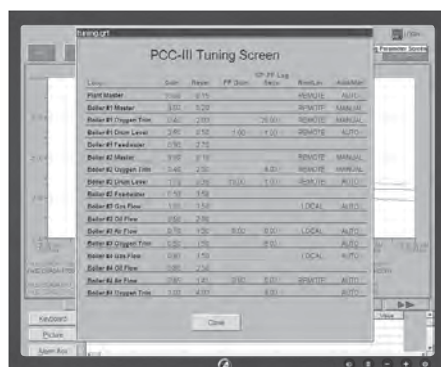
Plant Overview Display(s)  
At-a-glance monitoring of boiler plant



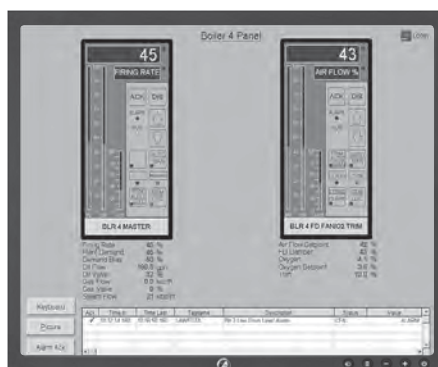
Historical Trending Display(s)  
An essential monitoring tool.  
Multiple (8) pen "Charts"



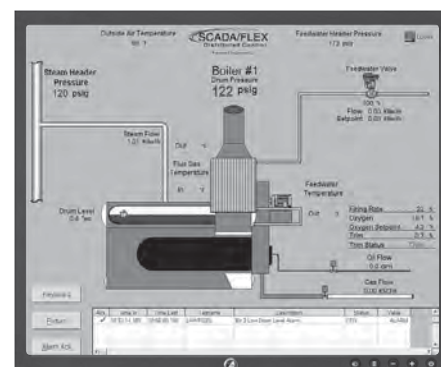
Alarm Display  
Alarm, events and operator actions are logged with time/date stamp and description



Tuning Displays  
Tuning parameters are presented along with process variable trends to facilitate commissioning and maintenance



Control Display(s)  
Intuitive workstation control mimics local controllers to maximize ease of use



Boiler Overview Display(s)  
Faster and improved understanding of boiler operation

# SCADA/FLEX DISTRIBUTED CONTROL

## Specifications

### Hardware

Processor: Intel Xeon 1.8GHz or better  
 Memory: 8 GB RAM  
 Drives: 600 GB Hard Drive, DVD ROM Drive  
 Monitor: 24" Flat Panel  
 (Computer hardware offerings will be updated as new equipment becomes available.  
 A job-specific, detailed proposal will include details on the computer and peripherals.)

### Software

HMI Graphics: Object-oriented  
 Platform: Intellution iFIX, Microsoft Windows, Visual Basic for Applications (VBA), Microsoft Excel® for Reports  
 Architecture: Real time Client/Server, OLE for Process Control (OPC)  
 Integration: SQL/ODBC API, OPC to/from third party OPC Client/Server (optional)  
 Security: Configured and synchronized with Windows

### Control Network

Medium: RS485 Standard and Ethernet (Fiber Optic optional)  
 Protocol: Modbus (ASCII or RTU mode)

### Printers

Alarms: Dot Matrix  
 Reports: Deskjet Graphic (included in Report Generation option)

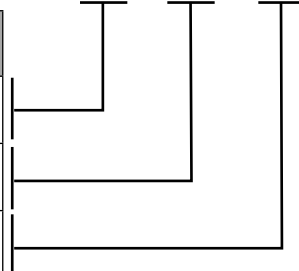
### UPS

Rating: 800 VA (~30 minutes)

### Ordering Information

Catalog Number: SCADA/Flex - CD8 - US4 - BM4

| Description<br>(select any combination)                                               | Catalog<br>Number |
|---------------------------------------------------------------------------------------|-------------------|
| Chief Dispatcher<br>(specify quantity of Boilers “-#”)                                | add “-CD” suffi   |
| UtilitySaver Burner Control System<br>(specify quantity of UtilitySaver Systems “-#”) | add “-US” suffi   |
| BurnerMate Boiler Control System<br>(specify quantity of BurnerMate Systems “-#”)     | add “-BM” suffi   |
| Optional Features                                                                     | Catalog<br>Number |
| Report Generation<br>(Option includes report deskjet graphic printer)                 | add “-R” suffi    |
| Development Software (Configuration Software)                                         | add “-DS” suffi   |



### Additional Ordering Information

Only “basic” system ordering information is provided. Please consult factory for the following:

- Additional Input and Control requirements, Balance of Plant, etc
- Additional SCADA/Flex Servers or Clients
- Remote Site Monitoring
- Ethernet or Fiber Optic Control Networks
- Interfaces to third-party systems or protocols
- SQL/ODBC API Integration



# SCADA/FLEX DISTRIBUTED CONTROL

## Suggested Specifications

### 1. Application

Provide a remote Supervisory Control And Data Acquisition (SCADA) system designed to provide remote operation, graphic display of information, alarm message display, report generation, historical trending and remote controller tuning. The SCADA system shall be networked to the boiler control and burner management systems.

### 2. Equipment Requirements

Communications between the data acquisition system, the individual controllers, and flame safeguards shall be via an industry standard protocol such as Modbus.

### 3. Equipment Hardware Features

The system shall use standard IBM PC compatible hardware to simplify future expansion, replacement and service requirements. Provide the following workstation hardware at a minimum: Intel Pentium IV micro-processor or newer, 2GB RAM, 80 GB Hard Drive, 32 bit SVGA video controller, 2" Flat Screen Monitor, 3.5" Floppy Drive, DVD ROM Drive, keyboard and Microsoft mouse, tower case for computer, alarm printer, tractor feed 9 pin dot matrix printer, shift report and trend deskjet printer and 1000VA UPS backup power system.

### 4. Equipment Software Features

The software package shall operate in conjunction with the Microsoft 7 operating system. Reports shall be prepared automatically using standard Microsoft Excel® spreadsheets. Software shall be controlled by mouse based to allow for easy selection of screens, manual/automatic status changes, start/stop functions, setpoint changes, and output changes without any special programming skills. The system shall be expandable in the future to a multi-workstation system via standard Ethernet LAN hardware. Any measured or calculated value shall be available to third party software via standard OLE for Process Control (OPC) Data Exchange as an option. Provide all necessary software to allow field the Data Acquisition system to be modified or expanded in the field, including graphics drawing programs, data base builders, report generators, etc. Systems based on "run time only" programs will not be acceptable.

### 5. Human Machine Interface (HMI) Terminal Operation

The operator, when the local controllers are enabled, shall have remote control of the following functions from the data acquisition terminal: Manual/Auto mode of each controller, Controller setpoint values, Controller output when in the manual mode, PID tuning parameters, Controller analog output values, Controller discrete output values. The HMI display shall provide a facsimile of the local controller and clearly labeled English language and engineering unit display of the control parameters. No special programming skills shall be required for any routine operating sequence.

### 6. Graphic Display

Information shall be displayed on the HMI as part of an easily understood pictorial representation of the process. At minimum, the following pictorial "screens" shall be available for observation: for example, a typical steam generator would display (when available): steam drum pressure, steam flow for each boiler, steam temperature, drum water levels for each boiler, flame failure, fuel flows, combustion air temperature, flue gas temperature, boiler efficiency (by ASME "losses" method), Air flow, Flue gas recirculation damper position, Outlet damper position, Controller Faceplate Grouping for each boiler, Trend Screens for each group of controlled and process variables as relates to each controller in the system. All values shall be displayed in engineering units adjacent to the pictorial point of measurement.

### 7. Remote Tuning

Each controller in the system shall be capable of remote tuning of gain, reset, rate and other important parameters via the SCADA System. Tuning the controllers shall be a "menu driven" operation and shall not require special programming skills. When each controller is placed in the remote tuning mode, a real time trend chart of controller inputs shall be displayed on the HMI to aid the technician in setting the proper parameter values. This function shall be password protected for security.

### 8. Alarm Generation

Where applicable, alarm status shall be displayed on the monitor generated process pictorials. In addition, all alarms shall be printed as they occur on the alarm printer, and displayed on the lower portion of each HMI display. The alarm log, as generated at the printer, shall indicate the time at which the alarm occurred, the time at which the alarm was acknowledged and the time at which the value returned to normal status. In addition to alarm conditions, this log shall also document status changes such as a transfer from automatic to manual, setpoint change, etc. so that the resultant printout is a true and complete log of plant operating conditions.

### 9. Report Generation

The log sheet printer shall print out: on demand, shift, daily, weekly, monthly, and yearly plant operating reports for evaluation by the plant manager. As an example, for a steam generator application, a report would list (when available):

1. Total steam generated by the plant and each boiler
2. Total fuel used by the plant and each boiler
3. Average cost of steam
4. Input-Output efficiency of the plant and each boiler
5. Items 1 through 4 shall also be reported on a "per degree day" basis where applicable
6. Combustion efficiency (by ASME "By Losses" Method) for each boiler
7. Make-up water flow in pounds and also as a percent of steam flow
8. Hours of operation for each boiler
9. Steam flow to each of the distribution headers

## SCADA/FLEX DISTRIBUTED CONTROL

### Suggested Specifications

#### 10. Historical Trending

The system shall be capable of storing the values from all transmitters as well as system computed values (such as efficiency and compensated flow rates) to hard disk at selected intervals. Stored data can be downloaded to an internal hard drive to archive or reload into the system for analysis. All data stored in the system shall be available on HMI or paper plot displays as strip chart records with up to eight channels per display. The horizontal and vertical axes of the trend displays shall be variable to provide the degree of overview or fine resolution required for each specific analysis. The software package shall be pre-programmed to give the operator a "menu" of standard trend displays. If a custom display is required, the user shall be able to generate the required display via help messages and a "fill-in-the blanks" menu. No special programming skills shall be required.

#### 11. Flame Safeguard Interface

The SCADA system may have dedicated communications between the computer and the Flame Safeguard systems so as to allow all alarms to be graphically represented on the monitor. The system must be capable of displaying and recording the following statistics: burner limits, individual lockouts, burner operation hours, total burner cycles, burner status, last six lockouts, total lockouts, and flame signal strength.

#### 12. Data Acquisition System Compatibility

The SCADA System may be expanded to cover other plant utilities. It is therefore essential that the SCADA System supplied for this project be "open" and easily adaptable to other brands of controllers, sensors and I/O hardware. At minimum, the system supplied under this contract must be able to communicate with 3 separate communication links simultaneously. The system must have available communication drivers for: Fireye and Honeywell flame safeguards and Preferred Instrument PCC III and PWC Controllers. The system must not be proprietary or dedicated to a single brand of controller or I/O hardware.

#### 13. Quality Assurance

All control functions shall be accomplished within the individual Boiler Control and Burner Management controllers and shall be monitored by the SCADA system so that the integrity of the control system shall not be dependent on the status of the SCADA system or the interconnecting network (In the event of a control network and/or a SCADA shutdown, local controllers must continue monitoring and controlling the plant). The SCADA system shall be a Preferred Instruments, Danbury, CT, SCADA/Flex.

# CHIEF DISPATCHER MODULATING LEAD/LAG CONTROLLERS

## Overview

### Better Steam or Hot Water System Control

- Model available for steam, hot water, and condensing boilers
- “Smart” boiler sequencing to improve response time
- Steam boiler “Base Load Auto-Shift” reduces cycling
- Hot water boiler “Header” or “Boiler” pump sequencing
- Firetube boiler thermal shock protection using blend valves
- Condensing boiler logic maximizes lower firing rate operation to increase efficiency

### Easy to Use

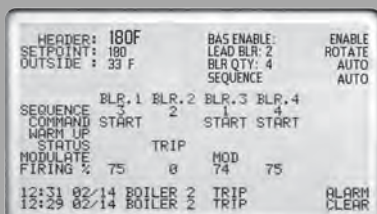
- “Plant Overview,” “Alarm,” and “Setup” displays enable informed initial setup and process assessment
- In a single wall-mounted enclosure, the Chief Dispatcher integrates a modem for off-site monitoring, RS485 Modbus communications, 24VDC power supplies and outdoor reset functions. No external control devices are required

### Easy to Order, Stock and Field Upgrade

- Complete system is ordered using a single part number
- “Plug In” option boards can be used to upgrade a system in the field

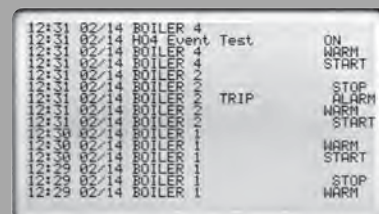


## LCD Graphic Display



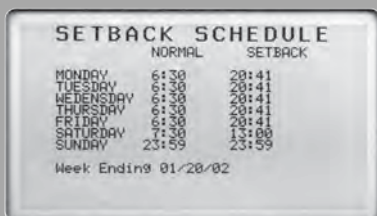
### Plant Overview Display(s)

At a glance control and monitoring of boiler status and lead/lag sequence.



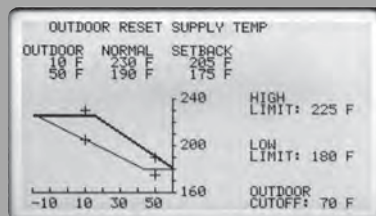
### Alarm/Event Summary Display

Up to 200 Alarms, events and operator actions are logged with time, date stamp, and description.



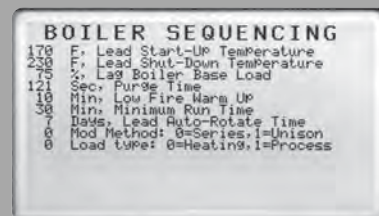
### Setback Display(s)

Simple Day/Night/Week Setback setup.



### Outdoor Reset Display

Easily configure normal and setback setpoints and limits. A graphical representation is automatically generated.

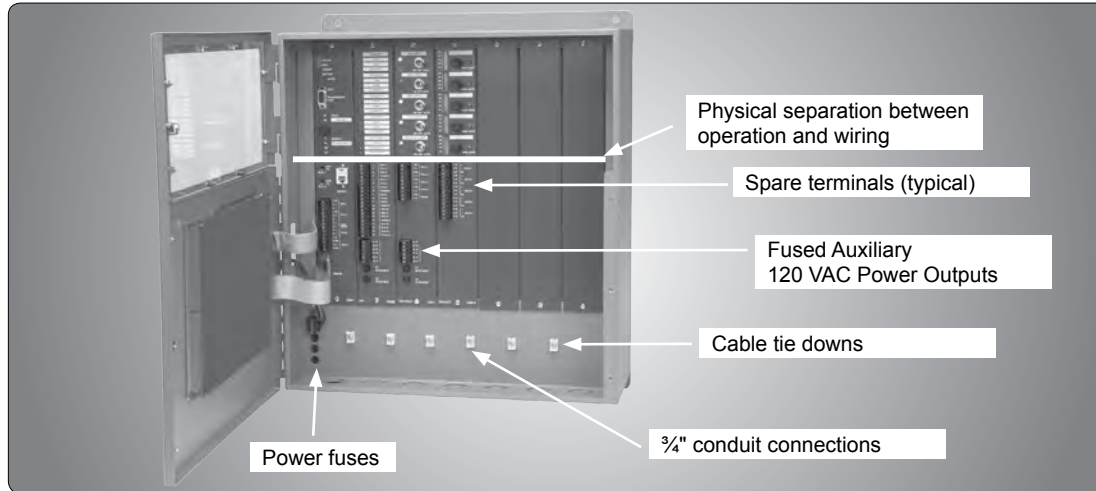


### Boiler Setup Displays

Simple Menu style “Fill-In-The-Blanks” setup.

# CHIEF DISPATCHER MODULATING LEAD/LAG CONTROLLERS

## Overview



*Chief Dispatcher with both doors open*

### “Smart” Boiler Sequencing

Boilers are automatically sequenced on/off to ensure that the number of boilers in service meets steam or hot water demand. If any boiler fails to start when called, or if a boiler trips during operation, the chief dispatcher immediately starts another boiler to replace the “faulted” boiler. The operator may manually select the lead boiler or allow the lead boiler to rotate automatically. Additionally, the total number of boilers in service may be set automatically or manually as selected by the operator or all boilers may be shutdown by a Building Automation System (BAS) “enable/disable” contact input.

### “Hard Manual” Backup

Hardwired control switches and dials provide simple manual control for easy troubleshooting and service. Each boiler has an individual firing rate bargraph, “manual” firing rate output knob, and “Auto/Manual” switch.

### Modbus Communication Interface

A factory configured RS485 Modbus interface is available for Building Automation or SCADA system monitoring and control.

### Building Automation System (Option ‘-BAS’)

A remote Hot Water Supply (HWS) temperature setpoint is set by either a Modbus or 4-20 mADC Building Automation System (BAS) outdoor reset input signal.



*PWC\_Remote™ Software*

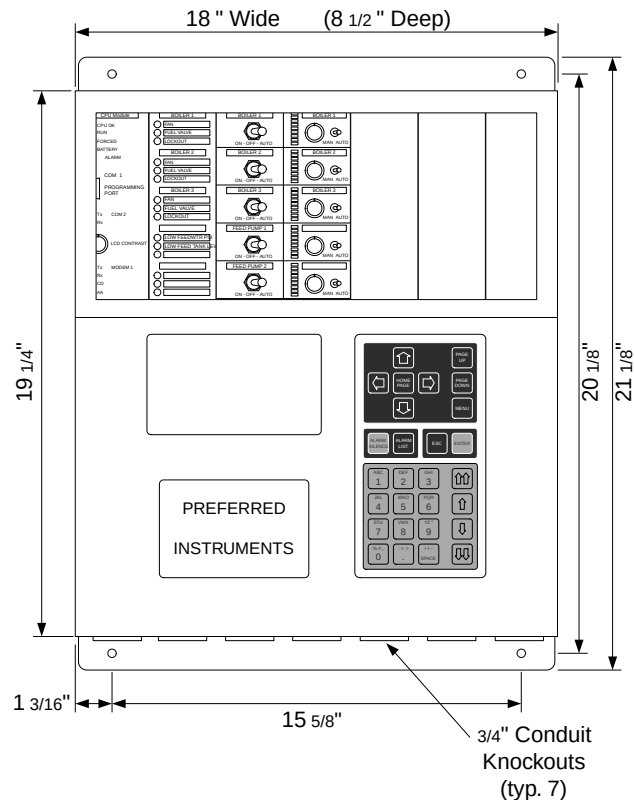
### Firing Rate Output (Option “-I” or “-P”)

Boiler Firing Rate Analog Output Cards may be ordered as ‘-P’ = 0-135 ohm or ‘-I’ = 4-20 mADC.



# CHIEF DISPATCHER MODULATING LEAD/LAG CONTROLLERS

## Specifications



### Mechanical

|                 |                              |
|-----------------|------------------------------|
| Case Size:      | 10 1/2" H x 18" W x 8 1/2" D |
| Enclosure Type: | Wall mounted                 |
| Case:           | 7 Slot, (CPU + 6 I/O Slots)  |
| Weight:         | 55 lbs.                      |

### Environmental

|                  |                                |
|------------------|--------------------------------|
| Operating Temp:  | 32° to 122° F (0° to 50° C)    |
| Storage Temp:    | -20° to 150° F (-28° to 65° C) |
| Humidity Limits: | 15% to 95% (noncondensing)     |
| Enclosure:       | NEMA 1                         |

### Performance

|                  |                            |
|------------------|----------------------------|
| Accuracy:        | 0.025% Analog I/O          |
| Resolution:      | 16 bit input/12 bit output |
| Microprocessor:  | 32 bit, 128k EEPROM        |
| Execution Cycle: | Five per second            |
| Time/Date Clock: | (battery backed)           |

### Operator Control Panel

|                      |                            |
|----------------------|----------------------------|
| LCD Graphic Display: | 2.9" H x 5.1" W            |
| Keyboard:            | Membrane, tactile feedback |

### Configuration

|                         |                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------|
| Standard Lead/Lag:      | Menu style<br>"Fill-In-The-Blanks" setup.                                                |
| Control Language:       | Function block style,<br>60 functions, 600 Blocks                                        |
| Security:               | 2 password levels                                                                        |
| Custom Blockware        |                                                                                          |
| Configuration Software: | PWC_Edit™ spread sheet based<br>or PWC_Draw™ graphical, editor.<br>(Windows PC Required) |

### Communication

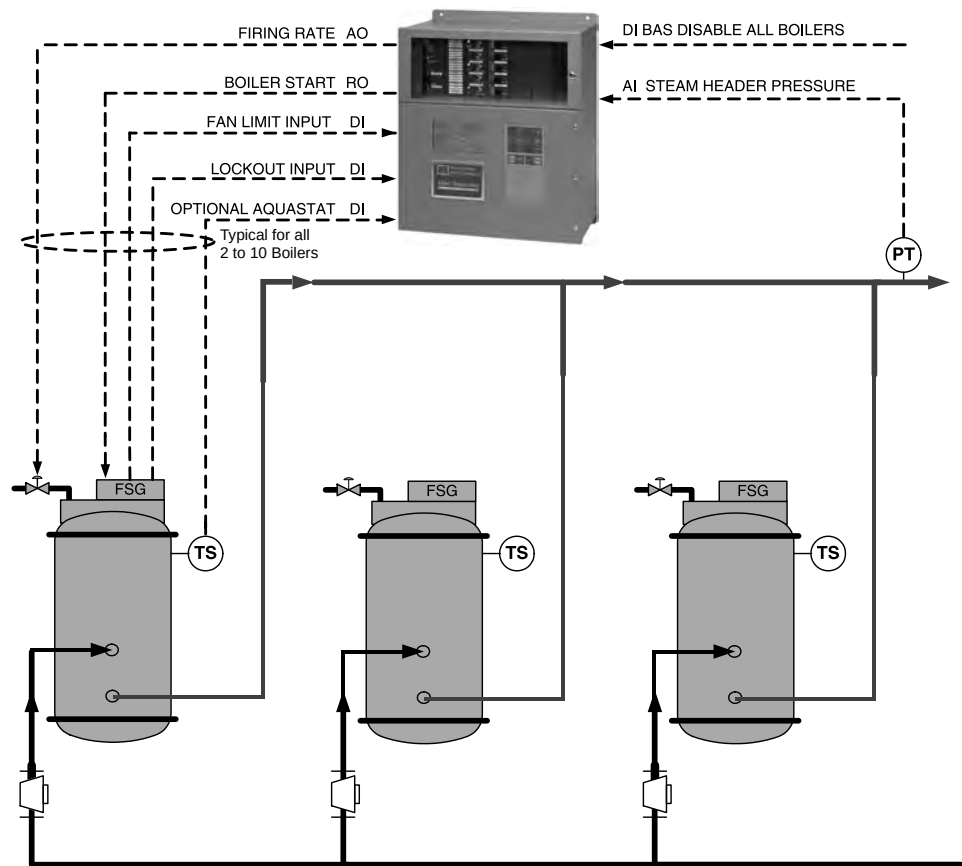
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| Control Network:  |                            |
| Protocol:         | Modbus (ASCII or RTU mode) |
| Speed:            | 1200 to 38,400 baud        |
| Type:             | RS485, optically isolated  |
| Programming Port: |                            |
| Speed:            | 38,400 baud                |
| Type:             | RS232, DB9F connector      |

### Electrical

|                        |                                                                               |
|------------------------|-------------------------------------------------------------------------------|
| Input Power:           | 120 VAC (+/- 15%), 12 A total,<br>0.7A internal<br>Built in surge suppressors |
| Internal Power Supply: | 24 VDC @ 300 mADC for<br>external use                                         |

## CHIEF DISPATCHER MODEL JC-CDST

### Steam Boilers Modulating Lead/Lag Controller



JC-CDST  
2 to 10 Steam Boilers

#### Application

The Chief Dispatcher Model JC-CDST optimizes steam system performance and helps extend Cast Iron Sectional, Finned-Tube, Firebox, Flexible Tube or Firetube boiler life.

#### 2 to 10 Modulating Boilers

Boiler firing rates are automatically adjusted to satisfy the overall plant steam heating load using accurate PID control. When desired the operator may set the firing rate manually.

#### Warm Standby

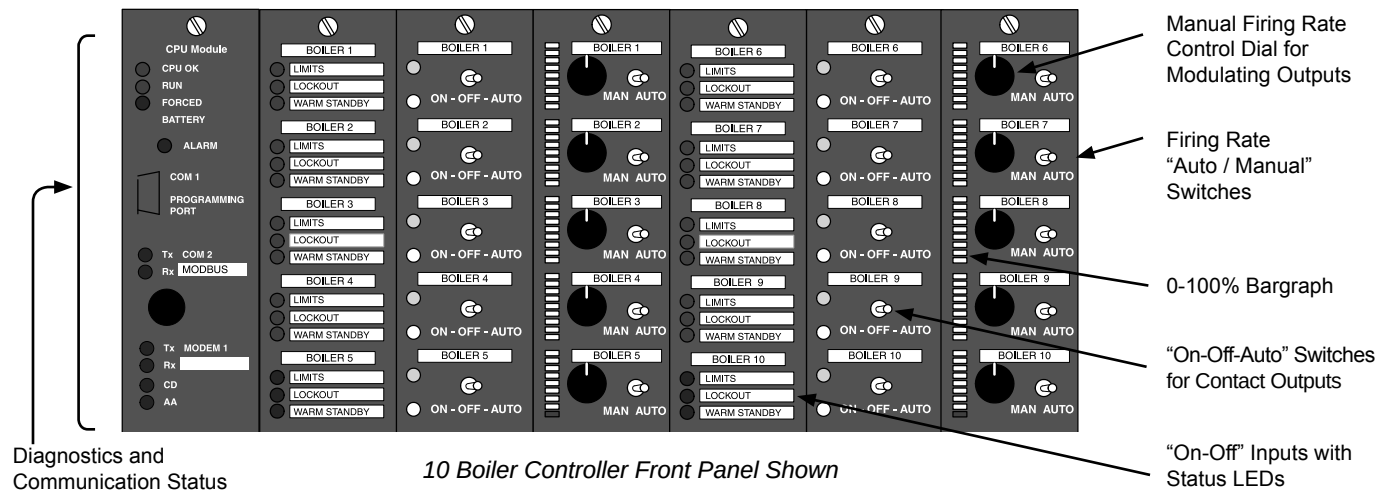
Each off-line boiler is periodically started and held at low fire until it returns to the “warm standby” temperature (Aquastat supplied by boiler manufacturer). This helps to minimize thermal shock when called on-line.

#### “Base Load Auto-Shift”

Normally, the Lag boilers remain base loaded for peak total plant efficiency. If the lead boiler firing rate approaches high fire, the lag boiler(s) will increase their firing rate to “help” the lead boiler. If the lead boiler approaches low fire, the lag boilers will decrease their firing rate to “help” the lead boiler. This method minimizes boiler on/off cycling due to short term load swings while maximizing total boiler plant efficiency. If desired, “unison” modulation can also be field selected (all boilers fire at the same rate).

# CHIEF DISPATCHER MODEL JC-CDST

## Steam Boilers Modulating Lead/Lag Controller



### Specifications

#### Panel Details

Controller: PWC  
 Case Size: 19¼" H X 18" W X 8½" D  
 Enclosure Type: Wall mounted, Weight: 55 lbs.

#### Inputs

Steam Pressure: 0 to 25 PSI, 0 to 200 PSI, or 0 to 500 PSI, 4-20 mADC  
 BAS, Boiler Disable: 120 VAC, optically isolated  
 Limits: 120 VAC, optically isolated (each boiler)  
 Boiler Lockout: 120 VAC, optically isolated (each boiler)  
 Warm Standby: 120 VAC, optically isolated (each boiler)

#### Outputs

Modulation: Isolated 4-20 mADC or 0-135 ohm (each boiler)  
 Boiler Start: Dry contact, 8 FLA, ½ HP, 120 VAC (each boiler)

| Order Sensors Separately<br>(Quantity as Required)  | Catalog<br>Number |
|-----------------------------------------------------|-------------------|
| Steam Pressure Sensor<br>0-25 PSI with syphon loop  | 70600             |
| Steam Pressure Sensor<br>0-200 PSI with syphon loop | 70601             |
| Steam Pressure Sensor<br>0-500 PSI with syphon loop | 70602             |

# CHIEF DISPATCHER MODEL JC-CDST

## Suggested Specifications

### 1. Application

Supply a fully integrated boiler control system to coordinate the operation of two (select up to ten) fully modulating steam boilers in order to maintain Steam Header Pressure at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Boiler Modulation

The control system shall provide a PID based control scheme. Modulation shall be field selectable as either "Unison" (all at the same firing rate) or as "Series". Series modulation shall include "Base Load Auto-Shift" logic in order to minimize boiler on/off cycling. Normally the lag boilers shall be base loaded at an operator adjustable firing rate for peak efficiency. When the lead boiler's firing rate approaches high fire, the lag boiler(s) will automatically modulate up from the base load firing rate to "help" the lead boiler without starting another lag boiler. If the lead boiler approaches low fire, the lag boilers will modulate toward low fire to "help" the lead boiler and prevent a short cycle of a lag boiler. When the lead boiler leaves the high or low fire position the lag boiler(s) resume firing at the normal base load for peak efficiency. If the load increase or decrease is long term, a lag boiler shall be cycled on or off as required. Modulation signals shall be 4-20 mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

### 3. Steam Header Pressure Setpoint

The operator may set the Steam Header Pressure Setpoint via a front panel display.

### 4. Boiler Sequence

The control system shall use both Steam Header Pressure and Boiler Firing Rate percent to start and stop the boilers and minimize the total number of boilers in operation. The controller shall start and stop boilers when the Steam Header Pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. To anticipate and minimize header pressure deviations, the control system shall start or stop the next boiler if the "lead" boiler has been near high or low fire for longer than the adjustable time delay. The control system shall monitor each boiler's lockout and limit circuits and shall rapidly and automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day / day of week (or month) schedule, or shall be manually selected by the operator. Provide a warm standby boiler shell aquastat input for each boiler. If recommended by the boiler manufacturer, each off-line boiler shall be started and held at low fire when the temperature drops. When called to run, the boiler shall hold at low fire until the temperature rises above the warm standby setting. Provide an aquastat release to modulate over-ride timer to prevent a protracted low fire hold. The Control System shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

### 5. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/date stamp and English language description.

### 6. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "hand-off-auto" control switches must be wired directly into every boiler start/stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 7. Communication

The Control System shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol, and to a Personal Computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

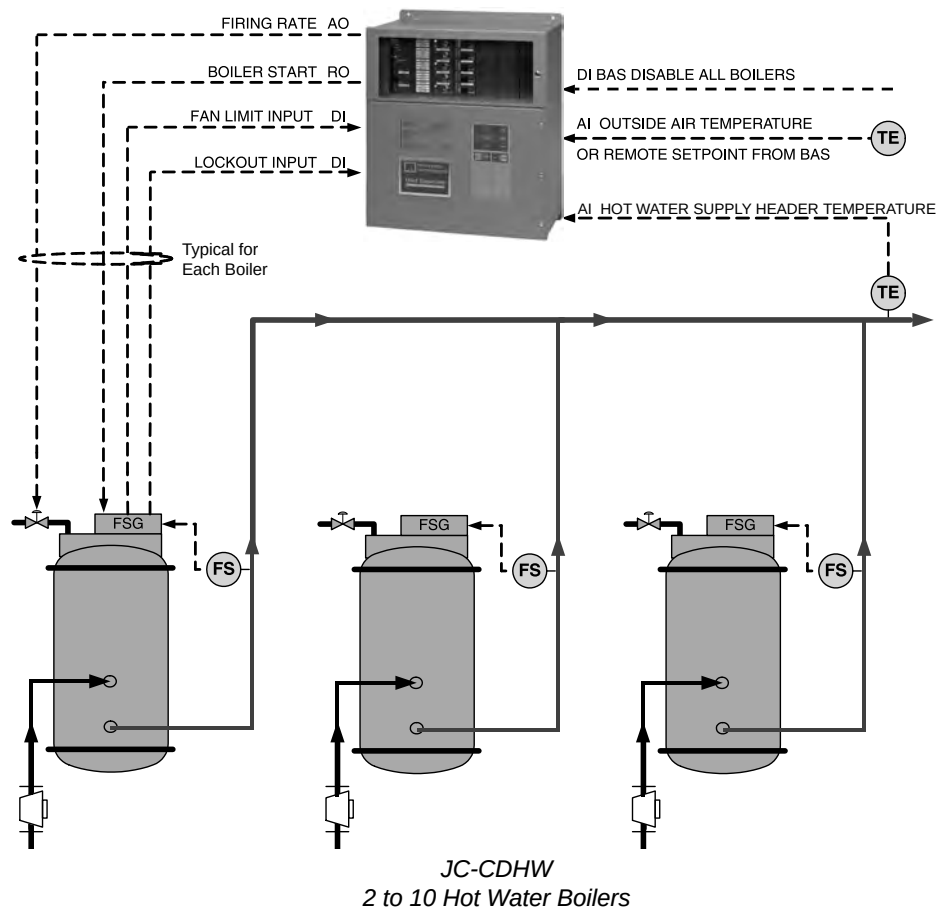
### 8. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDST-x-P ('x' = boiler quantity from 2 to 10; "-P" for 0-135 ohm; "-I" for 4-20 mA).



## CHIEF DISPATCHER MODEL JC-CDHW

### Hot Water Boilers Modulating Lead/Lag Controller



#### Application

The Chief Dispatcher Model JC-CDHW optimizes hot water system performance and helps extend Cast Iron Sectional, Finned-Tube, Firebox or Flexible Tube boiler life.

#### 2 to 10 Fully Modulating Boilers

Hot Water Supply (HWS) header temperature is maintained using accurate PID control. Multiple boilers are modulated in “Unison” (all at the same firing rate) to ensure even heat delivery. Lag boilers are brought up to the “Unison” firing rate using a predetermined Ramp Rate to meet the heating load with minimum overshoot. When desired, the operator may set the “unison” firing rate manually.

#### Outdoor Reset

Energy is saved by lowering the Hot Water Supply (HWS) temperature setpoint as the outside air temperature increases. Operating cost is reduced during warmer days. When desired, the operator may set the HWS setpoint manually.

#### Time of Day / Week Setback

This feature is used in heating applications to save energy by lowering the Hot Water Supply (HWS) temperature setpoint during times when the heating requirement is reduced, such as at night or on weekends and holidays.

#### Domestic Hot Water Priority (2 to 9 boiler systems)

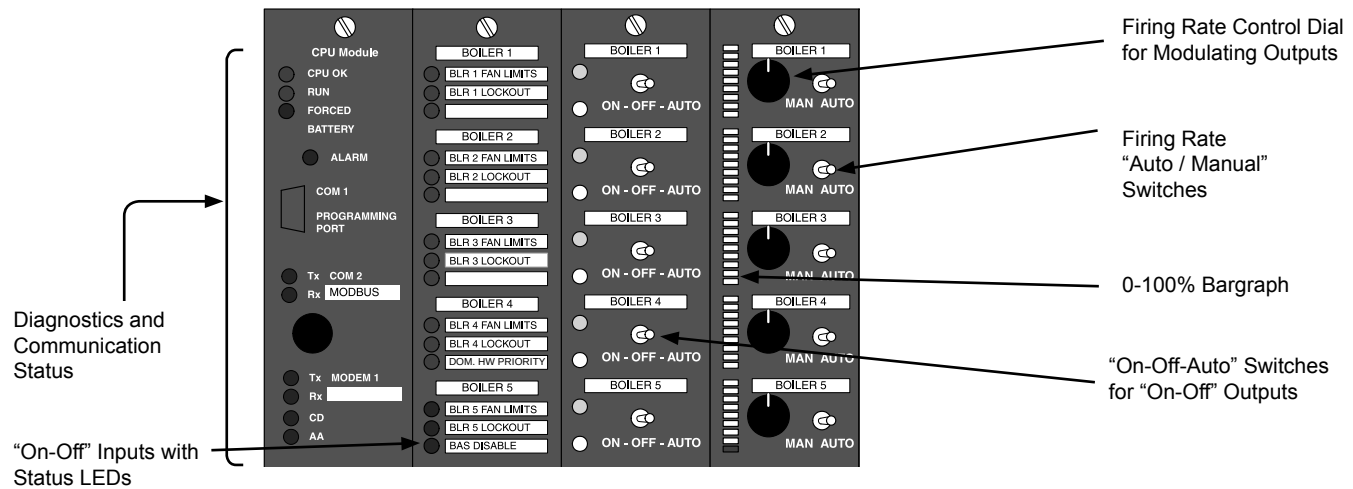
A temperature switch (thermostat) contact closure input will override the “outdoor reset and “setback” portion of the program and force the HWS temperature setpoint to a domestic hot water setpoint. A relay output is available to start a domestic hot water pump if required.

#### Condensing Boiler Logic (option “-C”)

Condensing boiler logic takes full advantage of the condensing boiler design by maximizing the number of boilers running near low fire to maximize efficiency.

# CHIEF DISPATCHER MODEL JC-CDHW

## Hot Water Boilers Modulating Lead/Lag Controller



5 Boiler Controller Front Panel Shown

### Specifications

#### Panel Details

Controller: PWC  
Case Size: 19¼" H X 18" W X 8½" D  
Enclosure Type: Wall mounted, Weight: 55 lbs.

#### Inputs

Hot Water Temperature: 0° to 300° F, Thermistor  
Outdoor Air Temperature: Thermistor (non "BAS" version)  
BAS Reset Setpoint: 4-20 mADC ("BAS" version)  
BAS Boiler Disable: 120 VAC, optically isolated (each boiler)  
Limits: 120 VAC, optically isolated (each boiler)  
Boiler Lockout: 120 VAC, optically isolated (each boiler)  
Domestic HW Priority: 120 VAC, optically isolated

#### Outputs

Modulation: Isolated 4-20 mADC or 0-135 ohm (each boiler)  
Boiler Start: Dry contact, 8 FLA, ½ HP, 120 VAC (each boiler)  
Domestic HW Circulation Pump: Dry contact, 8 FLA, ½ HP, 120 VAC

### Ordering Information

Specify Chief Dispatcher Catalog Number:

Boiler Quantity 2 to 10  
Analog Output Type 4-20 mADC - I  
0-135 ohm - P

JC-CDHW - 2 - P

| Optional Features                                                  | Catalog Number |
|--------------------------------------------------------------------|----------------|
| Building Automation System (BAS) 4-20 mADC Setpoint                | JC-CDHWxxx-BAS |
| Condensing Boiler Logic                                            | JC-CDHWxxx-C   |
| Order Sensors Separately (Quantity as Required)                    | Catalog Number |
| Hot Water Thermistor Temperature Sensor 0° to 300° F, 4½" depth    | 70610          |
| Thermowell, SS, 4½" x ½" NPT                                       | 70610W         |
| Outside Air Thermistor Temperature Sensor with weather-proof cover | 70612          |

## CHIEF DISPATCHER MODEL JC-CDHW

### Suggested Specifications

#### 1. Application

Supply a fully integrated boiler control system to coordinate the operation of two (select up to ten) fully modulating hot water boilers in order to maintain the Hot Water Supply (HWS) temperature at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.

#### 2. Boiler Modulation

The control system shall incorporate a HWS header temperature PID control scheme. Boilers shall be modulated in "Unison" (all at the same firing rate). Modulation signals shall be 4-20 mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

#### 3. Hot Water Supply (HWS) Temperature Setpoint

When the HWS Temperature control loop is in the "automatic" mode, the control system shall establish the HWS temperature setpoint based on the time of day, day of the week and the outside air temperature. When in "manual" mode the operator may set the HWS temperature via a front panel display. All temperatures and time/date data must be field adjustable through "fill-in-the-blanks" style displays. Alternately, the control system shall accept a 4-20 mADC outdoor air temperature reset setpoint signal from an external Building Automation System (BAS).

#### 4. Boiler Sequence

The control system shall utilize both HWS temperature and boiler firing rate percent to start and stop the boilers and shall minimize the total number of boilers in operation. The controller shall start and stop boilers when the HWS temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize header temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day, day of week (or month) schedule, or shall be manually selected by the operator. The boiler shall be run at low fire for warm-up for a preset low fire hold time. The base load ramp rate shall be field adjustable. The Control System shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

#### 5. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with Time/Date stamp and English language description.

#### 6. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "Hand-Off-Auto" control switches must be wired directly into every boiler and pump Start/Stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with Auto/Manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

#### 7. Communication

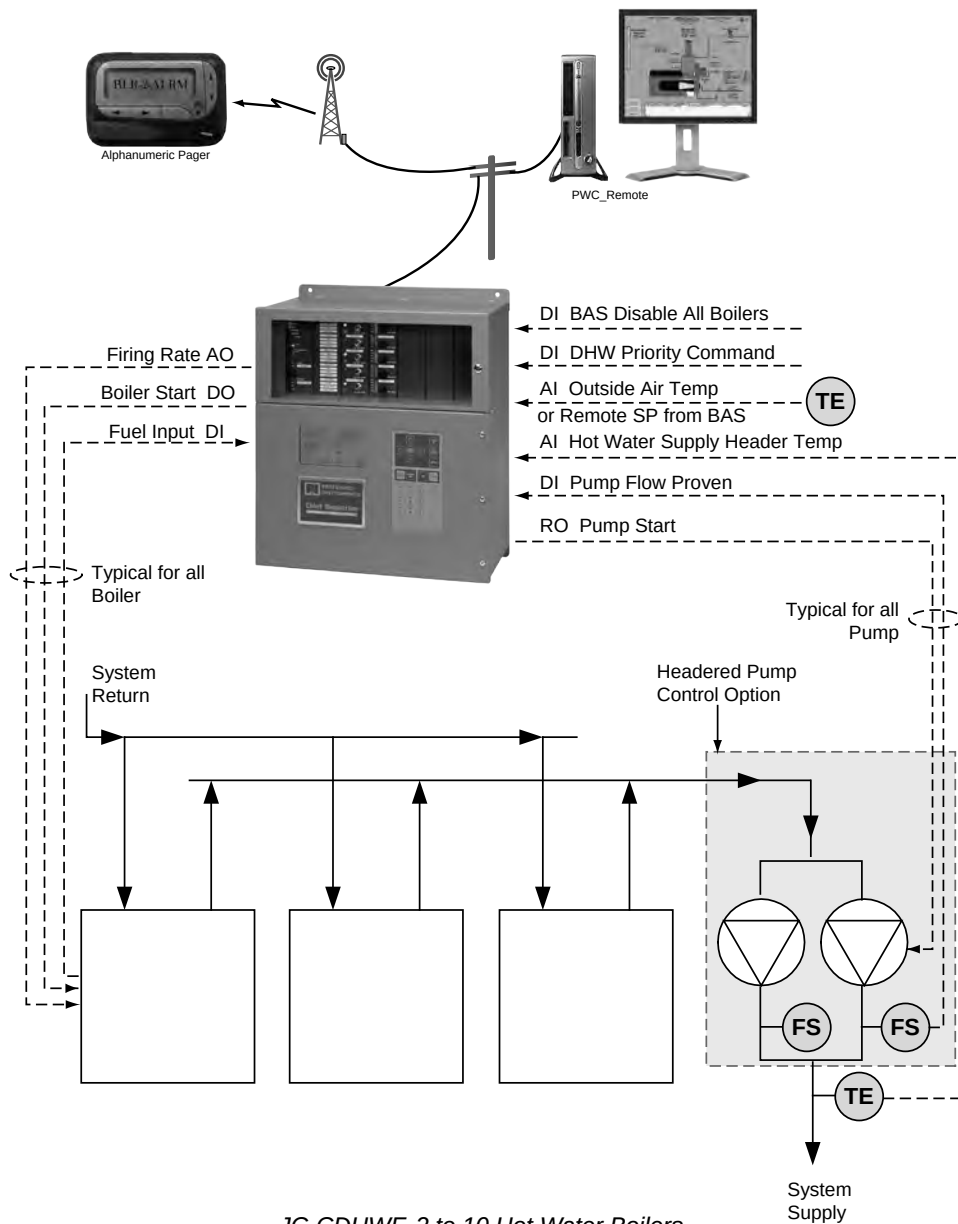
The Control System shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a Personal Computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

#### 8. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDHW-x-P ('x' = boiler quantity from 2 to 10; "-P" for 0-135 ohm; "-I" for 4-20 mA).

# CHIEF DISPATCHER MODEL JC-CDHWF

Condensing Hot Water Boilers Modulating Lead/Lag Controller



JC-CDHWF, 2 to 10 Hot Water Boilers  
and optional header pump control

## Application

The Chief Dispatcher Model JC-CDHWF optimizes hot water system performance and helps extend Cast Iron Sectional, Finned-Tube, Firebox or Flexible Tube boiler life.

### 2 to 10 Fully Modulating Boilers

Hot Water Supply (HWS) header temperature is maintained using accurate PID control. Multiple boilers are modulated in "Unison" (all at the same firing rate) to ensure even heat is delivered evenly. Lag boilers are brought up to the "unison" firing rate using a predetermined ramp rate to meet the heating load with minimum overshoot. When desired, the operator may set the "unison" firing rate manually.

### Outdoor Reset

Energy is saved by lowering the Hot Water Supply (HWS) temperature setpoint as the outside air temperature increases. Operating cost is reduced during warmer days. When desired, the operator may set the HWS setpoint manually.

### Simplified Design

The installation is reduced by monitoring only the fuel valve instead of the normal limits and lockout. Outdoor reset or BAS setpoint as well as how many boilers are installed is field selectable without reprogramming the unit.



## CHIEF DISPATCHER MODEL JC-CDHWF

### Condensing Hot Water Boilers Modulating Lead/Lag Controller

#### Time of Day / Week Setback

This feature is used in heating applications to save energy by lowering the Hot Water Supply (HWS) temperature setpoint during times when the heating requirement is reduced, such as at night or on weekends and holidays.

#### Domestic Hot Water Priority (2 to 9 boiler systems)

A temperature switch (thermostat) contact closure input will override the “outdoor reset” and “setback portion” of the program and force the HWS temperature setpoint to a domestic hot water setpoint. A relay output is available to start a domestic hot water pump if required.

#### Condensing Boiler Logic

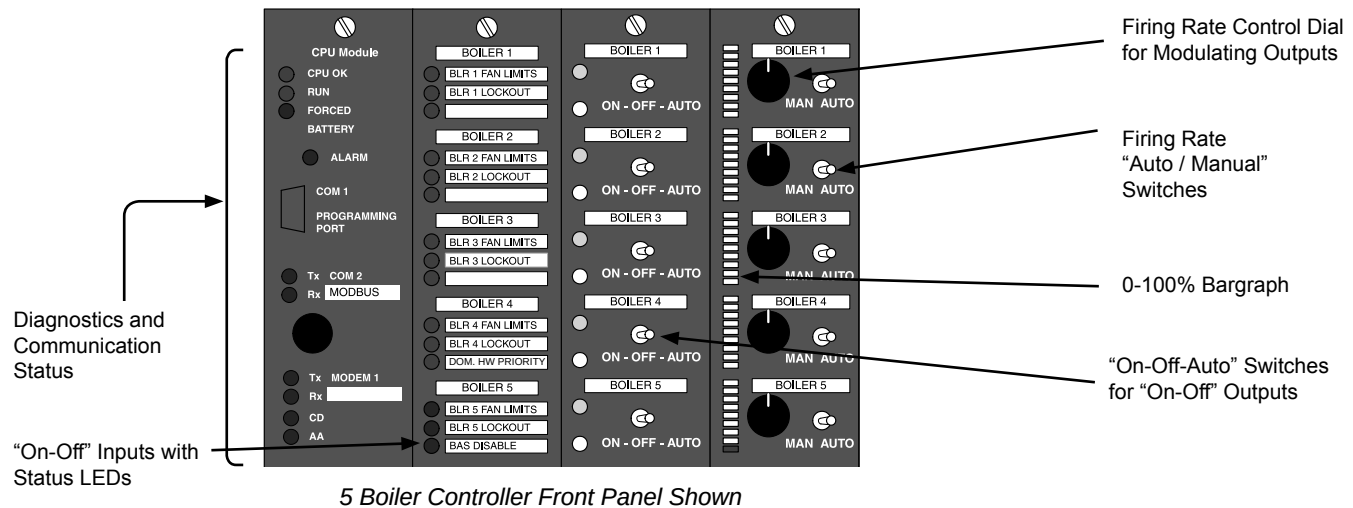
Condensing boiler logic takes full advantage of the condensing boiler design by maximizing the number of boilers running near low fire to increase efficiency.

#### Header Pump Control

Header circulating pumps are controlled to ensure a continuous flow of water through the heating system. Pumps are controlled for handling the plant, and a tripped pump is automatically replaced with a standby unit. The lead pump can be rotated manually or automatically.

# CHIEF DISPATCHER MODEL JC-CDHWF

Condensing Hot Water Boilers Modulating Lead/Lag Controller



## Specifications

### Panel Details

Controller: PWC  
Case Size: 19¼" H X 18" W X 8½" D  
Enclosure Type: Wall mounted, Weight: 55 lbs.

### Inputs

Hot Water Temperature: 0° to 300° F, Thermistor  
Outdoor Air Temperature: Thermistor  
BAS Reset Setpoint: 4-20 mADC  
BAS Boiler Disable: 120 VAC, optically isolated (each boiler)  
Fuel: 120 VAC, optically isolated (each boiler)  
Domestic HW Priority: 120 VAC, optically isolated

### Outputs

Modulation: Isolated 4-20 mADC or 0-135 ohm (each boiler)  
Boiler Start: Dry contact, 8 FLA, ½ HP, 120 VAC(each boiler)  
Domestic HW Circulation Pump: Dry contact, 8 FLA, ½ HP, 120 VAC

## Ordering Information

Specify Chief Dispatcher Catalog Number:

Boiler Quantity: 2 to 10  
Analog Output Type: 4-20 mADC - I, 0-135 ohm - P, Condensing  
Header Pump

JC-CDHWF - 2 - P C H

| Optional Features                                                 | Catalog Number |
|-------------------------------------------------------------------|----------------|
| Header Pump Control                                               | JC-CDHWFxxx-H  |
| Order Sensors Separately (Quantity as Required)                   | Catalog Number |
| Hot Water Thermistor Temperature Sensor 0° to 300° F, 4½" depth   | 70610          |
| Thermowell, SS, 4½" x ½" NPT                                      | 70610W         |
| Outside Air Thermistor Temperature Sensor with weatherproof cover | 70612          |

## CHIEF DISPATCHER MODEL JC-CDHWF

### Suggested Specifications

#### 1. Application

Supply a fully integrated boiler control system to coordinate the operation of two (select up to ten) fully modulating, condensing hot water boilers and header secondary water circulating pumps in order to maintain the Hot Water Supply (HWS) temperature at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.

#### 2. Boiler Modulation

The control system shall incorporate a HWS header temperature PID control scheme. Boilers shall be modulated in "Unison" (all at the same firing rate). Modulation signals shall be 4-20 mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

#### 3. Hot Water Supply (HWS) Temperature Setpoint

When the HWS Temperature control loop is in the "automatic" mode, the control system shall establish the HWS temperature setpoint based on the time of day, day of the week and the outside air temperature. When in "manual" mode the operator may set the HWS temperature via a front panel display. All temperatures and time/date data must be field adjustable through "fill-in-the-blanks" style displays. Alternately, the control system shall accept a 4-20 mADC outdoor air temperature reset setpoint signal from an external Building Automation System (BAS).

#### 4. Boiler Sequence

The control system shall use both HWS temperature and boiler firing rate percent to start and stop the boilers, minimizing the total number of boilers in operation. The controller shall start and stop boilers when the HWS temperature is outside the adjustable temperature limit for longer than the adjustable time delay. To minimize header temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor boiler fuel valve circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day, day of week (or month) schedule, or shall be manually selected by the operator. The boiler shall be run at low fire for warm-up for a preset low fire hold time. The base load ramp rate shall be field adjustable. The control system shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

#### 5. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events, and operator actions shall be logged with Time/Date stamp and English language description.

#### 6. Reliability

Include hardwired backup stations to permit manual operation of the plant if the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "Hand-Off-Auto" control switches must be wired directly into every boiler and pump Start/Stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with Auto/Manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

#### 7. Communication

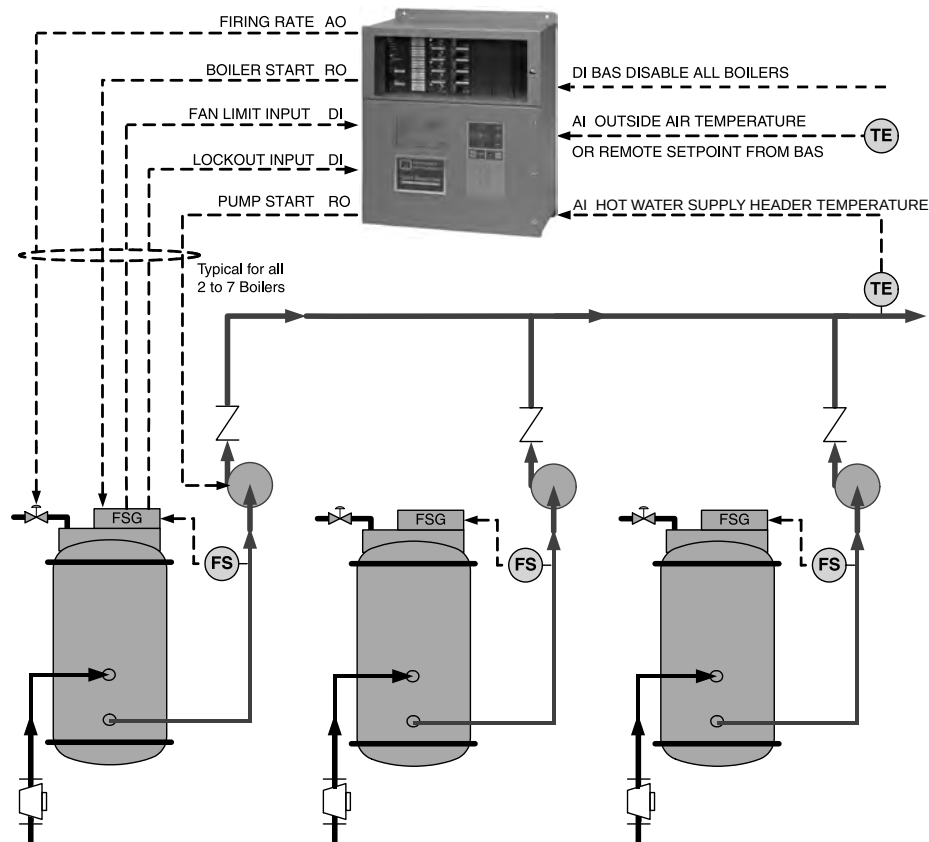
The Control System shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a Personal Computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be read. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be readable and writable.

#### 8. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDHWF-C-H-x-P ('x' = boiler quantity from 2 to 10; "-P" for 0-135 ohm; "-I" for 4-20 mA).

## CHIEF DISPATCHER MODEL JC-CDHWBP

### Hot Water Boilers with Boiler Pumps Modulating Lead/Lag Controller



2 to 7 Hot Water Boilers and Primary Loop Pumps

#### Application

The Chief Dispatcher Model JC-CDHWBP optimizes hot water system performance and helps extend Cast Iron Sectional, Finned-Tube, Firebox or Flexible Tube boiler life. Boiler pump sequencing ensures accurate temperature sensing, and boiler cool down.

#### 2 to 7 Fully Modulating Boilers

Hot Water Supply (HWS) header temperature is maintained using accurate PID control. Multiple boilers are modulated in “Unison” (all at the same firing rate) to ensure even heat delivery. Lag boilers are brought up to the “Unison” firing rate using a predetermined Ramp Rate to meet the heating load with minimum overshoot. The operator may set the “Unison” firing rate manually.

#### Boiler Pump Sequencing

In line, boiler pump sequencing keeps the lead boiler pump running (therefore water flowing past the header sensor) to ensure accurate header temperature sensing and provides pump shutdown delay for boiler cool down. Dedicated boiler outlet valves (relay output to open) can be controlled instead of dedicated boiler pump.

#### Outdoor Reset

Energy is saved by decreasing the Hot Water Supply (HWS) temperature setpoint as the outside air temperature increases. Operating cost is reduced during warmer days. The operator may set the HWS setpoint manually.

#### Time of Day / Week Setback

This feature is used in heating applications to save energy by lowering the Hot Water Supply (HWS) temperature setpoint during times when the heating requirement is reduced, such as nights, weekends, and holidays.

#### Domestic Hot Water Priority

A temperature switch (thermostat) contact closure input will override the Outdoor Reset and Setback portion of the program and force the HWS temperature setpoint to a Domestic Hot Water Setpoint. A relay output is available to start a domestic hot water pump if required.

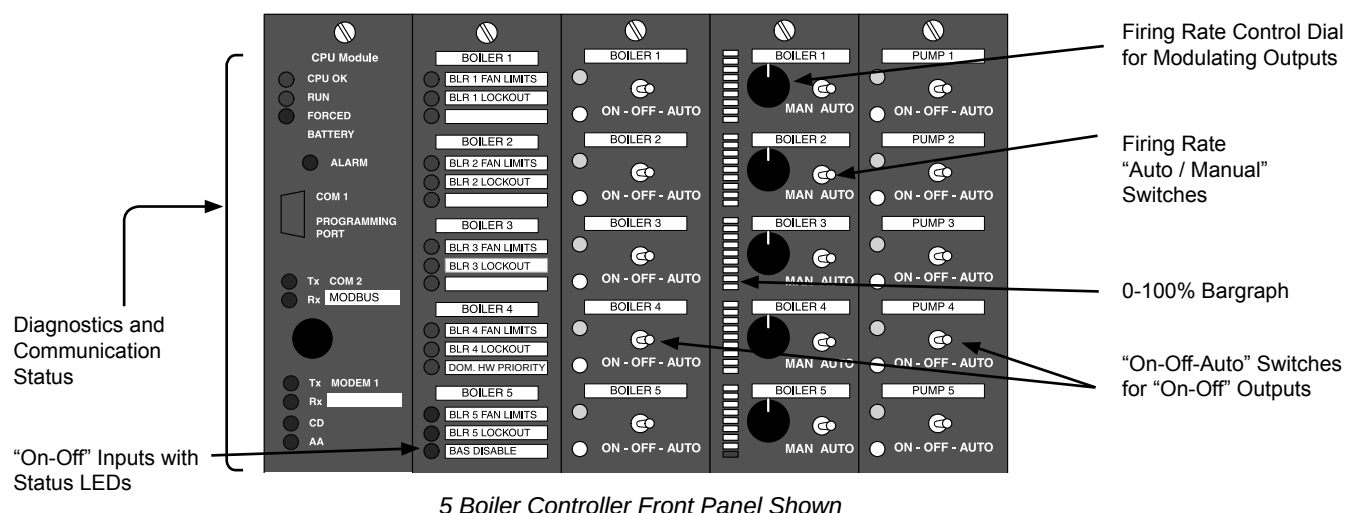
#### Condensing Boiler Logic (option “-C”)

Condensing boiler logic uses the condensing boiler design to maximize the number of boilers running near low fire to maximize efficiency.



# CHIEF DISPATCHER MODEL JC-CDHWBP

Hot Water Boilers with Boiler Pumps Modulating Lead/Lag Controller



5 Boiler Controller Front Panel Shown

## Specifications

### Panel Details

Controller: PWC  
Case Size: 19¼" H X 18" W X 8½" D  
Enclosure Type: Wall mounted, Weight: 55 lbs.

### Inputs

Hot Water Temperature: 0° to 300° F, Thermistor  
Outdoor Air Temperature: Thermistor (non "BAS" version)  
BAS Reset Setpoint: 4-20 mADC ("BAS" version)  
BAS Boiler Disable: 120 VAC, optically isolated (each boiler)  
Limits: 120 VAC, optically isolated (each boiler)  
Boiler Lockout: 120 VAC, optically isolated (each boiler)  
Domestic HW Priority: 120 VAC, optically isolated

### Outputs

Modulation: Isolated 4-20 mADC or 0-135 ohm (each boiler)  
Boiler Start: Dry contact, 8 FLA, ½ HP, 120 VAC (each boiler)  
Pump Start: Dry contact, 8 FLA, ½ HP, 120 VAC (each boiler)  
Domestic HW Circulation Pump: Dry contact, 8 FLA, ½ HP, 120 VAC

## Ordering Information

Specify Chief Dispatcher Catalog Number:

Boiler Quantity 2 to 7  
Analog Output Type 4-20 mADC - I  
0-135 ohm - P

| Optional Features                                                 | Catalog Number    |
|-------------------------------------------------------------------|-------------------|
| Building Automation System (BAS)                                  | add "-BAS" suffix |
| 4-20 mADC Setpoint                                                |                   |
| Condensing Boiler Logic                                           | add "-C" suffix   |
| Order Sensors Separately (Quantity as Required)                   | Catalog Number    |
| Hot Water Thermistor Temperature Sensor 0° to 300° F, 4½" depth   | 70610             |
| Thermowell, SS, 4½" x ½" NPT                                      | 70610W            |
| Outside Air Thermistor Temperature Sensor with weatherproof cover | 70612             |

# CHIEF DISPATCHER MODEL JC-CDHWBP

## Suggested Specifications

### 1. Application

Supply a fully integrated boiler control system to coordinate the operation of two (select up to seven) fully modulating hot water boilers and boiler primary water circulating pumps in order to maintain the Hot Water Supply (HWS) temperature at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Boiler Modulation

The control system shall incorporate a HWS header temperature PID control scheme. Boilers shall be modulated in "Unison" (all at the same firing rate). Modulation signals shall be 4-20 mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

### 3. Hot Water Supply (HWS) Temperature Setpoint

When the HWS Temperature control loop is in the "automatic" mode, the control system shall establish the HWS temperature setpoint based on the time of day, day of the week and the outside air temperature. When in "manual" mode the operator may set the HWS temperature via a front panel display. All temperatures and time/date data must be field adjustable through "fill-in-the-blanks" style displays. Alternately, the control system shall accept a 4-20 mADC outdoor air temperature reset setpoint signal from an external Building Automation System (BAS).

### 4. Boiler Sequence

The control system shall utilize both HWS temperature and boiler firing rate percent to start and stop the boilers and shall minimize the total number of boilers in operation. The controller shall start and stop boilers when the HWS temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize header temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day, day of week (or month) schedule, or shall be manually selected by the operator. The boiler shall be run at low fire for warm-up for a preset low fire hold time. The base load ramp rate shall be field adjustable. The control system shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

### 5. Boiler Pump Sequence

Include independently operated primary water pump control to allow boiler warm-up to the return water temperature before the boilers start, continue water flow for an adjustable cool down period after the boiler has stopped, and ensure water is always moving past the header temperature sensor even after the last boiler has been stopped. The pump shall immediately stop if any trips occur during pre-purge, pilot, or main flame trial for ignition.

### 6. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/date stamp and English language description.

### 7. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "hand-off-auto" control switches must be wired directly into every boiler and pump start/stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 8. Communication

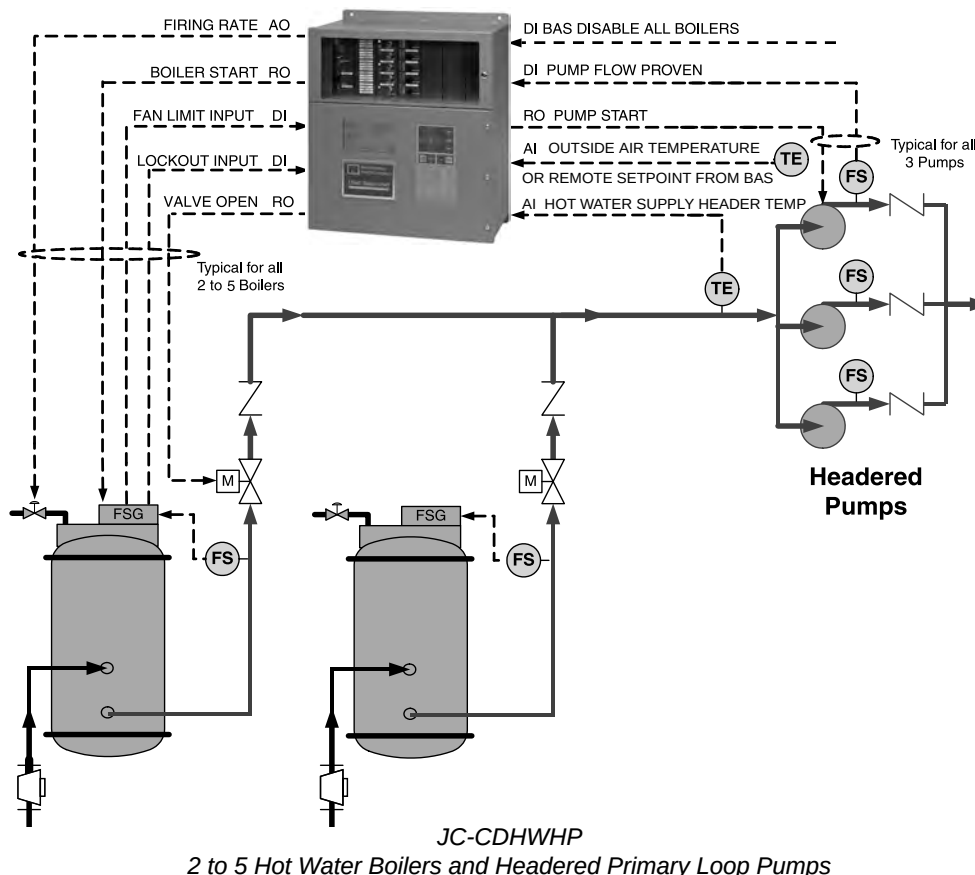
The control system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a Personal Computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be readable and writable.

### 9. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDHWBP-X-P ('X' = boiler quantity from 2 to 7; "-P" for 0-135 ohm; "-I" for 4-20 mA).

## CHIEF DISPATCHER MODEL JC-CDHWP

### Hot Water Boilers with Header Pumps Modulating Lead/Lag Controller



#### Application

The Chief Dispatcher Model JC-CDHWP optimizes hot water system performance, and helps extend Cast Iron Sectional, Finned-Tube, Fire Box or Flexible Tube boiler life. Header pump sequencing ensures accurate temperature sensing and a failed pump is replaced with a backup pump.

#### 2 To 5 Modulating Boilers

Hot Water Supply (HWS) header temperature is maintained using accurate PID control. Multiple boilers are modulated in “unison” (all at the same firing rate) to ensure even heat delivery. Lag boilers are brought up to the “unison” firing rate using a predetermined ramp rate to meet the heating load with minimum overshoot. When desired, the operator may set the “unison” firing rate manually.

#### Header Pump Sequencing

Header pump sequencing keeps the lead boiler pump running (therefore water flowing past the header sensor) to ensure accurate header temperature sensing and provides pump shutdown delay for boiler cool down. Additionally, a failed pump is automatically replaced with a backup.

#### Outdoor Reset

Energy is saved by lowering the Hot Water Supply (HWS) temperature setpoint as the outside air temperature increases. Operating cost is reduced during warmer days. When desired, the operator may set the HWS setpoint manually.

#### Time Of Day / Week Setback

This feature is used in heating applications to save energy by lowering the Hot Water Supply (HWS) temperature setpoint during times when the heating requirement is reduced, such as at nights, weekends, and holidays.

#### Domestic Hot Water Priority

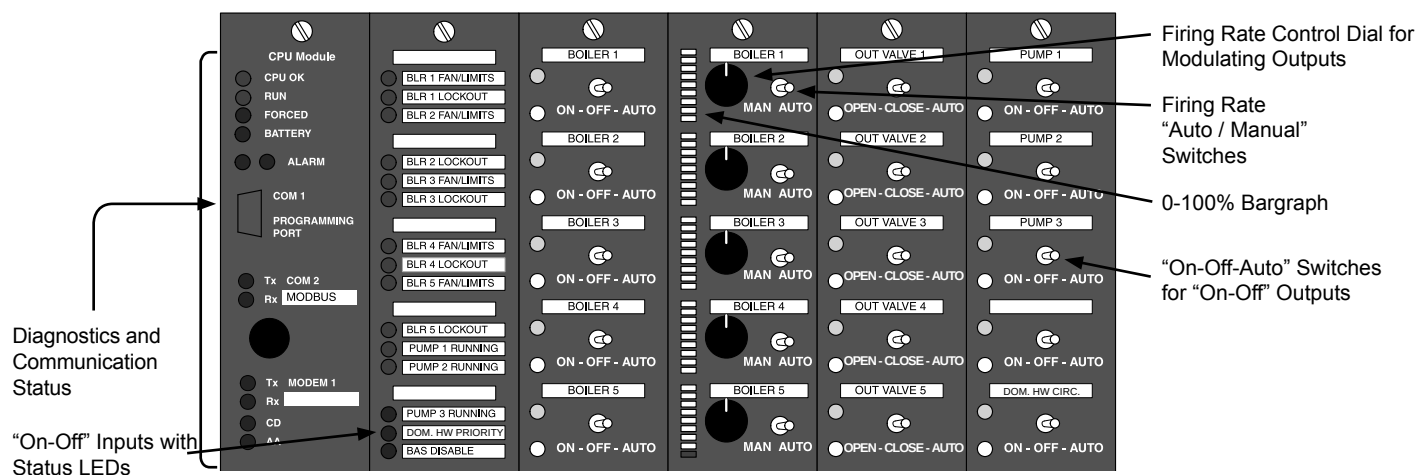
A temperature switch (thermostat) contact closure input will override the “outdoor reset” and “setback” portion of the program and force the HWS temperature setpoint to a “domestic hot water setpoint.” A relay output is available to start a domestic hot water pump if required.

#### Condensing Boiler Logic (Option “-C”)

Condensing boiler logic takes full advantage of the condensing boiler design by maximizing the number of boilers running near low fire to maximize efficiency.

# CHIEF DISPATCHER MODEL JC-CDHWHP

Hot Water Boilers with Header Pumps Modulating Lead/Lag Controller



5 Boiler Controller Front Panel

## Specifications

### Panel Details

Controller: PWC  
Case Size: 19 1/4" H X 18" W X 8 1/2" D  
Enclosure Type: Wall mounted, Weight: 55 lbs.

### Inputs

Hot Water Header: 0° to 300° F, Thermistor  
Outdoor Air: Thermistor (non "-BAS" version)  
BAS Reset Setpoint: 4-20 mADC ("BAS" version)  
BAS Boiler Disable: 120 VAC, optically isolated  
Limits: 120 VAC, optically isolated (each boiler)  
Boiler Lockout: 120 VAC, optically isolated (each boiler)  
Pump Flow Proven: 120 VAC, optically isolated (each boiler)  
Domestic HW Priority: 120 VAC, optically isolated

### Outputs

Modulation: Isolated 4-20 mADC or 0-135 ohm (each boiler)  
Boiler Start: Dry Contact, 8 FLA, 1/2 HP, 120 VAC (each boiler)  
Pump Start: Dry Contact, 8 FLA, 1/2 HP, 120 VAC (each boiler)  
Valve Open: Dry Contact, 8 FLA, 1/2 HP, 120 VAC (each boiler)  
Domestic HW Circulation Pump: Dry Contact, 8 FLA, 1/2 HP, 120 VAC

## Ordering Information

Specify Chief Dispatcher Catalog Number:

Boiler Quantity 2 to 5  
Analog Output Type 4-20 mADC - I  
Header Pump Quantity 2 to 3

JC-CDHWHP - 2 - P - 2

| Optional Features                                                  | Catalog Number    |
|--------------------------------------------------------------------|-------------------|
| Building Automation System (BAS) 4-20 mADC Setpoint                | add "-BAS" suffix |
| Condensing Boiler Logic                                            | add "-C" suffix   |
| Order Sensors Separately (Quantity as Required)                    | Catalog Number    |
| Hot Water Thermistor Temperature Sensor 0° to 300° F, 4 1/2" depth | 70610             |
| Thermowell, SS, 4.5" x 1/2 NPT                                     | 70610W            |
| Outside Air Thermistor Temperature Sensor with weatherproof cover  | 70612             |



# CHIEF DISPATCHER MODEL JC-CDHWHP

## Suggested Specifications

### 1. Application

Supply a fully integrated boiler control system to coordinate the operation of two (select up to five) fully modulating hot water boilers, two (select up to three) header primary water circulating pumps and boiler water flow control valves in order to maintain the Hot Water Supply (HWS) temperature at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Boiler Modulation

The control system shall incorporate a HWS header temperature PID control scheme. Boilers shall be modulated in "unison" (all at the same firing rate). Modulation signals shall be 4-20mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

### 3. Hot Water Supply (HWS) Temperature Setpoint

When the HWS Temperature control loop is in the "automatic" mode, the control system shall establish the HWS temperature setpoint based on the time of day, day of the week and the outside air temperature. When in "manual" mode the operator may set the HWS temperature via a front panel display. All temperatures and time/date data must be field adjustable through "fill-in-the-blanks" style displays. Alternately, the control system shall accept a 4-20 mADC outdoor air temperature reset setpoint signal from an external Building Automation System (BAS).

### 4. Boiler Sequence

The control system shall utilize both HWS temperature and boiler firing rate percent to start and stop the boilers and shall minimize the total number of boilers in operation. The controller shall start and stop boilers when the HWS temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize header temperature deviations the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day, day of week (or month) schedule, or shall be manually selected by the operator. The boiler shall be run at low fire for warm-up for a preset low fire hold time. The base load ramp rate shall be field adjustable. The control system shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

### 5. Header Pump Sequence

Provide main header primary water pump control to improve fired equipment availability. Start the quantity of header pumps as required for the number of boilers in operation. The control system shall monitor pump outlet flow switch status to automatically start a standby pump when a command to start the pump fails to produce flow. System must keep at least one pump running to ensure water is always moving past the header temperature sensor even after the last boiler has been stopped.

### 6. Boiler Water Flow Control Valve Sequence

Provide boiler water flow valve control to prevent water from flowing through off-line boilers (and lowering the HWS temperature); continue water flow for an adjustable cool down period after the boiler has stopped, and ensure water is always moving past the header temperature sensor even after the last boiler has been stopped. The valve shall be immediately closed if any trips occur during pre-purge, pilot, or main flame trial for ignition.

### 7. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/date stamp and English language description.

### 8. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "Hand-Off-Auto" control switches must be wired directly into every boiler, pump, and valve start/stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 9. Communication

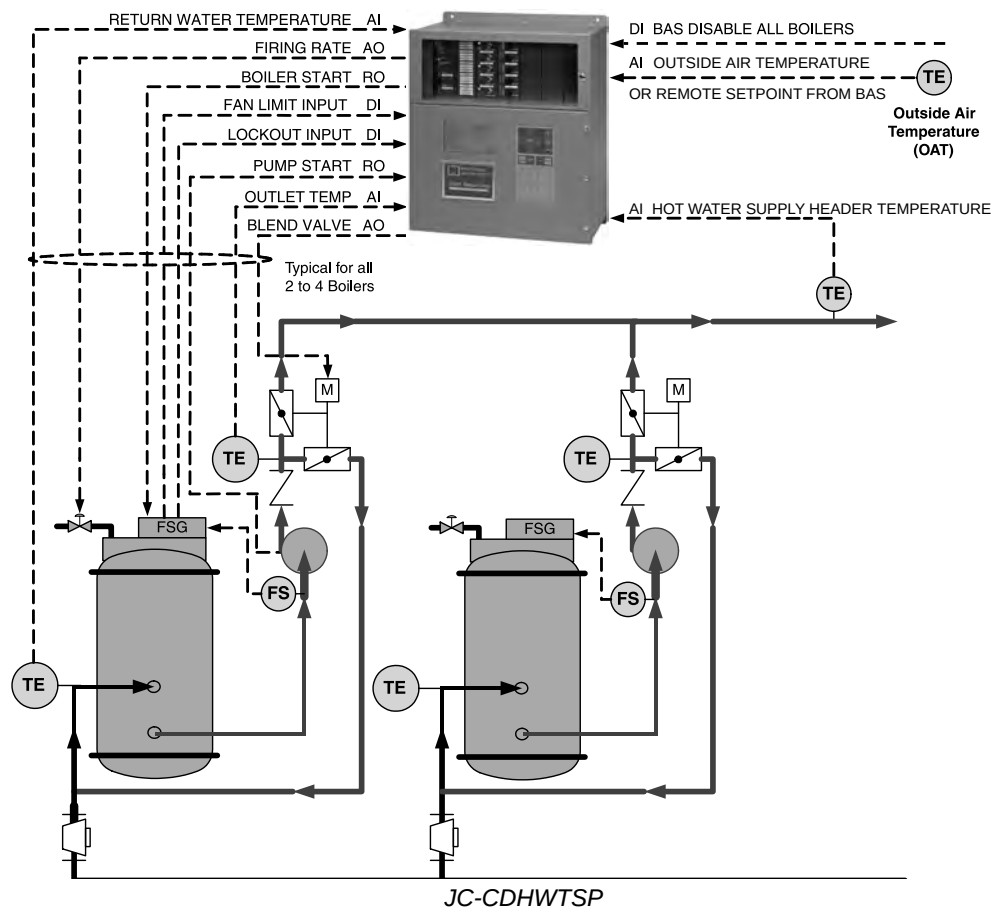
The control system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

### 10. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDHWHP-x-P-y ("x" = boiler quantity from 2 to 5; "-P" for 0-135 ohm; "-I" for 4-20 mA; "y" = pump quantity from 2 to 3).

## CHIEF DISPATCHER MODEL JC-CDHWTSP

Hot Water Boilers with Thermal Shock Protection Modulating Lead/Lag Controller



2 to 4 Hot Water Boilers, Primary Loop Pumps and Blend Valves

### Application

The Chief Dispatcher Model JC-CDHWTSP will optimize hot water system performance and help extend boiler life. Blend valves are used to allow off-line boiler warm-up and prevent thermal shock.

### 2 To 4 Modulating Boilers

Hot Water Supply (HWS) header temperature is maintained using accurate PID control. Multiple boilers are modulated in “unison” (all at the same firing rate) to ensure even heat delivery. Lag boilers are brought up to the “unison” firing rate using a predetermined ramp rate to meet the heating load with minimum overshoot. The operator may set the “unison” firing rate manually. Each boiler has an individual boiler outlet temperature sensor. If any boiler approaches its high temperature shutdown limit, it will cut back firing rate individually to prevent a boiler trip.

### Boiler Pump Sequencing

In line boiler pump sequencing keeps the lead boiler pump running (water flows past the header sensor) to ensure accurate header temperature sensing and provides pump shutdown delay for boiler cool down.

### Thermal Shock Protection

Individual boiler outlet 3-way recirculating valves are automatically positioned based on the boiler start sequence, boiler outlet and return water temperatures. If the boiler return water temperature drops below a low temperature setpoint, the valve opens to allow hot boiler outlet water to

blend with cold return water temperature. The valve slowly repositions toward 0% recirculation after return water rises above setpoint. When a boiler is called to operate, the 3-way valve is set to 95% recirculation. After the boiler starts and the outlet temperature is close to supply temperature setpoint, the valve slowly repositions toward 0% recirculation.

### Outdoor Reset

Energy is saved by lowering the Hot Water Supply (HWS) temperature setpoint as the outside air temperature increases. Operating cost is reduced during warmer days. The operator may set the HWS setpoint manually.

### Time Of Day/ Week Setback

This feature is used in heating applications to save energy by lowering the Hot Water Supply (HWS) temperature setpoint during times when the heating requirement is reduced, such as at night or on weekends and holidays.

### Domestic Hot Water Priority

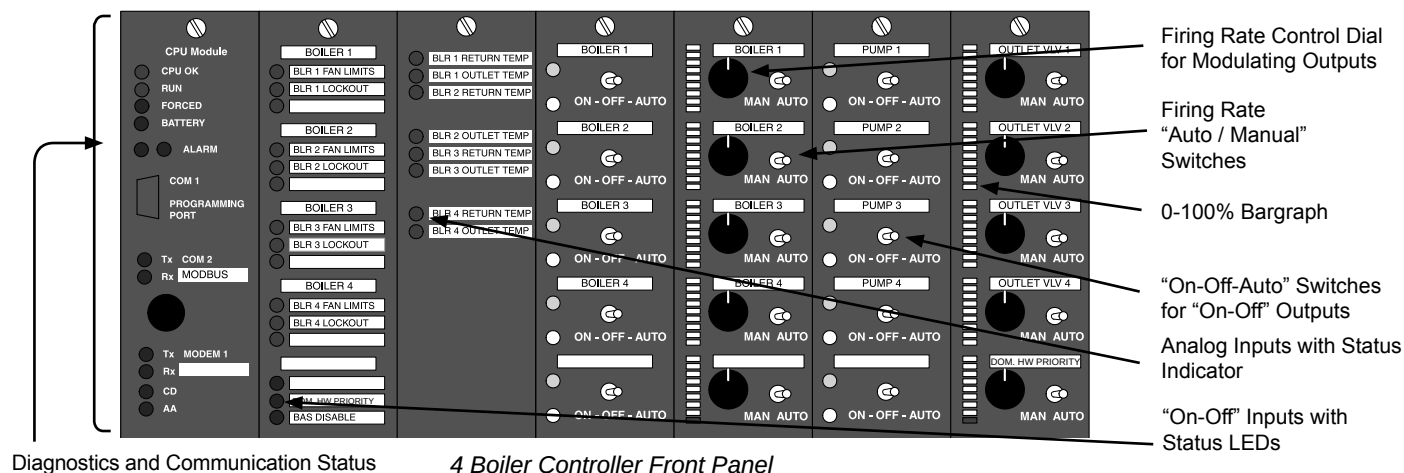
A temperature switch (thermostat) contact closure input will override the “outdoor reset” and “setback” portion of the program and force the HWS temperature setpoint to a domestic hot water setpoint. A relay output is available to start a domestic hot water pump if required.

### Condensing Boiler Logic (Option “-C”)

Condensing boiler logic takes full advantage of the condensing boiler design by maximizing the number of boilers running near low fire to maximize efficiency.

# CHIEF DISPATCHER MODEL JC-CDHWTSP

Hot Water Boilers with Thermal Shock Protection Modulating Lead/Lag Controller



Diagnostics and Communication Status

4 Boiler Controller Front Panel

## Specifications

### Panel Details

Controller: PWC  
Case Size: 19 1/4" H X 18" W X 8 1/2" D  
Enclosure Type: Wall mounted, Weight: 55 lbs.

### Inputs

Hot Water Temperature: 0° to 300° F, Thermistor  
Outlet Water: Thermistor (each boiler)  
Return Water: Thermistor (each boiler)  
Outdoor Air: Thermistor (non "-BAS" version)  
BAS Reset Setpoint: 4-20 mADC ("-BAS" version)  
BAS, Boiler Disable: 120 VAC, optically isolated  
Limits: 120 VAC, optically isolated (each boiler)  
Boiler Lockout: 120 VAC, optically isolated (each boiler)  
Domestic HW Priority: 120 VAC, optically isolated

### Outputs

Boiler Modulation: Isolated: 4-20 mADC or 0-135 ohm (each boiler)  
Balancing Valve: Isolated: 4-20 mADC (each boiler)  
Boiler Start: Dry contact, 8 FLA, 1/2 HP, 120 VAC (each boiler)  
Pump Start: Dry contact, 8 FLA, 1/2 HP, 120 VAC (each boiler)  
Domestic HW Circulation Pump: Dry contact, 8 FLA, 1/2 HP, 120 VAC

## Ordering Information

Specify Chief Dispatcher Catalog Number:

Boiler Quantity 2 to 4  
Analog Output Type 4-20 mADC - I  
0-135 ohm - P

| Optional Features                                            | Catalog Number    |
|--------------------------------------------------------------|-------------------|
| Building Automation System (BAS) 4-20 mADC Setpoint          | add "-BAS" suffix |
| Condensing Boiler Logic                                      | add "-C" suffix   |
| Order Sensors Separately (Quantity as Required)              | Catalog Number    |
| Hot Water Thermistor Temp. Sensor 0° to 300° F, 4 1/2" depth | 70610             |
| Thermowell, SS, 4 1/2" x 1/2" NPT                            | 70610W            |
| Outside Air Thermistor Temp. Sensor with weatherproof cover  | 70612             |

# CHIEF DISPATCHER MODEL JC-CDHWTSP

## Suggested Specifications

### 1. Application

Supply a fully integrated boiler hot water control system to coordinate the operation of two (select up to four) fully modulating hot water boilers, boiler water circulating pumps and boiler water flow control valves to maintain Hot Water Supply (HWS) temperature at setpoint and provide thermal shock protection. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Boiler Modulation

The control system shall incorporate a "cascade with cutback" HWS temperature PID control scheme. The HWS temperature shall be compared with a setpoint to establish a target boiler firing rate. If an individual boiler outlet temperature exceeds a pre-set maximum setpoint, that boiler's firing rate shall be automatically cutback by a PID loop to prevent a high temperature trip. Boilers shall be modulated in "unison" (all at the same firing rate). Modulation signals shall be 4-20 mADC or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.

### 3. Hot Water Supply (HWS) Temperature Setpoint

When the HWS Temperature control loop is in the "automatic" mode, the control system shall establish the HWS temperature setpoint based on the time of day, day of the week and the outside air temperature. When in "manual" mode the operator may set the HWS temperature via a front panel display. All temperatures and time/date data must be field adjustable through "fill-in-the-blanks" style displays. Alternately, the control system shall accept a 4-20mADC outdoor air temperature reset setpoint signal from an external Building Automation System (BAS).

### 4. Boiler Sequence

The control system shall use both HWS temperature and boiler firing rate percent to start and stop the boilers, minimizing the total number of boilers in operation. The controller shall start and stop boilers when the HWS temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize header temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate on a time of day, day of week (or month) schedule, or shall be manually selected by the operator. The boiler shall be run at low fire for warm-up for a preset low fire hold time. The control system shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

### 5. Boiler Pump Sequence

Include independently operated primary water pump control. System must keep at least one pump running to ensure water is always moving past the header temperature sensor.

### 6. Boiler Water Flow Control Valve Sequence

Provide control for an electric actuator, with slow opening (2 minute), flow balancing, two valve assembly for each boiler. The valve assembly shall link a boiler outlet valve and boiler water recirculation valve so that they operate as a single unit. The valves shall be arranged so that as one valve closes, the other valve opens, ensuring a continuous

flow of water through the boiler. The assembly shall accept a single 4-20 mADC signal to position both valves. This valve shall prevent water from flowing through off-line boilers (and lowering the HWS temperature), allow boiler warm-up to return water temperature before the boiler starts, continue water flow for an adjustable cool down period after the boiler has stopped, and ensure water is always moving past the header temperature sensor even after the last boiler has been stopped. Slowly jog open the valve over a 10-minute period (adjustable) to prevent boiler thermal shocking. If the boiler return water temperature is 50° F (adjustable) below the boiler outlet water temperature, the valve shall slowly jog closed, causing boiler outlet water to blend with the excessively cold return water. When the return water temperature returns to an acceptable range, the boiler outlet valve shall slowly jog open.

### 7. Operator Controls, Trends, Indications and Alarms

The control system shall include an 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/date stamp and English language description.

### 8. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "hand-off-auto" control switches must be wired directly into every boiler and pump start/stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 9. Communication

The control system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be readable and writable.

### 10. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-CDHWTSP-x-P ('x' = boiler quantity from 2 to 4; "-P" for 0-135 ohm; "-I" for 4-20 mADC).



## FEEDWATER CENTER

### Overview

Boiler feedwater control systems are often the most archaic controls in the steam plant. Poor boiler waterside control contributes to scaling, corrosion, and eventually hot spots and tube failures. The Preferred **Feedwater Center** can control the surge tank, Deaerator (DA) tank, transfer pumps, and feedwater pumps (on-off or VSD) to improve water quality and feedwater system reliability.

#### Better Feedwater Delivery Control

- “Smart” Pump Sequencing
- Pump Speed demand based Start-Stop
- Header Pressure based Start-Stop
- Lead-Lag Sequence
- Field Adjustable Parameters

#### Easy to Use

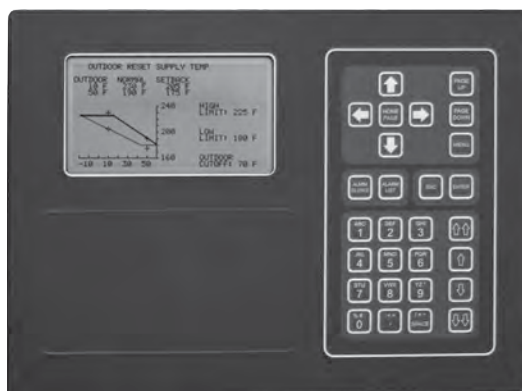
- “Overview”, “Alarm”, “Historical Trend” and “Setup” displays enable informed initial setup and process assessment.
- In a single NEMA 4 wall-mounted enclosure, the Feedwater Center integrates a modem for off-site monitoring, RS485 Modbus communications and 24 VDC power supplies.
- Optional 10” Operator Interface Touchscreen (OIT) provides graphical overviews as well as Ethernet TCP/IP and BacNet IP communication to BAS systems.

#### Easy to Order, Stock and Field Upgrade

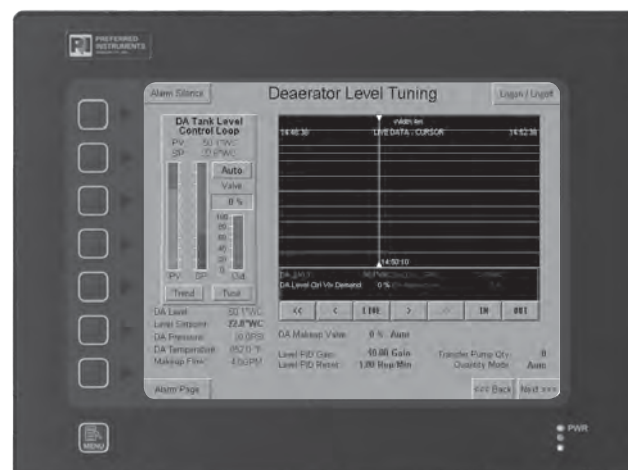
- Complete system is ordered using a single part number.
- “Plug In” option boards can be used to upgrade a system in the field.



Feedwater Center Control System



Standard Keypad/Display



With the optional 10" color touch screen, trend screens are provided to make it easy to tune level and temperature loops. Display brings plant overviews, outdoor reset, alarms and event status and setup displays right to the operator's touch.

## FEEDWATER CENTER

### Overview



*Feedwater Center Control System  
shown with optional 10" color touch screen OIT*

#### Smart Pump Sequencing

In "headered mode," pumps are automatically sequenced on/off to ensure that the number of pumps in service meets the demand. If any pump fails to start when called, the Feedwater Center immediately starts another pump to replace the faulted pump. The operator may manually select the lead pump or allow the lead pump to rotate automatically. Additionally, the total number of pumps in service may be set automatically or manually by the operator or all pumps may be shutdown by a building automation system (BAS) 'enable/disable' contact input.

#### Easy Installation & Setup

The Feedwater Center integrates Modbus communications, relays, 24 VDC power supplies, and outdoor reset functions into a single wall mountable controller. Simple menu-style fill-in-the-blanks setup displays minimize commissioning and training time.

#### LCD Graphic Display

LCD graphic display brings plant overviews, outdoor reset, alarms and event status and setup displays right to the operator's touch.

#### Alarms & Event Summary

Up to 200 alarms, system events and operator actions are listed in "first in first out" order with a time/date stamp. Alarms include system fault, pump failure and both over and under temperature conditions.

#### Hard Manual Backup

Hardwired control switches and dials provide simple manual control for easy troubleshooting and service. Each pump has an individual speed demand bar graph, a manual speed demand output knob, and an auto/manual switch.

#### Modbus Communication Interface

A factory configured RS485 MODBUS interface is available for building automation or SCADA system monitoring and control.

#### Optional Features

The Feedwater Center has many features that can be added or removed according to your needs. This controller was designed to accommodate the needs of any 1-4 pump system. It is able to run with a surge and a deaerator tank (or one of each, or none). It accommodates 0-3 transfer pumps and 0-4 feed water pumps. The JC-FWC-FC can be used in headered pump applications as well as individual feed water pumps to each boiler. The JC-FWC-FC can have all of these following sensors;

#### Temperature:

- Condensate Return Line
- DA Tank

#### Pressure:

- DA Tank
- Feedwater Header
- Steam Header
- Make Up Water

#### Level:

- 1 DA Tank
- 1 Surge Tank

#### Flow:

- Make Up Water Flow
- Condensate Return Flow

As well as controlling the speeds of up to three transfer pumps and four boiler feed pumps. The Feedwater Center controls a number of valves in order to maintain levels/pressures/flow rates within the system.

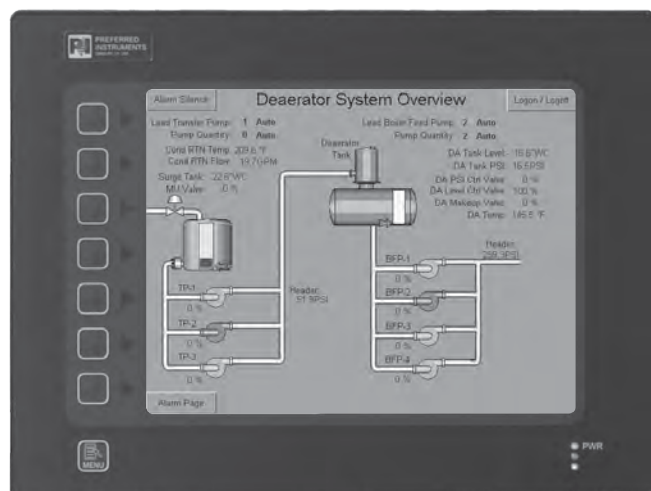
The following valves can be maintained:

- DA Level Valve
- DA PSI Control Valve
- Surge Tank Make Up Water Valve
- Chemical Feed Pump Valve

This system is easily configured by using the menu driven initial set-up screens. No programming knowledge is required.

## FEEDWATER CENTER

### Touch Screen Overview

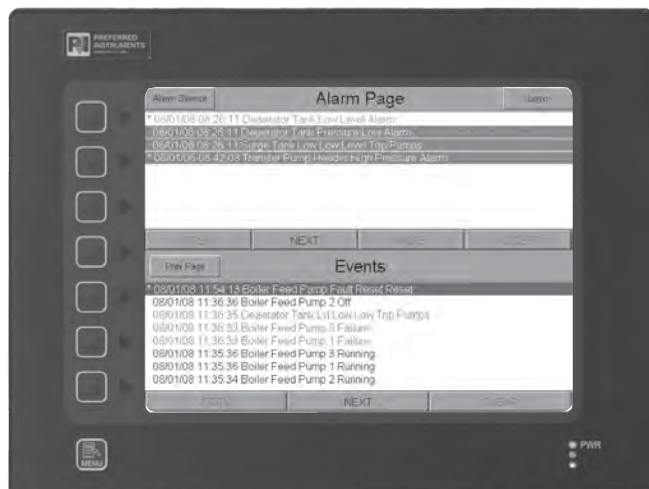


#### Touch Screen Overview

The optional 10" Operator Interface Terminal (OIT) touch screen provides graphical representation of current system status. Pump status, level indication, and valve position are all readily available on the system overview page.

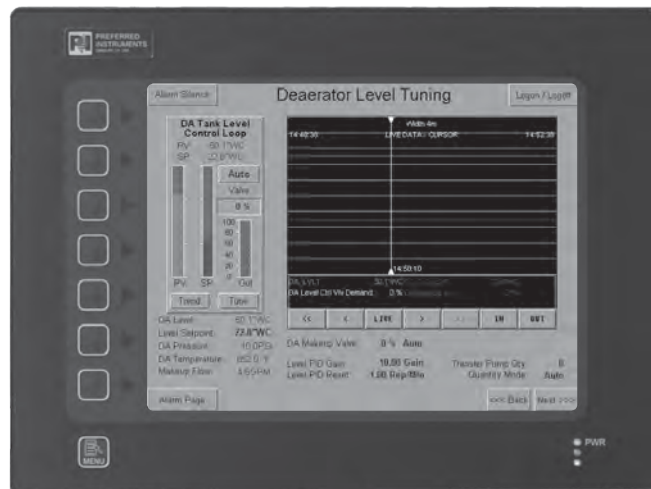
#### Setup Parameters

All parameters are available through the setup pages on the touch screen. System features and control logic are adjusted depending on the initial setup parameters.



#### Alarm Page

The alarm and events screen lists all current alarms and all recent control events. This screen helps diagnose boiler operation before they impact boiler operation.



#### Tuning Page

Tuning pages allow the user to view control loops for tuning purposes. Historical data is saved to a compact flash card and can be viewed through a PC.

# FEEDWATER CENTER

## Overview

The Preferred Feedwater Center is available in four models, each with different capabilities. To select the correct model for each application, consult the hardware configurations, input/outputs provided, and sample specifications on the following pages.

| Catalog Number | Description                             | PWC Hardware Configuration |
|----------------|-----------------------------------------|----------------------------|
| JC-FWC-FC      | Full Control                            | PWCN4-CDROOOA              |
| JC-FWC-NV      | No VSDs                                 | PWCN4-CDROxxA              |
| JC-FWC-NS      | No Surge Tank/Transfer Pumps            | PWCN4-CDHOOxA              |
| JC-FWC-NVS     | No VSDs and no Surge Tank/Transfer Pump | PWCN4-CDHxxxx              |

Below is a complete list of the inputs and outputs for each of the four Feedwater Center models.

| JC-FWC- <u>xxx</u>            | -FC | -NV | -NS | -NVS | Field Device                                |
|-------------------------------|-----|-----|-----|------|---------------------------------------------|
| <b>Digital Inputs</b>         |     |     |     |      |                                             |
| FW Pump Running               | 4   | 4   | 4   | 4    | 120 VAC - (e.g. current sensing relay)      |
| Boiler Running/Call For Water | 4   | 4   | 4   | 4    | 120 VAC - BLR Run/Drum Level Switch         |
| TP Pump Running               | 3   | 3   |     |      | 120 VAC - CSR/Aux Contact Motorstarter      |
| DA Low Level Cutoff Switch    | 1   | 1   | 1   | 1    | 120 VAC - Level Switch                      |
| ST Low Level Cutoff Switch    | 1   | 1   |     | 1    | 120 VAC - Level Switch                      |
| Water Softener Alarm          | 1   | 1   | 1   | 1    | 120 VAC - Contact From Softener             |
| Disable                       | 1   | 1   | 1   | 1    | 120 VAC - Contact From BAS                  |
| <b>Analog Inputs</b>          |     |     |     |      |                                             |
| DA Level                      | 1   | 1   | 1   | 1    | 4-20mA Level Transmitter                    |
| DA Temperature                | 1   | 1   | 1   |      | Thermowell (part numbers 70610, 70611)      |
| DA PSI                        | 1   | 1   | 1   |      | 4-20mA PSI Transmitter (part number 7060X)  |
| FW Header PSI                 | 1   | 1   | 1   | 1    | 4-20mA PSI Transmitter (part number 7060X)  |
| Steam PSI                     | 1   | 1   | 1   |      | 4-20mA PSI Transmitter (part number 7060X)* |
| Makeup Flow                   | 1   | 1   | 1   |      | 4-20mA Flow Meter                           |
| Makeup Pressure               | 1   | 1   | 1   |      | 4-20mA PSI Transmitter (part number 7060X)  |
| Condensate Return Temperature | 1   | 1   | 1   |      | Thermowell (part numbers 70610, 70611)      |
| Condensate Return Flow        | 1   | 1   | 1   |      | 4-20mA Flow Meter                           |
| Surge Tank Level              | 1   | 1   |     |      | 4-20mA Level Transmitter                    |
| <b>Digital Outputs</b>        |     |     |     |      |                                             |
| FW Pump Start                 | 4   | 4   | 4** | 4**  | Dry Contact (close to start)                |
| TP Pump Start                 | 3   | 3   |     |      | Dry Contact (close to start)                |
| Water Softener Regen Cycle    | 1   | 1   | 1** |      | Dry Contact (close to start)                |
| <b>Analog Outputs</b>         |     |     |     |      |                                             |
| FW Pump Speed                 | 4   |     | 4   |      | 4-20mA Output                               |
| TP Pump Speed                 | 3   |     |     |      | 4-20mA Output                               |
| ST MU Water Valve             | 1   | 1   |     |      | 4-20mA Output                               |
| Chem Feed Pump                | 1   | 1   | 1   |      | 4-20mA Output                               |
| DA PSI Control Valve          | 1   | 1   | 1   |      | 4-20mA Output                               |
| DA Level Control Valve        | 1   | 1   | 1   |      | 4-20mA Output                               |

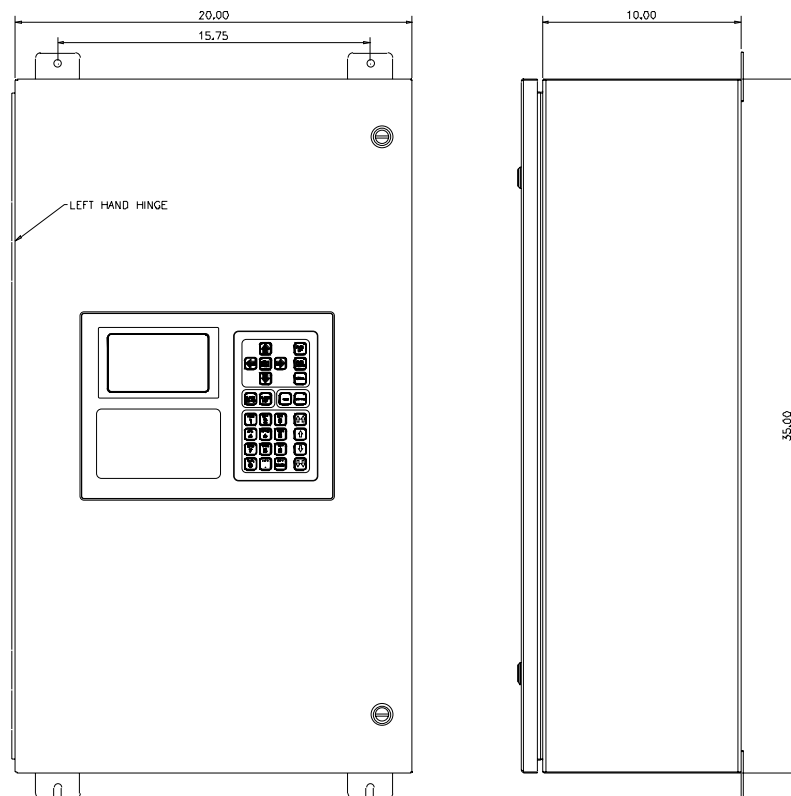
\*Steam PSI transmitter must be scaled similar to the Feedwater PSI transmitter

\*\*HOA switches provided on -NS and -NVS models



# FEEDWATER CENTER

## Specifications



### Mechanical:

Enclosure Size: 35" H x 20" W x 10" D  
 Enclosure Type: Wall mount, NEMA 4  
 Mounting Hole Pattern: (4) 5/16" dia.  
 Weight: 70 lbs.

### Environmental

Operating Temp: 32° to 122° F (0° to 50° C)  
 Storage Temp: -20° to 150° F (-28° to 65° C)  
 Humidity Limits: 15% to 95% (noncondensing)  
 Enclosure: NEMA 4

### Performance

Accuracy: 0.025% analog I/O  
 Resolution: 16 bit input/12 bit output  
 Microprocessor: 32 bit, 128k EEPROM  
 Execution Cycle: Five per second  
 Time/Date Clock: (battery backed)

### Operator Control Panel

LCD Display: 2.9" H x 5.1" W  
 Keyboard: Membrane, tactile feedback

### Configuration

Standard Lead/Lag: Menu style  
 "Fill-In-The-Blanks" setup.  
 Control Language: Function block style,  
 60 functions, 600 Blocks

Custom Blockware  
 Configuration  
 Software:

PWC\_Edit™ spread sheet based  
 or PWC\_Draw™ graphical, editor.  
 (Windows PC Required)

### Communication

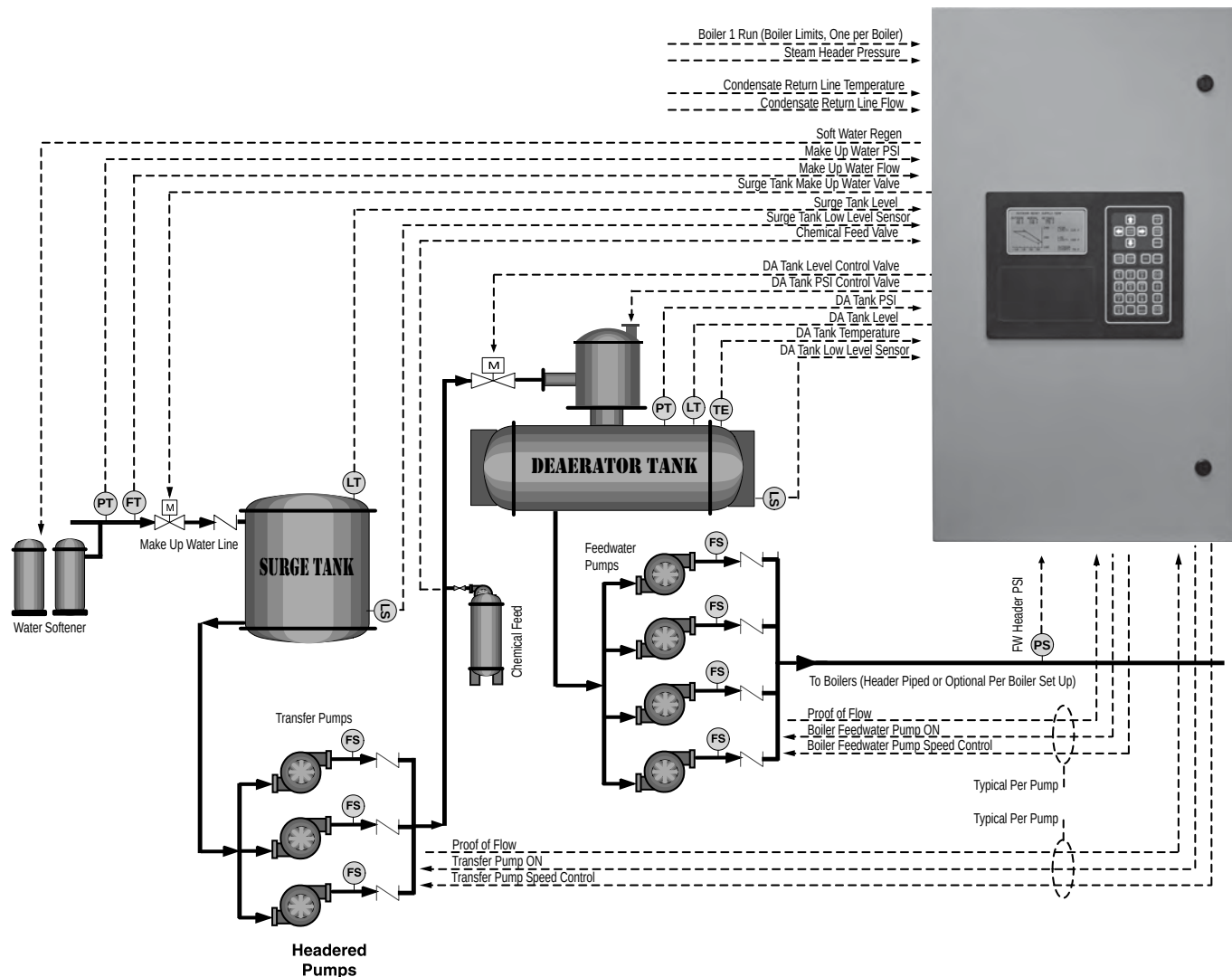
Control Network:  
 Protocol: Modbus (ASCII or RTU mode)  
 Speed: 1200 to 38,400 baud  
 Type: RS485, optically isolated  
 Programming Port:  
 Speed: 38,400 baud  
 Type: RS232, DB9F connector

### Electrical

Input Power: 120 VAC (+/- 15%), 12 A total,  
 0.7A internal  
 Built-in surge suppressors  
 Internal Power  
 Supply: 24 VDC @ 300 mADC for  
 external use

# FEEDWATER CENTER MODEL JC-FWC-FC

## Feedwater Delivery Controller



JC-FWC-FC, Full Control

### Application

The Feedwater Center Model JC-FWC-FC includes all available features and capabilities required to control feedwater delivery systems including DA level and pressure control, surge tank level control, transfer pump control, feedwater pump control, chemical feed pump control and water softener regeneration.

### Up to 4 Feedwater Pumps

Pumps use “smart” sequencing to ensure the proper number of pumps are running to satisfy the feedwater demand.

# FEEDWATER CENTER MODEL JC-FWC-FC

## Feedwater Delivery Controller - Specification

### 1. Application

Supply a fully integrated Feedwater Control system to coordinate the operation of (up to) four VSD controlled Feedwater pumps, Deaerator level and pressure control, (up to) three transfer pumps, water softener regeneration and chemical feed. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Pump VSD Modulation

The control system shall provide a PID based control scheme. As demand increases, the speed of the pump will increase. Each running pump will modulate in unison. Modulation signals shall be 4-20 mADC and shall be electrically isolated channel-channel and channel-ground.

### 3. Headered Feedwater Pressure Setpoint

The Feedwater pressure setpoint must be field selectable between steam header based or manual. In steam header based mode, the Feedwater pressure setpoint must be calculated based on an adjustable deviation from the actual steam header pressure. In manual, the operator may set the Feedwater Header Pressure Setpoint via a front panel display.

### 4. Pump Sequence

The control system shall use both Feedwater header pressure (Deaerator level for transfer pumps) and pump speed to start and stop the pumps and minimize the total number of pumps in operation. The controller shall start and stop pumps when the Feedwater header pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. To anticipate and minimize header pressure deviations, the control system shall start or stop the next pump if the "lead" pump has been near maximum or minimum speed for longer than the adjustable time delay. The control system shall monitor each pump's flow switch and shall rapidly and automatically replace any pump that fails to prove flow. The lead pump shall either automatically rotate on a time of day/ day of week (or month) schedule, or shall be manually selected by the operator. The control system shall be field adjustable to "per boiler" mode which would run one feedwater pump per boiler. Additionally, the control system shall be field adjustable to choose between headered or boiler specific piping to determine which pumps should be started. A 120 VAC Discrete input is to be provided as a Deaerator low level signal that disables all Feedwater Pumps. A 120 VAC Discrete input is to be provided as a surge tank low level signal that disables all transfer pumps.

### 5. Deaerator Control

The control system shall output a demand signal based on DA Level. When used with transfer pumps, this is the speed at which the transfer pumps must run. Without transfer pumps, this would drive a level control valve. The control system shall drive a Deaerator pressure control valve based on Deaerator pressure.

### 6. Surge Tank Control

The control system shall output a command to a fresh water makeup valve based on surge tank level. Field adjustable level for valve at 0% open and valve at 100% open shall be provided.

### 7. Chemical Feed Control

The control system shall monitor makeup water flow and send that flow signal to a chemical feed pump.

### 8. Soft Water Regeneration Control

The control system shall initiate a soft water regeneration cycle based on time, or upon receiving a soft water alarm. The operator shall also be able to initiate the soft water regeneration cycle manually.

### 9. Monitor Points

The control system shall monitor Deaerator temperature, fresh water makeup pressure, condensate return flow and condensate return temperature for display purposes.

### 10. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/ date stamp and English language description.

### 11. Communication

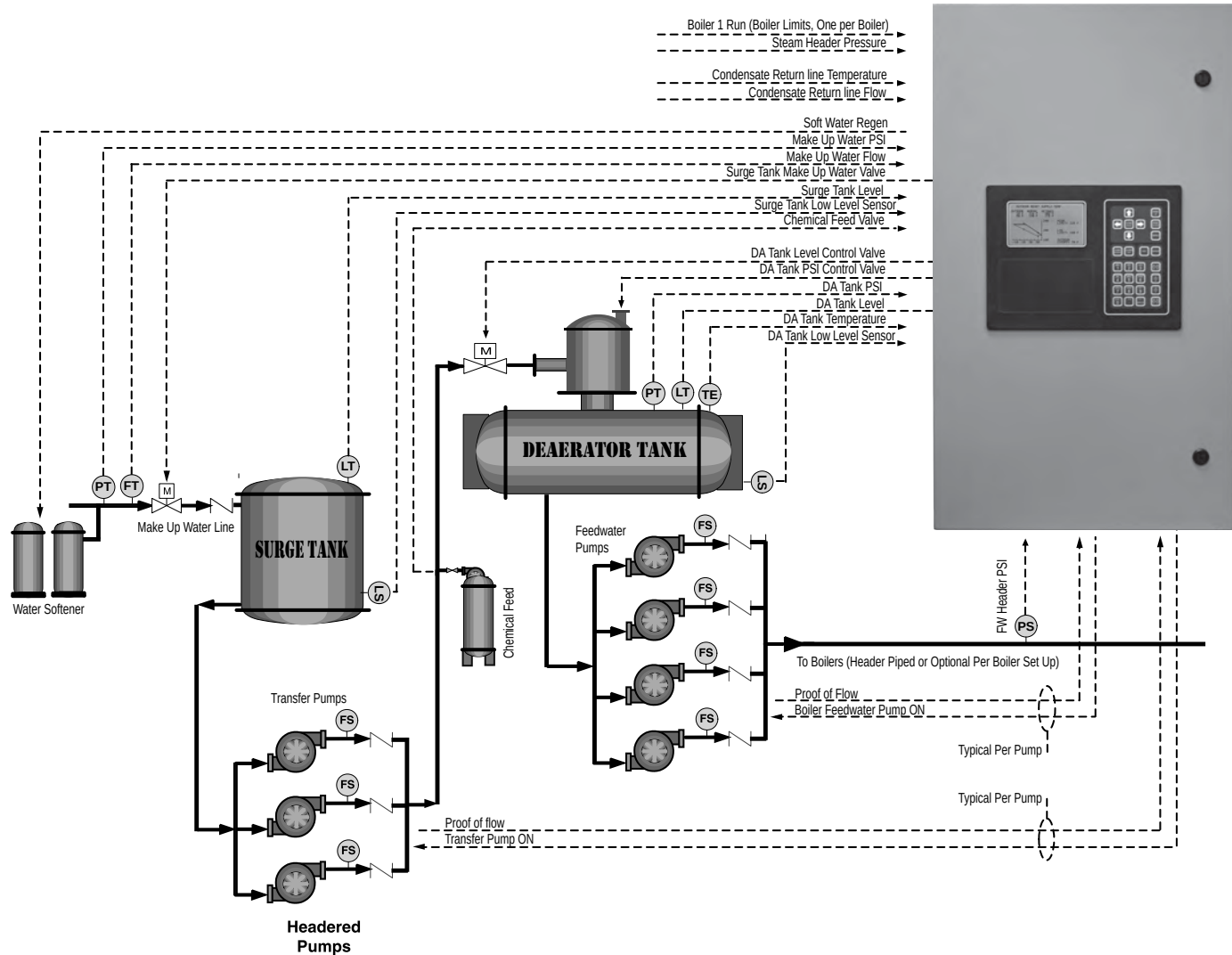
The Control System shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be easily read. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be readable and writable.

### 12. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-FWC-FC.

# FEEDWATER CENTER MODEL JC-FWC-NV

## Feedwater Delivery Controller



JC-FWC-NV, Full Control for pumps without VSDs

### Application

The Feedwater Center Model JC-FWC-NV includes all available features and capabilities required to control feedwater delivery systems including DA level and pressure control, surge tank level control, transfer pump control, feedwater pump control, chemical feed pump control and water softener regeneration.

### Up to Four Feedwater Pumps

Pumps use “smart” sequencing to ensure the proper number of pumps are running to satisfy the feedwater demand.



# FEEDWATER CENTER MODEL JC-FWC-NV

## Feedwater Delivery Controller - Specification

### 1. Application

Supply a fully integrated Feedwater control system to coordinate the operation of (up to) four Feedwater pumps, Deaerator level and pressure control, (up to) three transfer pumps, water softener regeneration and chemical feed. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Headered Feedwater Pressure Setpoint

The Feedwater pressure setpoint must be field selectable between steam header based or manual. In steam header based mode, the Feedwater pressure setpoint must be calculated based on an adjustable deviation from the actual steam header pressure. In manual, the operator may set the Feedwater header pressure setpoint via a front panel display.

### 3. Pump Sequence

The control system shall use Feedwater Header Pressure (Deaerator Level for Transfer Pumps) to start and stop the pumps and minimize the total number of pumps in operation. The controller shall start and stop pumps when the Feedwater header pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. The control system shall monitor each pump's flow switch and shall rapidly and automatically replace any pump that fails to prove flow. The lead pump shall either automatically rotate on a time of day/ day of week (or month) schedule, or shall be manually selected by the operator. The control system shall be field adjustable to "per boiler" mode which would run one feedwater pump per boiler. Additionally, the control system shall be field adjustable to choose between headered or boiler specific piping to determine which pumps should be started. A 120 VAC Discrete input is to be provided as a Deaerator low level signal that disables all Feedwater pumps. A 120 VAC Discrete input is to be provided as a surge tank low level signal that disables all transfer pumps.

### 4. Deaerator Control

The control system shall output a demand signal based on DA level. When used with transfer pumps, this is the speed at which the transfer pumps must run. Without transfer pumps, this would drive a level control valve. The control system shall drive a Deaerator pressure control valve based on Deaerator pressure.

### 5. Surge Tank Control

The control system shall output a command to a fresh water makeup valve based on surge tank level. Field adjustable level for valve at 0% open and valve at 100% open shall be provided.

### 6. Chemical Feed Control

The control system shall monitor makeup water flow and send that flow signal to a chemical feed pump.

### 7. Soft Water Regeneration Control

The control system shall initiate a soft water regeneration cycle based on time, or upon receiving a soft water alarm. The operator shall also be able to initiate the soft water regeneration cycle manually.

### 8. Monitor Points

The control system shall monitor Deaerator temperature, fresh water makeup pressure, condensate return flow and condensate return temperature for display purposes.

### 9. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time /date stamp and English language description.

### 10. Communication

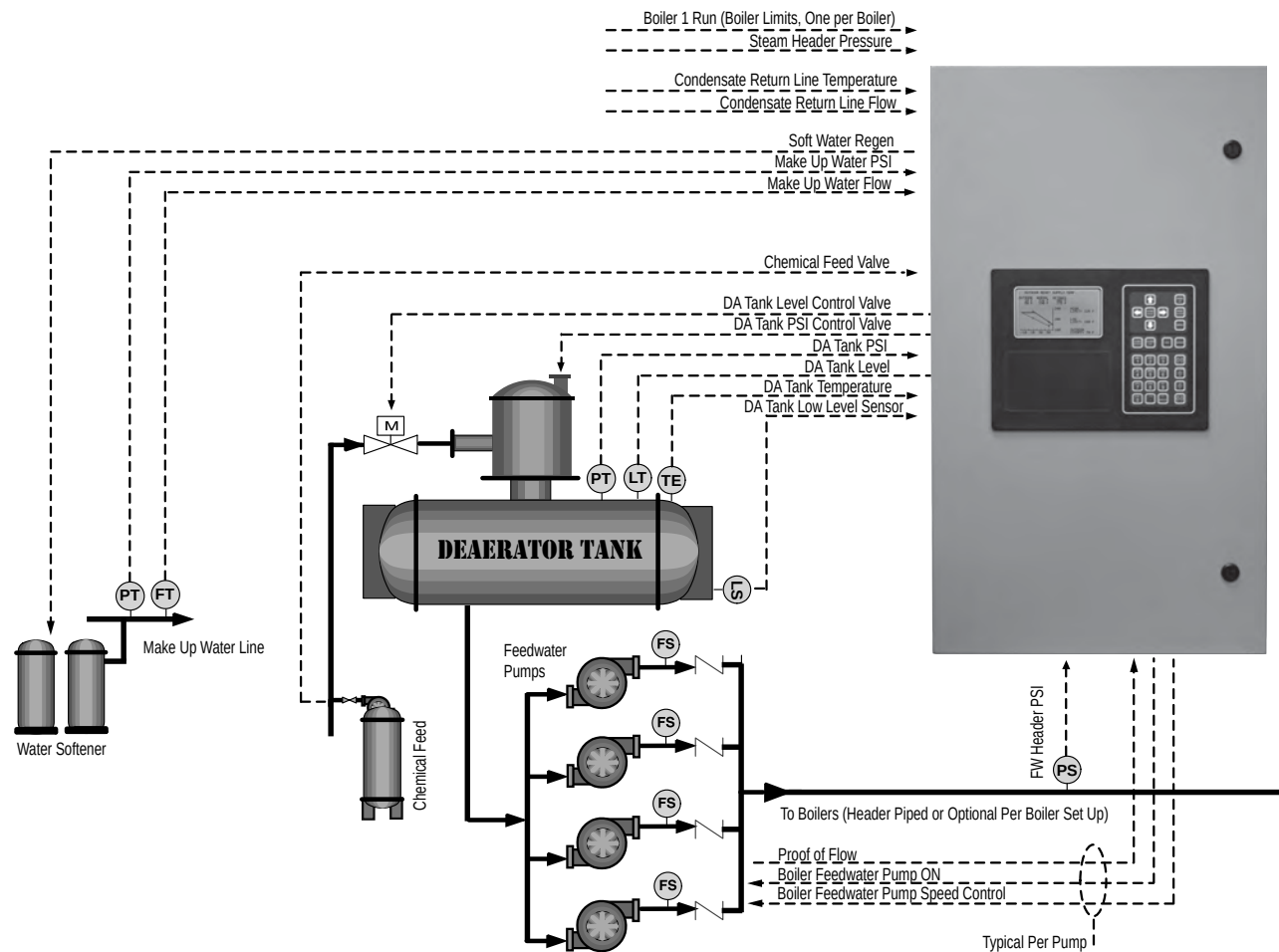
The control system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/ stop, warm standby, and firing rate status shall be easily read. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

### 11. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-FWC-NV.

# FEEDWATER CENTER MODEL JC-FWC-NS

## Feedwater Delivery Controller



JC-FWC-NS, Full Control for systems without surge tanks

### Application

The Feedwater Center Model JC-FWC-NS includes all available features and capabilities required to control feedwater delivery systems including DA level and pressure control, feedwater pump control, chemical feed pump control and water softener regeneration.

### Up to Four Feedwater Pumps

Pumps use “smart” sequencing to ensure the proper number of pumps are running to satisfy the feedwater demand.

# FEEDWATER CENTER MODEL JC-FWC-NS

## Feedwater Delivery Controller - Specification

### 1. Application

Supply a fully integrated Feedwater control system to coordinate the operation of (up to) four VSD controlled Feedwater pumps, Deaerator level and pressure control, water softener regeneration and chemical feed. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Pump VSD Modulation

The control system shall provide a PID based control scheme. As demand increases, the speed of the pump will increase. Each running pump will modulate in unison. Modulation signals shall be 4-20 mADC and shall be electrically isolated channel-channel and channel-ground.

### 3. Headered Feedwater Pressure Setpoint

The Feedwater pressure setpoint must be field selectable between steam header based or manual. In steam header based mode, the feedwater pressure setpoint must be calculated based on an adjustable deviation from the actual steam header pressure. In manual, the operator may set the Feedwater header pressure setpoint via a front panel display.

### 4. Pump Sequence

The control system shall use both Feedwater header pressure and pump speed to start and stop the pumps and minimize the total number of pumps in operation. The controller shall start and stop pumps when the Feedwater header pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. To anticipate and minimize header pressure deviations, the control system shall start or stop the next pump if the "lead" pump has been near max or min speed for longer than the adjustable time delay. The control system shall monitor each pump's flow switch and shall rapidly and automatically replace any pump that fails to prove flow. The lead pump shall either automatically rotate on a time of day/ day of week (or month) schedule, or shall be manually selected by the operator. The control system shall be field adjustable to "per boiler" mode which would run one feedwater pump per boiler. Additionally, the control system shall be field adjustable to choose between headered or boiler specific piping to determine which pumps should be started. A 120 VAC Discrete input is to be provided as a Deaerator low level signal that disables all Feedwater pumps.

### 5. Deaerator Control

The control system shall trigger a demand signal based on DA Level. When used with transfer pumps, this is the speed at which the transfer pumps must run. Without transfer pumps, this would drive a level control valve. The control system shall drive a Deaerator pressure control valve based on Deaerator pressure.

### 6. Chemical Feed Control

The control system shall monitor makeup water flow and send that flow signal to a Chemical feed pump.

### 7. Soft Water Regeneration Control

The control system shall initiate a soft water regeneration cycle based on time, or upon receiving a soft water alarm. The operator shall also be able to manually start the soft water regeneration cycle.

### 9. Monitor Points

The control system shall monitor Deaerator temperature, fresh water makeup pressure fresh water makeup flow, condensate return flow and condensate return temperature for display purposes.

### 10. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/ date stamp and English language description.

### 11. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "hand-off-auto" control switches must be wired directly into every boiler start/ stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/ manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 12. Communication

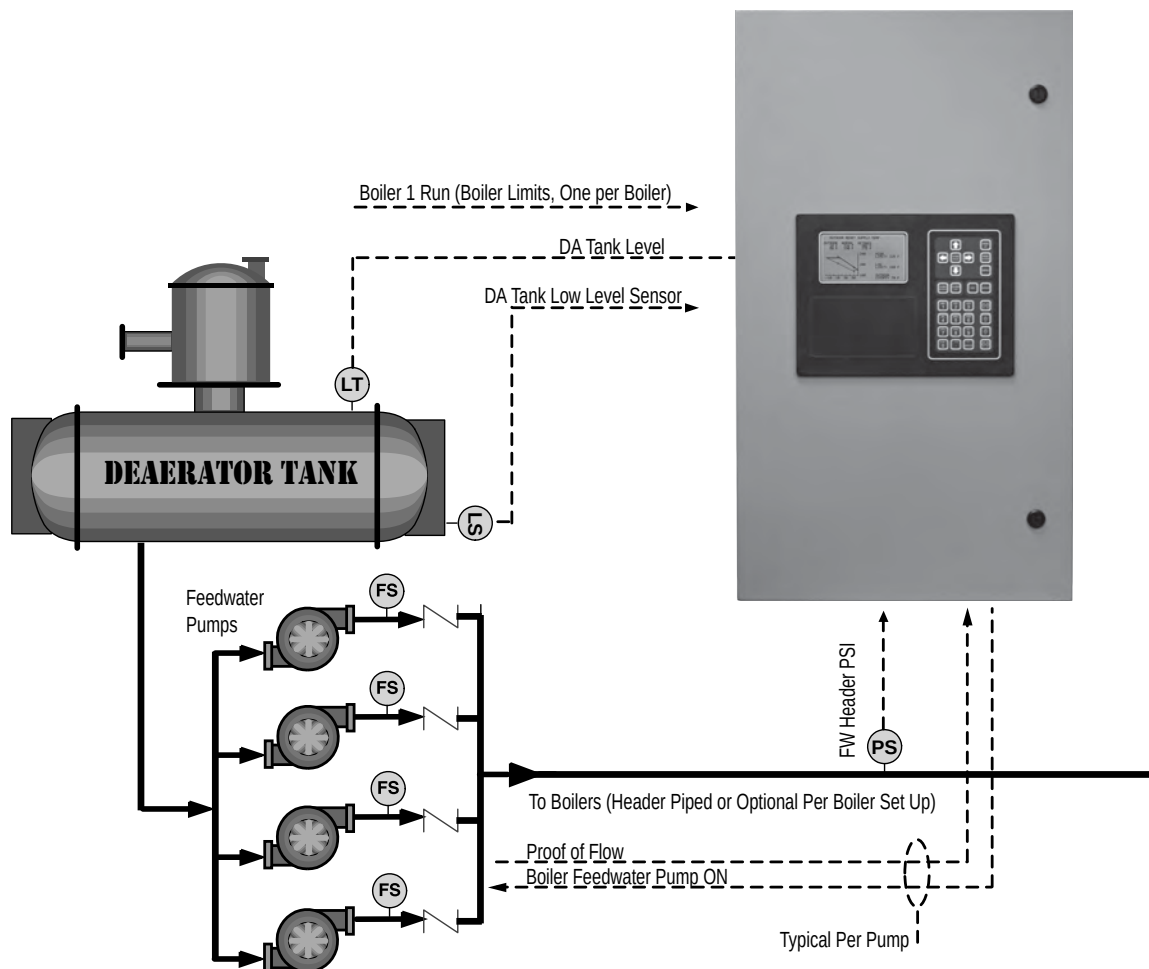
The control system shall be capable of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be easily read. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

### 13. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-FWC-NS.

## FEEDWATER CENTER MODEL JC-FWC-NVS

Feedwater Delivery Controller



*JC-FWC-NVS, Full Control for systems without surge tank or VSD controlled pumps*

### Application

The Feedwater Center Model JC-FWC-NVS includes all available features and capabilities required to control feedwater pumps.

### Up to Four Feedwater Pumps

Pumps use “smart” sequencing to ensure the proper number of pumps are running to satisfy the feedwater demand.



# FEEDWATER CENTER MODEL JC-FWC-NVS

## Feedwater Delivery Controller - Specification

### 1. Application

Supply a fully integrated Feedwater control system to coordinate the operation of (up to) four Feedwater pumps. The control system shall be microprocessor-based and suitable for wall mounting.

### 2. Headered Feedwater Pressure Setpoint

The Feedwater pressure setpoint must be field selectable between Steam header based or manual. In steam header based mode, the Feedwater pressure setpoint must be calculated based on an adjustable deviation from the actual Steam header pressure. In manual, the operator may set the Feedwater header pressure setpoint via a front panel display.

### 3. Pump Sequence

The control system shall use Feedwater header pressure to start and stop the pumps and minimize the total number of pumps in operation. The controller shall start and stop pumps when the Feedwater header pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. The control system shall monitor each pump's flow switch and shall rapidly and automatically replace any pump that fails to prove flow. The lead pump shall either automatically rotate on a time of day/ day of week (or month) schedule, or shall be manually selected by the operator. The control system shall be field adjustable to "per boiler" mode which would run one feedwater pump per boiler. Additionally, the control system shall be field adjustable to choose between headered or boiler specific piping to determine which pumps should be started. A 120 VAC Discrete input is to be provided as a Deaerator low level signal that disables all Feedwater pumps.

### 4. Operator Controls, Trends, Indications and Alarms

The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with time/ date stamp and English language description. The control system shall include a minimum of 200 point memory.

### 5. Reliability

Include hardwired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hardwired "hand-off-auto" control switches must be wired directly into every boiler start/ stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/ manual switch, output control knob and output level indicator (bargraph, analog meter or digital display).

### 6. Communication

The control system shall have the ability of simultaneously communicating to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a personal computer. The individual boiler limits, lockout, start/ stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be easily read and written.

### 7. Quality Assurance

The control system shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be a Preferred Instruments, Danbury, CT, Model JC-FWC-NS.

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Overview



The **BurnerMate Universal** offers complete boiler control in an economic, off-the-shelf, pre-programmed controller. Separate processors are used for flame safeguard and combustion control for NFPA 85 compliance. Configuration is done in the field using the LCD key pad, the optional touch screen, or our exclusive BMU\_Edit software on your PC. BMU functions include:

- Advanced flame safeguard control including first out annunciation, nuisance trip protection, and lockout snapshot
- Combustion control (jackshaft, parallel positioning, with optional oxygen trim) using up to ten servos and up to four Variable Speed Drives (VSDs)
- Draft control
- Feedwater control: single, two-element, or three-element.
- Large 10" color touch screen with pre-programmed graphic pages

The BurnerMate Universal is available for immediate delivery, requires no programming, and is recognized by U.L.

### Advanced Flame Safeguard Control

The BurnerMate Universal takes burner safety to a higher level. Instead of one digital input proving the boiler limits are made, the BMU accepts over forty boiler limits into separate digital inputs. This makes first out annunciation easy, as well as advanced diagnostics to quickly pinpoint why a boiler tripped and what needs to be done to bring it on line again. One or two flame scanners can be used for added reliability, or increased boiler safety. Flame safety control features include:

- Support for up to three fuels (oil, natural gas, and a second gas fuel).

- Fuel changeover can be initiated locally or remotely either shutting down the boiler during the fuel change, or changing fuel "on-the-fly". Fuel change can be initiated manually, or remotely via contacts or Modbus
- Monitors up to nine recycling limits, up to 33 shutdown limits and one or two flame scanners.
- All limit inputs are 120 VAC, wired in parallel, and separately annunciated
- During a shutdown, all major status bits are recorded and saved for up to the last 10 lockouts.
- Adjustable time delays are available for many limits to avoid trips
- Gas valve leak test logic can be configured (with or without a vent valve)
- Automated daily low water cutout blowdown with level switch test can be configured to alarm or shut down the burner if a faulty low water cutout switch is detected.
- Optional oil gun purge logic can be configured (blow-through into the furnace, or suctioned back out of the gun via scavenger pump)
- High flue gas temperature shutdown is included for additional dry boiler protection
- To reduce combustibles in the furnace, the burner can be driven to low fire before it is shut down

### Fuel Air Ratio Control

The BMU supports single point positioning (jackshaft) combustion control and parallel positioning combustion control. Oxygen trim can be added to either control strategy by adding a Preferred ZP probe. A link trim actuator (LTA) can be used to vary the air output in a single point positioning system. Fuel valves and air dampers are controlled by high precision (0.1° accuracy) digital electric servos. Each digital servo includes a microprocessor and all servos are networked to the BMU chassis. BMU fuel-air ratio control functions include:

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## System Overview

- Jackshaft or parallel positioning combustion control is supported.
- Up to ten high-precision servos are networked to the controller, and 4-20 mA outputs are available to control VSDs for FD fan, FGR fan, ID fan or FW pump
- Up to 11 combustion control points can be programmed for each output
- Separate points are available for standby, purge, and light-off positions
- Optional O<sub>2</sub> trim control is supported
- Separate points are provided for each fuel's VSD and VSD bypass mode for a total of six curves per servo or analog output
- Atomizing (steam or air) pressure (or differential pressure) control setpoints can be input as a function of firing rate
- Windbox oxygen control (monitored by a separate oxygen analyzer) allows the technician to enter a windbox oxygen vs. firing rate curve. The BMU trims the FGR damper (or FGR fan VSD) to maintain FGR flow (as measured by windbox oxygen content) on curve at all firing rates
- During boiler purge, all servos are stroked and their feedback signals are checked for servo integrity

### Boiler Control Functions

Many of the most common boiler control functions are incorporated in the BMU. This simplifies the control system and often eliminates the need for additional relays, timers, or other control hardware mounted in the burner management system enclosure. Additionally, the BMU accepts hard-wired inputs for burner off/on and remote firing rate that make it easily integrated with the Preferred Chief Dispatcher lead/lag sequencer. Other control functions include:

- Burner firing rate control (local PID control, remote firing rate input, or remote set point input)
- Draft control with optional firing rate feed forward. Controlled outputs include a stack damper, or an ID fan VSD
- Feedwater control (single, two-, or three-element) Controlled outputs include a feedwater control valve or feedwater pump VSD
- Outdoor air temperature reset for hot water boilers.
- Warm standby and domestic hot water override
- Low fire hold based on boiler shell or flue gas temperature
- Five auxiliary relays can be configured to control common boiler room auxiliaries
- Supervised or automatic water column blowdown and low water level test logic
- Boiler cold start function allows for adjustable boiler thermal shock protection



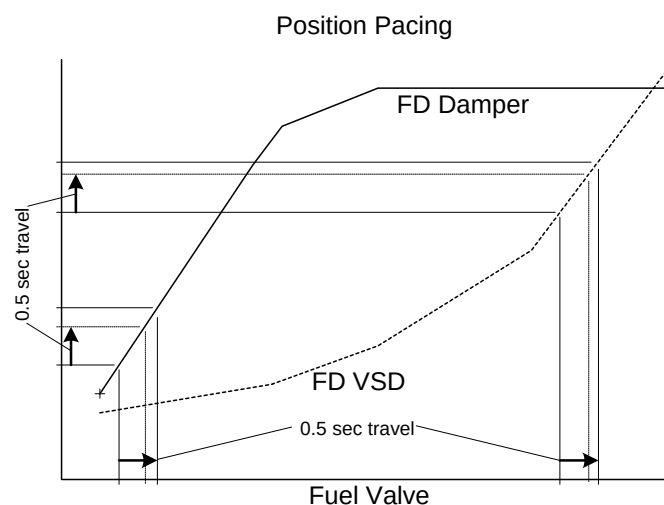
*BMU-SM-15 Servo Motor with optional 'QD' electrical Quick-Connects.*

### High Precision Digital Electric Servo Motors

The servo motors provided as part of the BurnerMate Universal are unique to Preferred. The BMU communicates digitally with a microprocessor controller board in each servo. The controller board precisely positions the servo motor and performs continuous safety diagnostics. A high precision, sealed feedback potentiometer continuously reports the servo position to the controller board and back to the BMU chassis. The controller board includes pushbuttons for ZERO, CW, and CCW "jogging" of the servo motor. In addition, LEDs provide important diagnostic information for each servo motor. Servos are available with quick-disconnect fittings to reduce wiring time. Torque ratings for the servo motors start at 3 ft-lb for small control valves and go up to 720 ft-lb for large air dampers or stack dampers.

### BMU Fuel-Air-FGR Cross Limited Position Pacing

"Position Pacing" is a unique feature of the BurnerMate Universal that assures the positions of all Fuel, Air, and FGR Servos and related VSD speeds remain "on curve."



*Two Servo Example of Position Pacing*

## BURNERMATE UNIVERSAL BOILER CONTROLLER

### System Overview

During load swings, position pacing helps avoid:

- Periods of lean combustion that can cause rumbling, vibration, or flame-outs during firing rate increases
- Fuel rich conditions that can cause smoking, burn-back, and excessive CO or unburned hydrocarbons during firing rate decreases

BMU “Position Pacing” assures that all servo actuators remain “on curve” in the following manner:

- All fuel, air, FGR Servos and VSDs move together and “on curve” --there is no fuel or air “lead” or “lag”
- Each servo and VSD has precise position or speed feedback to ensure that all devices are cross limited.
- The BMU “knows” how far each servo actuator and VSD can move in 0.5 seconds and uses “self-adaptive” position pacing to ensure that load changes never cause any servo or VSD to lag behind the others
- Every 0.5 seconds, the BMU examines all curves to “find” the servo or VSD worst case 0.5 second ‘shift’ caused by a requested firing rate change
- Based on the curves, all other servos or VSDs target positions are “scaled back” to assure ALL devices arrive “on curve” at the end of the next 0.5 second move

BMU “position pacing” is fully automatic, provides for safer combustion control and drastically improved firing rate response times and requires no adjustments by the user.

#### Flame Scanners

The BurnerMate Universal system includes a line of Preferred Instruments flame scanners. Digital, microprocessor-based scanners are available in ultraviolet (UV) infrared (IR) and self-checking UV models. Flame detector and amplifier are integrated into the scanner head to eliminate the need for separate (panel-mounted) scanner amplifiers. Scanner housings are machined from anodized aluminum. Scanner mounts are 1/2" NPTF for the UV and IR versions, and 1" NPTF for the self-checking UV model. Each scanner includes a cooling air port for hot or dirty applications. Scanners include two LEDs--one blinks intermittently depending on the intensity of the flame signal, the other LED illuminates when the scanner closes the “Flame Detected” relay output. Electrical connection is by a threaded military-style quick disconnect. The scanners output a contact closure for flame proving and a 4-20 mA flame strength signal for troubleshooting diagnostics. One or two scanners can be connected to a single BMU controller. All scanners include the same pinout and military-style quick disconnect allowing for scanners to be easily changed. The BMU can be used with any other manufacturer’s flame relay that produces a 120 VAC contact closure when flame is proven.



BMU Servo and Controller Board  
(with QD option)



Up to four servos connect to each BMU-JBOX terminal. Each servo has a low voltage and high voltage quick connect cable. A single BMU-CABLE, and 120 VAC H, N, and G wires provide the “home run” termination to the BMU chassis.

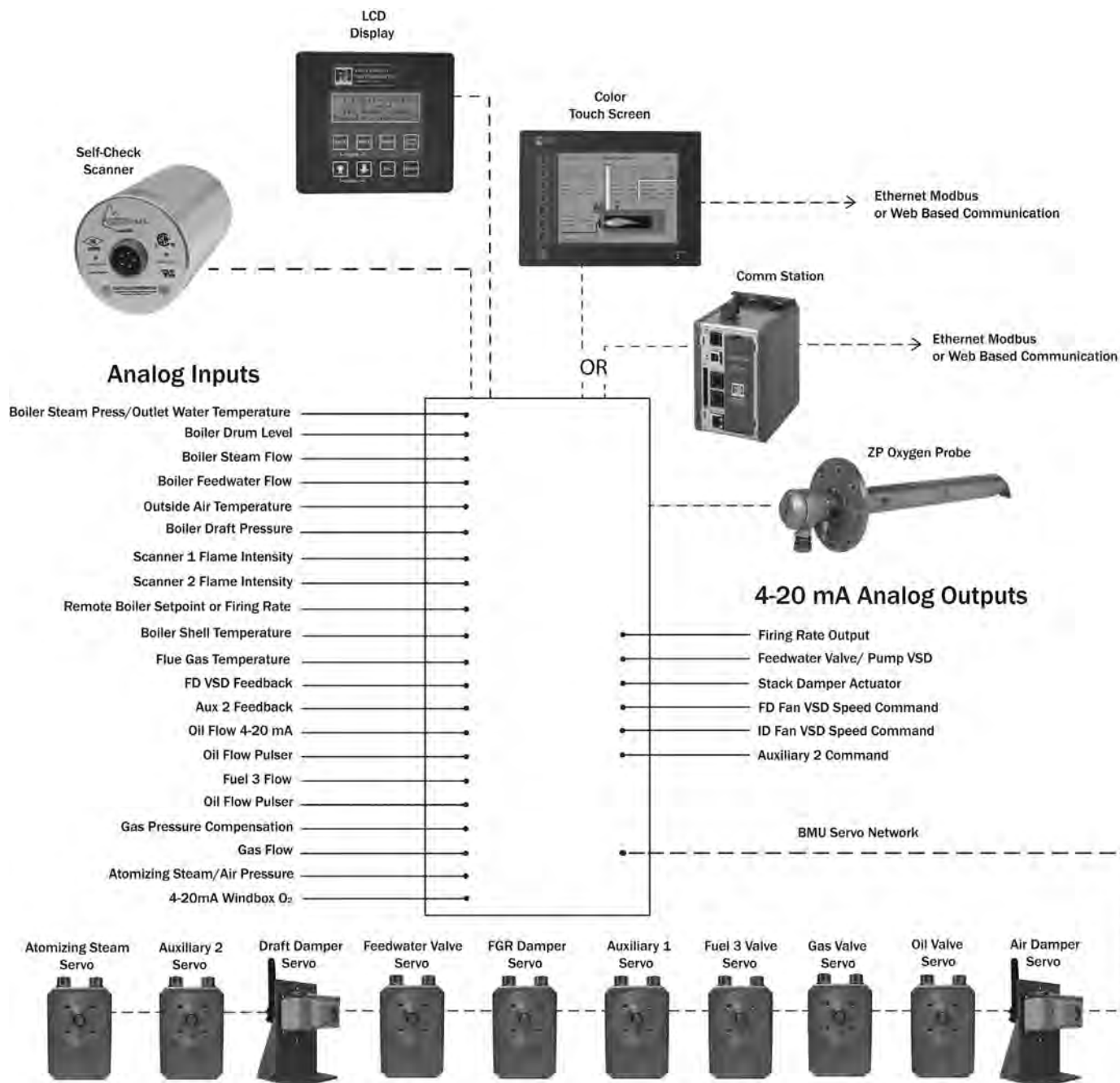


BMU scanners available in ultraviolet, infrared, and self-checking ultraviolet. All connect by military-style quick disconnect fittings.



# BURNERMATE UNIVERSAL BOILER CONTROLLER

## System Overview



### Digital Communication

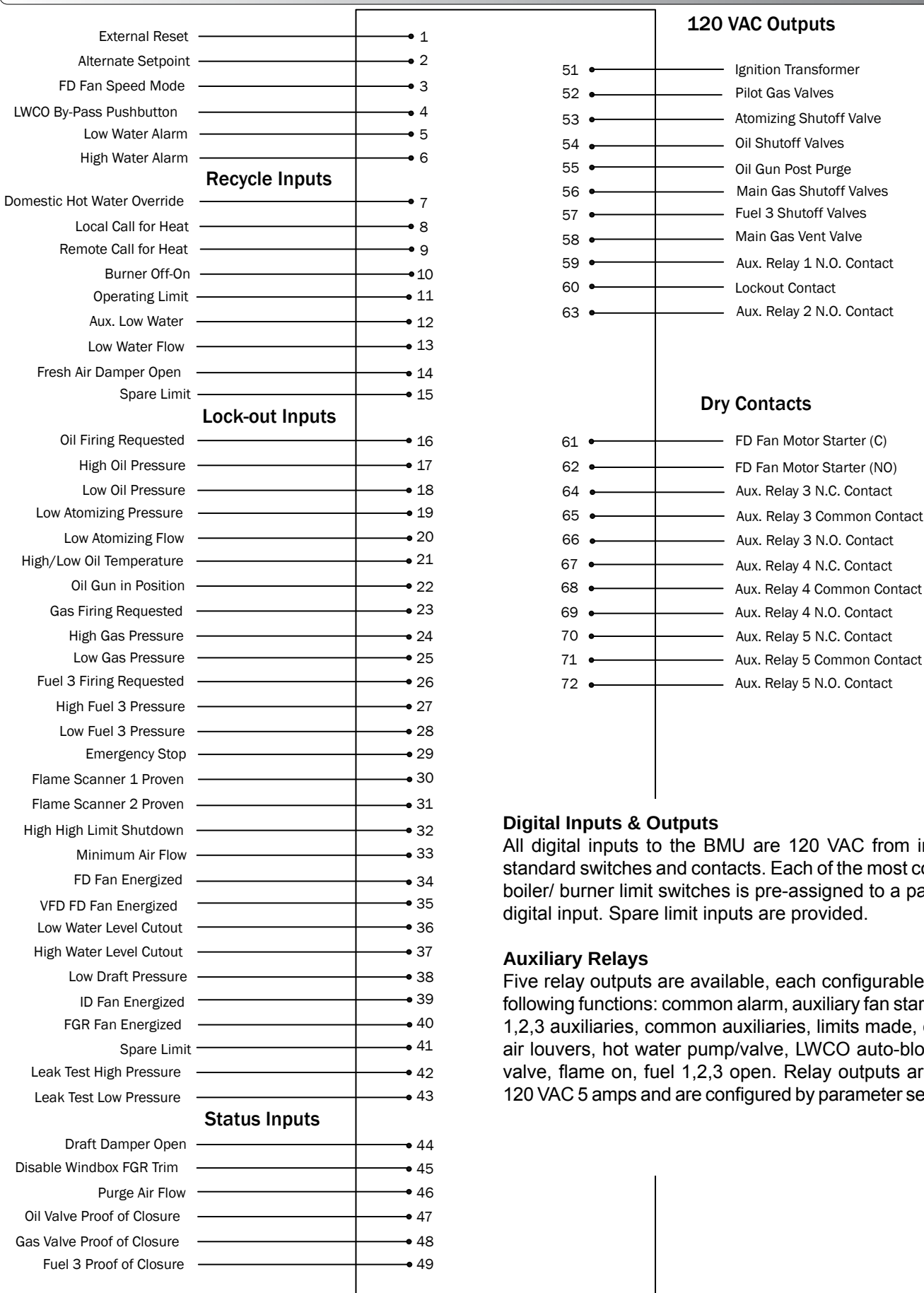
The BurnerMate Universal communicates via a secure, safety rated digital protocol with the required LCD keypad and the servo network. The BMU chassis communicates via Modbus to the optional touchscreen OIT and optional CommStation OIT-Bridge. Both the touchscreen OIT or OIT-Bridge act as protocol converters and can speak Modbus, Modbus over Ethernet, or a number of other open digital protocols to a Building Automation System (BAS) or Energy Management System (EMS). Both the touchscreen OIT and the OIT-Bridge are pre-loaded with over 75 standard graphic pages. Boiler overview screens can be field-selected to resemble the boiler being fired.

### Analog Communication

The BurnerMate Universal accepts industry standard 4-20 mA, 0-5 VDC, 1-5 VDC, thermocouple, and thermistor inputs. Analog inputs are self-powered by the BMU. Engineering units, or scaled values are entered by parameter selection during the BMU setup. Analog outputs are 4-20 mA and are available only for the devices shown above. All other outputs are on the BMU servo network.

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## System Overview



# BURNERMATE UNIVERSAL BOILER CONTROLLER

## System Overview

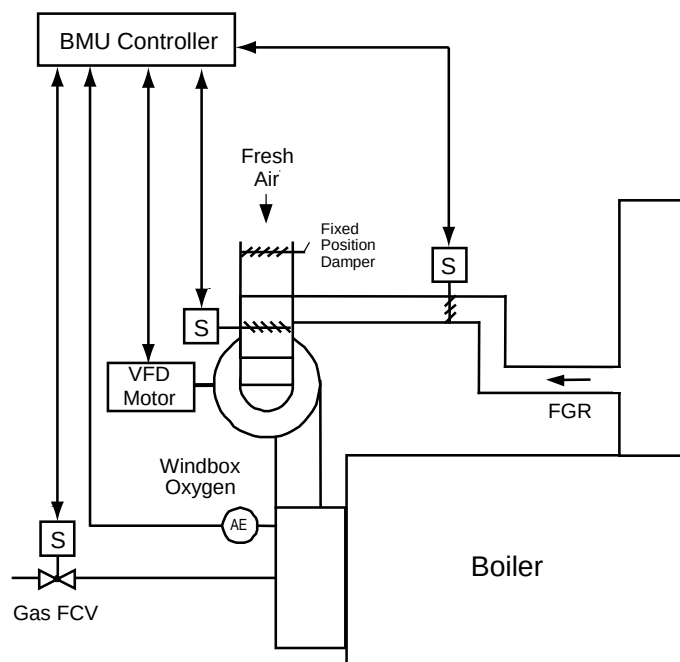
### Windbox Oxygen FGR Control

Many modern low NOx and ultra low NOx burners have challenging limits of flammability. They require precise amounts of flue gas recirculation (FGR) for all firing rates, despite changes in boiler load and ambient conditions. Since metering FGR flow rates is impractical we measure windbox oxygen for closed loop control with a reliable process variable measurement. Automatic control of windbox oxygen content has proven an effective means of consistent FGR flow.

### Atomizing Steam Pressure Control

Traditional atomizing steam pressure control is hampered by the limited turndown capabilities of existing atomizing steam differential pressure regulating valves. The oil flame is often over-atomized at low fire, under-atomized at high fire, or both. This problem has been solved, but by using very expensive control valves with self-contained regulators/positioners. The BurnerMate Universal controller monitors atomizing steam pressure, and modulates an inexpensive quarter turn flow control valve to deliver virtually any steam pressure required at any firing rate. Alternately, an atomizing steam/ oil differential pressure transmitter can be used and the BurnerMate Universal will hold the steam/ oil differential pressure "on curve" at all firing rates.

Because this system uses a tight shut-off characterized ball valve instead of a self-operated pressure regulating valve, a separate atomizing steam shutoff valve is not required. Simply program the controller so that atomizing steam pressure is zero during boiler standby, and the flow control valve will be driven fully closed. Many boiler technicians like to open the atomizing steam valve during purge to blow any water out of the line and get the line hot prior to lighting off the oil burner. The BurnerMate Universal provides separate

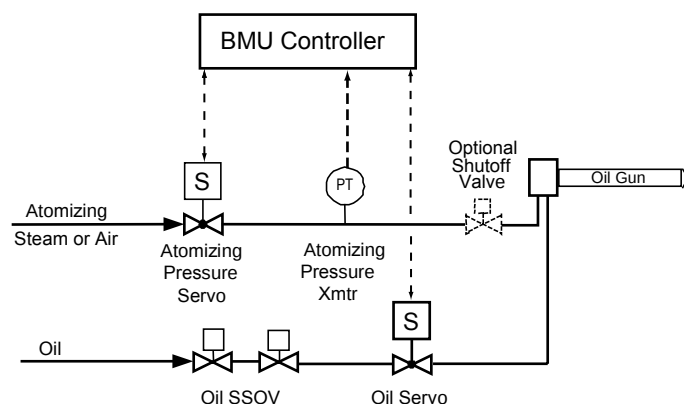


Windbox oxygen FGR control schematic

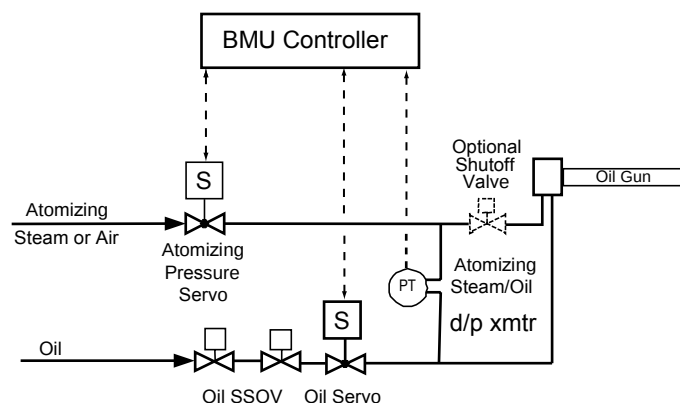
points for standby, purge, and ignition to accommodate this practice.

### Fuel Flow Meter Display and Totalizing

To monitor and track fuel usage (and savings) the BMU displays and totalized fuel flows for up to three fuels. Fuel flows are also available on Modbus to communicate with a plant Energy Management System (EMS)



Atomizing steam pressure is monitored and held "on curve" at all boiler firing rates.



In this configuration, atomizing steam/oil differential pressure is monitored and held "on curve" at all boiler firing rates.

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## System Overview

### Low Fire Fuel Transfer

The BurnerMate Universal allows the user to change fuels without shutting down the boiler, in accordance with NFPA 85 ***Procedures for Single Burner Simultaneous Firing of Two Fuels for Fuel Transfer Only***. The fuel changeover is done at low fire, but the loss of production is much less than shutting down the boiler, purging, and re-lighting. This procedure can be very convenient for lighting off difficult oil-fired burners, or No. 6 oil fired burners.

The BurnerMate Universal handles the low fire fuel transfer according to the following sequence:

1. The burner fires the “old” fuel in release to modulate mode.
2. The fuel request inputs change (either locally by the key pad, or remotely by a BAS) indicating what the desired “new” fuel will be.
3. The curve data for the new fuel is checked for errors.
4. The BMU waits for the new fuel's limits to make.
5. Both fuel actuators are sent to their ignition positions.
6. The controller ‘paces’ to the ignition position with all combustion actuators/VSDs ‘on curve’.
7. The BMU waits until both fuels reach their ignition positions.
8. The air damper/VSDs are then biased up to provide additional air for the new fuel.
9. Oxygen, FGR, and full metering trim are nulled through the biased air phases.
10. The BMU waits until the damper/VSDs are at their biased position(s)
11. The BMU then opens the new fuel SSOVs. The old fuel flame ignites the new fuel.
12. The BMU waits for MTFI seconds to allow the flame to stabilize.
13. The BMU closes the old fuel SSOVs.
14. The air bias is then removed.
15. The BMU waits for 10 seconds to allow the air damper/VSDs to get back “on curve”.
16. The BMU then returns to the release to modulate state with only the new fuel firing.

A fuel selector switch with a center “Dual” position allows an operator to manually extend the dual fuel firing period up to a maximum of 90 seconds (field adjustable).

Low fire fuel transfer is enabled by parameter selection, and is protected by an “engineer” level password.

### Tandem Oil/Gas Valve Servo Option

For retrofit applications, the BurnerMate Universal allows replacement of the jackshaft actuator on a gas and oil fired burner with a single BMU servo and maintains the linkage to the oil and gas valves. The air damper is taken off the linkage and driven by a second servo for parallel positioning control of both fuels. A ZP probe can be added to the system for parallel positioning with oxygen trim control. This features reduces the number of servos required for a gas/ oil burner retrofit, and speeds installation.

Separate curves are provided for standby, purge, and ignition positions for oil and gas. The BMU positions the gas/ oil valve (jackshaft) actuator based on the BMS fuel selection and the corresponding fuel's curve data.



**BURNERMATE UNIVERSAL BOILER CONTROLLER**  
Ordering Information



**BMU Chassis Selection**

There are several BMU chassis to choose from depending on the functionality required in the control system and the mounting of the (required) LCD key pad. The “basic” chassis supports all the flame safeguard, combustion control, and other boiler control functions of the BMU.

The “expanded” chassis supports all of the above functions plus draft, feedwater control, atomizing steam/air pressure control, FGR windbox oxygen control, as well as flow meter signal display and totalizing. Physically, the expanded chassis contains an extra analog I/O board mounted within the chassis housing.

To enable oxygen monitoring or oxygen trim, the “Z” designation in the fifth digit of the part number must be specified. The “Z” option and BMU chassis do not need to be purchased at the same time, this feature can be field-activated at a later date. The ZP probe and connecting cable are purchased separately.

The sixth digit in the part number specifies the mounting of the required LCD key pad. In most instances, the key pad will be shipped loose to be flush-mounted on the door of an enclosure. Alternatively, it can be mounted in the chassis cover either horizontally or vertically for landscape or portrait chassis orientation, respectively. The key pad is required whether or not the optional 10” OIT color touch screen is provided.

**BMU Chassis Specifications**

**Electrical**

|                |                     |
|----------------|---------------------|
| Input Voltage: | 120 VAC (+/- 15%)   |
| Frequency:     | 60 Hz, single phase |
| Consumption:   | 42 VA               |

**Environmental**

|                        |                            |
|------------------------|----------------------------|
| Operating Temperature: | 32 to 140 deg. F           |
| Storage Temperature:   | -20 to 150 deg. F          |
| Humidity:              | 15 to 95%<br>noncondensing |

Ordering Information

| Chassis Description                                                                                                                                                                                                                                                                                                                                                                                                     | Catalog Number |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                         | BMU - _ _ _ 0  |
| “Basic” controller chassis supports up to seven (7) independent servo actuators--3 for fuel, 1 for air, 1 for FGR and 2 Auxiliaries. Also two (2) 4 to 20 madc outputs for FD fan VSD/or Auxiliary 2 curve (if not a servo)                                                                                                                                                                                             | 0              |
| “Expanded” controller chassis is required for draft or feedwater control. Supports up to ten (10) independent servo actuators--3 fuel, 1 air, 1 FGR, 1 feedwater flow control valve, 1 draft damper and atomizing steam flow control valve. Also up to six (6) 4 to 20 madc outputs for: firing rate, FD, ID fan VSDs, Auxiliary 2 valve or damper, a draft damper and a feedwater control valve or feedwater pump VSD. | 1              |
| Controller does not support ZP oxygen probe                                                                                                                                                                                                                                                                                                                                                                             | 0              |
| Controller supports ZP oxygen probe (field upgradable)                                                                                                                                                                                                                                                                                                                                                                  | Z              |
| LCD key pad is shipped loose (standard)                                                                                                                                                                                                                                                                                                                                                                                 | N              |
| LCD key pad is flush-mounted on the BMU controller chassis cover for landscape chassis mounting                                                                                                                                                                                                                                                                                                                         | H              |
| LCD key pad is flush-mounted on the BMU controller chassis cover for portrait chassis mounting                                                                                                                                                                                                                                                                                                                          | V              |

Instruments & Controls

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

### BMU Standard Enclosure Options

Four standard enclosure options are offered for the BMU. The standard enclosures are NEMA 12, hinged on the left, include two locking mechanisms, and feature the following components, mounted and wired:

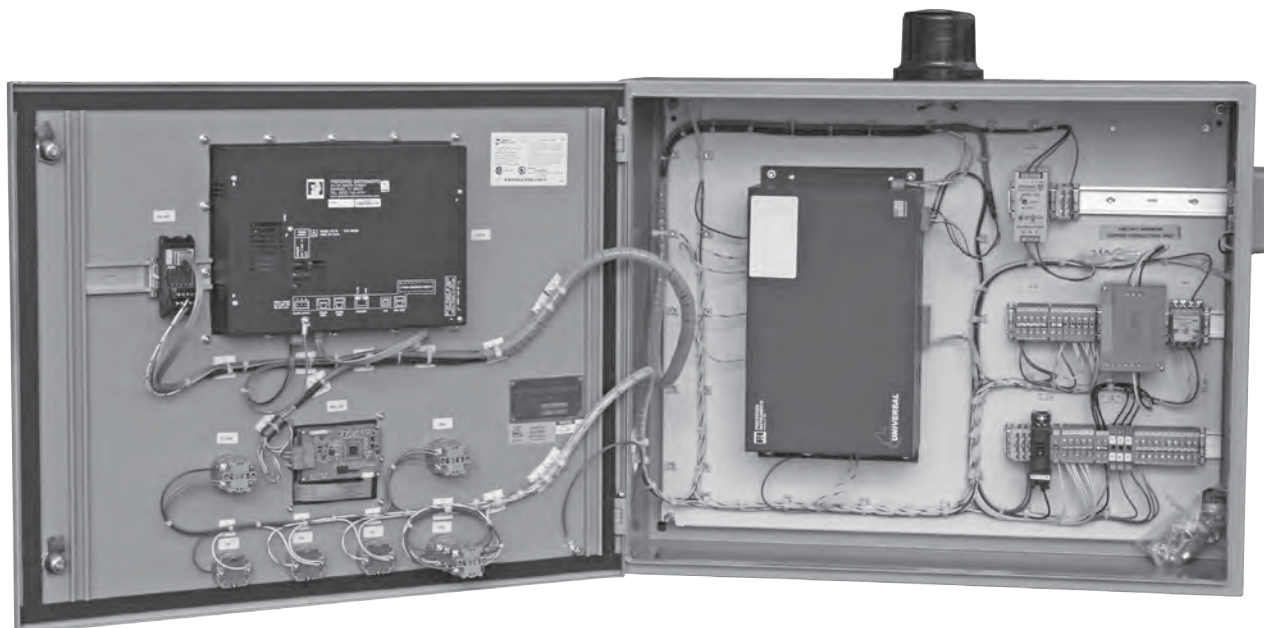
- LCD key pad, burner off-on selector switch, fuel selector switch, pilot lights, and an emergency stop pushbutton mounted on the enclosure door.
- A beacon and alarm horn are mounted and wired to the enclosure shell.
- BMU chassis, circuit breaker, fuses, and 24 VDC power supply (if OIT options are specified) and a number of 120 VAC terminals.
- The panel-mounted devices are factory-wired as shown. All other devices are field-wired directly to the BMU terminals. Standard drawings showing the panel arrangement and the internal wiring schematic are presented in the BurnerMate Universal Instruction Manual.



BMU-PANEL-2430-OIT

Additional DIN rail is provided to mount other devices as required, in the field. Custom designed cabinet are available. Consult factory for options, lead times, and pricing.

| Description                           | Catalog Number      |
|---------------------------------------|---------------------|
| Control Panel, 24"H x 30"W x 10"D     | BMU-PANEL243010     |
| Control Panel, 30"H x 24"W x 10"D     | BMU-PANEL302410     |
| OIT Control Panel, 24"H x 30"W x 10"D | BMU-PANEL243010-OIT |
| OIT Control Panel, 30"H x 24"W x 10"D | BMU-PANEL302410-OIT |
| Custom Designed Enclosure             | Consult Factory     |



Interior view of BMU-PANEL-2430-OIT standard enclosure

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

### BMU Digital Servo Actuators

BMU servos are available in output torques from 3 ft-lb to 720 ft-lbs. Each includes an actuator positioner board, and integral feedback potentiometer. The feedback potentiometer is used to prove servo position thereby eliminating the need for auxiliary proof of position switches. Servos can be used for the following control functions:

- Natural gas, fuel oil and/ or "other gas" flow control valve(s)
- FD fan damper
- Auxiliary final control element (second FD fan damper, atomizing steam/ air valve or ...)
- FGR damper
- Preferred Instruments LTA oxygen trim actuator
- Jackshaft actuator
- Boiler outlet (stack) damper
- Feedwater control valve
- Auxiliary servo for air sleeve, second gas FCV, etc.

For the larger "UM" Actuators a floor stand is included as a standard. Damper/ actuator interconnecting linkage rod, linkage rod ends and drive arms must also be purchased.

| "SM" Model Description                                                                               | Catalog Number           |
|------------------------------------------------------------------------------------------------------|--------------------------|
| Servo Actuator, 3 ft-lb. Torque (Shaft Extension required)                                           | BMU-SM-03                |
| As above w/15 ft-lb. Torque (Shaft Extension required)                                               | BMU-SM-15                |
| As above w/37 ft-lb. Torque (Shaft Extension required)                                               | BMU-SM-37                |
| Electrical Quick Disconnect Option                                                                   | BMU-SM-xx-QD             |
| "UM" Model Description                                                                               | Catalog Number           |
| Rotary Actuator, 72 ft-lb. torque. Includes floor stand, positioner board and interconnecting cable. | BMU-UM-072-FS            |
| As above w/140 ft-lb. torque                                                                         | BMU-UM-140-FS            |
| As above w/280 ft-lb. torque                                                                         | BMU-UM-280-FS            |
| As above w/420 ft-lb. torque                                                                         | BMU-UM-430-FS            |
| As above w/720 ft-lb. torque                                                                         | BMU-UM-720-FS            |
| Electrical Quick Disconnect Option                                                                   | BMU-SM-xx-QD             |
| Model Description                                                                                    | Catalog Number**         |
| BMU Comm Quick Disconnect Cable                                                                      | COMM-CABLE-ASSEMBLY-xx** |
| BMU Power Quick Disconnect Cable                                                                     | PWR-CABLE-ASSEMBLY-xx**  |
| BMU Quick Connect Termination Box                                                                    | BMU-JBOX                 |
| BMU "Home Run" Cable                                                                                 | BMU-CABLE-xx**           |

Servo mounting needs to be as solid as possible to minimize hysteresis and ensure consistent burner settings.

### BMU Chassis Specifications

#### Electrical

|            |                                           |
|------------|-------------------------------------------|
| Motor:     | 120 VAC (+/- 15%),<br>60 Hz, single phase |
| BMU-SM     | < 0.2 A                                   |
| BMU-UM     | < 2 A                                     |
| BMU-UM-720 | 3.4 A                                     |
| Positioner | 24 VDC, 23 mA                             |

#### Servo Performance

|             |                                    |
|-------------|------------------------------------|
| Speed:      | 25 sec/90°                         |
| Rotation:   | 15° to 180° (SM)<br>0° to 90° (UM) |
| Duty Cycle: | 100%                               |
| Accuracy:   | +/- 0.1° (SM)<br>+/- 0.4° (UM)     |

#### Environmental

|                       |               |
|-----------------------|---------------|
| NEMA Rating:          | NEMA 12       |
| BMU-SM                | NEMA 4        |
| Operating Temperature | 32° to 140° F |

#### Mechanical

|           |                                           |
|-----------|-------------------------------------------|
| BMU-SM-3  | 4" W x 5.8" H x 5.5"<br>8 mm "D" shaft    |
| BMU-SM-15 | 5" W x 5.8" H x 5.5"<br>12 mm "D" shaft   |
| BMU-SM-37 | 5" W x 6.7" H x 5.5" D<br>12 mm "D" shaft |

Consult factory for BMU-UM dimensions

\*\*Specify cable length in feet (3, 6, or 12ft)

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

| Standard Valve Mounting Bracket/Coupling Part Numbers                         |            |             |               |                                               |
|-------------------------------------------------------------------------------|------------|-------------|---------------|-----------------------------------------------|
| Valve Manufacturer & Model                                                    | Valve Size | Servo Model | Bracket Model | Coupling Model                                |
| Honeywell V51E Gas Butterfly Valves/5 PSIG rating                             | 1-1/2"     | BMU-SM-15   | Factory       | Factory                                       |
|                                                                               | 2"         | BMU-SM-15   | "             | "                                             |
|                                                                               | 2-1/2"     | BMU-SM-15   | 26189         | B-20154                                       |
|                                                                               | 3"         | BMU-SM-15   | C-30009       | B-20154                                       |
|                                                                               | 4"         | BMU-SM-15   | C-30009       | B-20154                                       |
| Hauck BVA Gas & Air Butterfly Valves/5 PSIG rating                            | 1-1/2"     | BMU-SM-15   | Factory       | Factory                                       |
|                                                                               | 2"         | BMU-SM-15   | "             | "                                             |
|                                                                               | 2-1/2"     | BMU-SM-15   | "             | "                                             |
|                                                                               | 3"         | BMU-SM-15   | "             | "                                             |
| Eclipse BV-A Full Port Gas Butterfly Valves (360 deg. rotation)/5 PSIG rating | 3/4"       | BMU-SM-15   | Factory       | Factory                                       |
|                                                                               | 1"         | BMU-SM-15   | "             | "                                             |
|                                                                               | 1-1/4"     | BMU-SM-15   | Factory       | Factory                                       |
|                                                                               | 1-1/2"     | BMU-SM-15   | "             | "                                             |
|                                                                               | 2"         | BMU-SM-15   | "             | "                                             |
|                                                                               | 2-1/2"     | BMU-SM-15   | "             | "                                             |
|                                                                               | 3"         | BMU-SM-15   | "             | "                                             |
| Milwaukee BB Series Gas Butterfly Valves/150 PSIG rating                      | 3/4"       | BMU-SM-37   | 26178         | (1) 26173-1B<br>(1) 26179<br>(2) 5636-008A-10 |
|                                                                               | 1"         | BMU-SM-37   | 26178         | (1) 26173-1B<br>(1) 26179<br>(2) 5636-008A-10 |
|                                                                               | 1-1/4"     | BMU-SM-37   | 26178         | (1) 26173-1B<br>(1) 26179<br>(2) 5636-008A-10 |
|                                                                               | 1-1/2"     | BMU-SM-37   | 26178         | (1) 26173-1B<br>(1) 26179<br>(2) 5636-008A-10 |
|                                                                               | 2"         | BMU-SM-37   | 26178         | (1) 26173-1B<br>(1) 26179<br>(2) 5636-008A-10 |



# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information



*BMU-UM-72-FS Servo with Integral Floor Stand*

| Standard Valve Mounting Bracket/Coupling Part Numbers (continued)                                    |        |            |         |                                           |
|------------------------------------------------------------------------------------------------------|--------|------------|---------|-------------------------------------------|
| Milwaukee "HP1L" & "HP1W" Series Gas Butterfly Valves/150 PSIG rating                                | 2-1/2" | BMU-SM-37  | Factory | Factory                                   |
|                                                                                                      | 3"     | BMU-SM-37  | 20150   | 20149-1                                   |
|                                                                                                      | 4"     | BMU-SM-37  | 20150   | 20149-1                                   |
| Hauck MOV & MCOV Oil Valves/ 300 PSIG rating                                                         | 3/8"   | BMU-SM-15  | Factory | Factory                                   |
|                                                                                                      | 1/2"   | BMU-SM-15  | 26177   | 26180-1                                   |
| Worcester CPT Characterized Seat Ball Valves/300 PSIG rating (gas, water, or steam)                  | 1/2"   | BMU-SM-15  | Factory | Factory                                   |
|                                                                                                      | 3/4"   | BMU-SM-15  | Factory | Factory                                   |
|                                                                                                      | 1"     | BMU-SM-37  | 26187   | 26186                                     |
|                                                                                                      | 1-1/2" | BMU-SM-37  | 20136   | 20140                                     |
| FlowTek Series 8000 Characterized Seat Ball Valves. 300 PSIG rating (gas, water, or steam)           | 1/2"   | BMU-SM-15  | 20135   | (2) 26173<br>(1) 20152<br>(2) 5636-008-10 |
|                                                                                                      | 3/4"   | BMU-SM-15  | 20135   | 20152                                     |
|                                                                                                      | 1"     | BMU-SM-15  | 20136   | 20138                                     |
|                                                                                                      | 1-1/4" | BMU-SM-37  | 20136   | 20138                                     |
|                                                                                                      | 1-1/2" | BMU-SM-37  | 20143   | (2) 26173<br>(1) 20152<br>(2) 5636-008-10 |
|                                                                                                      | 2"     | BMU-SM-72  | 20143   | 20146                                     |
| FlowTek Series "F15" & "RF15" Characterized Seat Ball Valves. 150 PSIG rating (gas, water, or steam) | 2"     | BMU-SM-72  | 20143   | 20146                                     |
|                                                                                                      | 2-1/2" | BMU-SM-72  | 20144   | B-20009                                   |
|                                                                                                      | 3"     | BMU-SM-140 | 20144   | 20163                                     |
|                                                                                                      | 4"     | BMU-SM-140 | 20167   | B-20016                                   |

## BURNERMATE UNIVERSAL BOILER CONTROLLER

### Ordering Information



*ZP Zirconium Oxide In-situ Oxygen Probe*

#### ZP Oxygen Analyzer Probe

The BMU uses the same ZP probe as the BurnerMate TS, PCC-III, and UtilitySaver. The ZP controller/ amplifier is built into the BMU chassis.

ZP probes should be field calibrated with test gases every 6-12 months. However, a new probe includes factory calibration parameters that can be entered into the BMU LCD key pad. This eliminates the need to have calibration gas during the initial start-up.

The BMU allows for stack oxygen indication, and oxygen trim depending on the parameter selections made during commissioning. When a stack temperature thermocouple is installed, the BMU calculates combustion efficiency for No. 2 oil, No. 6 oil, or natural gas.

| Model Description                                                                                                                                                                                                                                                                                                                                               | Catalog Number |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| In-Situ Detector & Probe Assembly 20"                                                                                                                                                                                                                                                                                                                           | ZP-20          |
| In-Situ Detector & Probe Assembly 30"                                                                                                                                                                                                                                                                                                                           | ZP-30          |
| In-Situ Detector & Probe Assembly 45"                                                                                                                                                                                                                                                                                                                           | ZP-45          |
| In-Situ Detector & Probe Assembly 65"                                                                                                                                                                                                                                                                                                                           | ZP-65          |
| In-Situ Detector & Probe Assembly 90"                                                                                                                                                                                                                                                                                                                           | ZP-90          |
| ZP Probe Connecting Cable – Seven Wire. Specify length required (Maximum is 500 feet)                                                                                                                                                                                                                                                                           | 190130         |
| ZP Probe Mounting Kit, Includes:<br>(1) 3" 125# Cast iron threaded flange<br>(1) 3" Pipe, half-coupling, threaded<br>(1) 3" x 8" long pipe nipple, threaded<br>(8) Hex nut, 5/8-11<br>(8) Washer, 5/8<br>(2) 1/8" Ball valve (brass)<br>(1) 3" Gasket<br>(50) Foot copper tubing, 1/4" OD<br>(8) Hex head screw, 5/8-11 x 2 1/2<br>(2) Straight fitting (brass) | 190680         |

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

### BurnerMate Universal OIT Touch Screen

All of the control functions of the BurnerMate Universal can be accessed through the LCD key pad. The BMU-OIT-10 color touch screen display is available for enhanced graphics and communications. Supported communication protocols include:

- 10/100 Base Ethernet, Modbus TCP/IP, Modbus RTU, SCADA/BAS connection, BacNet IP, and BMU connection
- One RS-485 port

Over 75 pre-programmed graphics pages are included. Boiler overview screens are field-selectable to fit the application.

### Touch Screen Specifications

#### Electrical

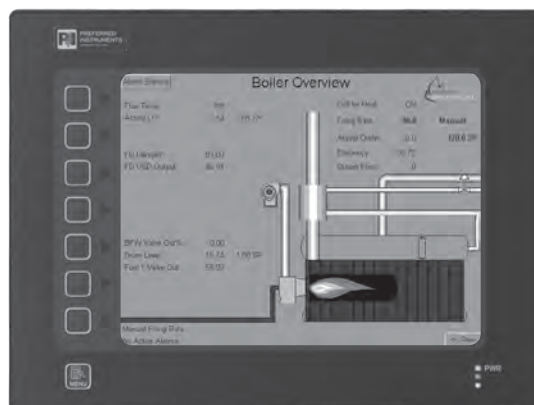
Input Voltage: 24 VDC, 1.4 A

#### Monitor Performance

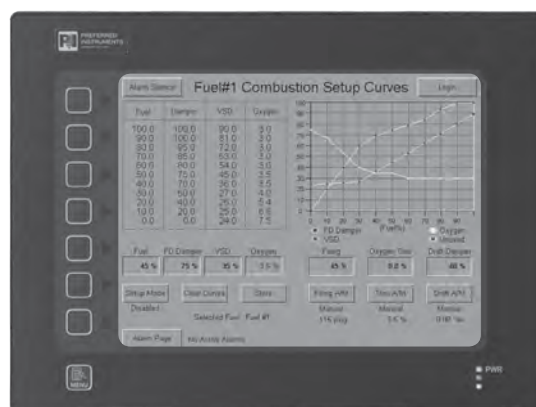
Size: 10.4"  
Colors: 256 VGA  
Resolution: 640 x 480 pixels

#### Environmental

NEMA Rating: NEMA 4X (flush-mount)



Typical Boiler Overview Screen

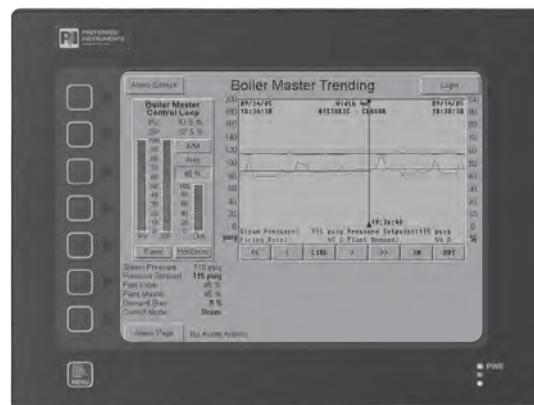


Fuel Combustion Curve Setup Screen

| Description                                                                                                 | Catalog Number |
|-------------------------------------------------------------------------------------------------------------|----------------|
| 10.4" Operator Interface Terminal Color Touch Screen Display with BMU operation and commissioning displays. | BMU-OIT10      |
| OIT Terminal Wiring Adapter                                                                                 | 190777         |
| 120 VAC/24 VDC/2.5 A DIN rail power supply                                                                  | 92443          |



Controller I/O screens help troubleshoot problems



Trending screens help fine-tune control loops

## BURNERMATE UNIVERSAL BOILER CONTROLLER

### Ordering Information

#### BMU Flame Scanners

The BMU can accept one or two flame scanners. They are available in ultraviolet, infrared, and ultraviolet self-checking versions.

#### Unitized Design

The BMU scanners, like most modern flame scanners, are unified. This means the flame detector and amplifier circuitry are combined and housed in the scanner. This eliminates the need for a separate enclosure-mounted amplifier. Whether the flame detector contains an ultraviolet, infrared, or self-checking ultraviolet detector, the outputs to the BMU are the same—a contact closure that proves flame is detected, and a 4-20 mA signal proportional to the flame signal. In the BMU, the 4-20 mA signal is used for flame indication only.

#### Advanced Diagnostics

On-board diagnostics in the flame scanners, and built in to the BMU, make trouble-shooting of a flame scanning problem easy. All BMU scanners contain two LEDs on the front of the scanner. The “flame status” (left) LED blinks at a rate proportional to the flame signal strength. The “flame relay” LED illuminates continuously when the flame signal is sufficient to close the flame proven relay.

In addition to the two LEDs, the scanners output a 4-20 mA signal to the BMU, proportional to the flame signal. The flame signal strength can be viewed from several screens on the BMU.

#### BMU Scanners Feature:

- Digital flame signal processing for more reliable flame detection.
- High quality fused silica quartz lens.
- Machined alloy housing with NEMA 4 seals.
- Military specification components used in essential integrated circuits and connectors.
- Military-style quick disconnect fittings allow for scanner replacement without rewiring.
- Redundant flame relay contacts are fully supervised.

#### UV Self-Check Scanners Feature:

- Detector and signal processors automatically checked every 10 seconds.
- New optical interrupter technology with 100 million cycle life span. (That's over 30 years!)
- Rugged 1" NPTF scanner mounting.

#### Ultra-Violet Flame Scanners

The BMU-UV and BMU-UVSC flame scanners use a UV detector tube as a sensing element. Incoming UV radiation from a flame is focused and amplified optically. The UV radiation energizes the detector tube, which works on the Geiger-Mueller principle. The BMU-UVSC self-checking detector and pulse processor are continuously supervised



BMU-UVSC and IR Flame Scanners

by means of the unique optical interrupter mechanism that breaks the UV light path between lens and detector tube. The scanner's pulse processor is fail-safe by nature, since any failure mode results in a total loss of signal.

#### Infrared Frequency-Based Scanners

The BMU-IR flame scanner uses a lead sulfide sensing element. The presence of a flame is detected by sensing the variations of flame luminosity. This technique aids discrimination of flame radiated energy and background radiation from heated furnace parts. Consult factory for availability of IR scanners.

| Application                  | Recommended Scanner |    |
|------------------------------|---------------------|----|
|                              | UVSC                | IR |
| Gas Only Fired               | X                   |    |
| No. 2 Oil, Air Atomized      | X                   |    |
| No. 2 Oil, Steam Atomized    |                     | X  |
| No. 2 Oil, Pressure Atomized | X                   |    |
| No. 6 Oil, Steam Atomized    |                     | X  |
| No. 6 Oil, Rotary Cup        |                     | X  |
| Digester or Landfill Gas     | X                   |    |
| Refinery Gas                 | X                   |    |



## BURNERMATE UNIVERSAL BOILER CONTROLLER

### Ordering Information

#### Scanner Application

Consult the burner manufacturer to determine the most effective flame scanner type for your burner application. However, typically ultraviolet (UV) scanners are used for gas flames and infrared (IR) scanners are used for heavy oil, or steam-atomized light oil flames. Preferred's UV flame scanners are traditional UV tube scanners. The IR scanner uses a lead sulfide detector.

Because UV tube scanners can fail showing flame (runaway scanner condition) a self-checking UV scanner should be used for applications where the burner does not typically cycle off at least once in each eight hour period. IR scanners do not typically fail showing flame.

| Description                                                                                 | Catalog Number |
|---------------------------------------------------------------------------------------------|----------------|
| Ultraviolet Self-Check Scanner; 10 ft cable & connector                                     | BMU-UVSC-10C   |
| Ultraviolet Non Self-Check Scanner; 10 ft cable & connector                                 | BMU-UV-10C     |
| Infrared Non Self-Check Scanner; 10 ft cable & connector. Consult factory for availability. | BMU-IR-10C     |
| Scanner Cable (lengths other than 10')                                                      | 5000-02-xx     |

|                                                                                                                                      | BMU-UVSC-10C<br>Ultraviolet<br>Self-Check Scanner                                                                                                   | BMU-UV-10C<br>Ultraviolet<br>Non Self-Check Scanner                                                                 | BMU-IR-10C<br>Infrared<br>Non Self-Check Scanner                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Mechanical:<br>Overall Length<br>Diameter<br>Housing Construction<br>Finish<br>Sight Tube Connection<br>Purge Air Connection         | 7" (177.8 mm)<br>3.25" (82.5 mm)<br>Machined 5052 Alum.<br>Clear Anodized<br>1" NPT (female)<br>3/8" NPT (female)                                   | 3" (76.2 mm)<br>2.25" (57.15 mm)<br>Machined 5052 Alum.<br>Clear Anodized<br>1/2" NPT (female)<br>3/8" NPT (female) | 3" (76.2 mm)<br>2.25" (57.15 mm)<br>Machined 5052 Alum.<br>Clear Anodized<br>1/2" NPT (female)<br>3/8" NPT (female) |
| Electrical:<br>Supply Voltage<br>Required Power<br>Contact Output<br>Current Output<br>Current Output specs<br>(2 wire current loop) | 120 VOLT 50/60 HZ<br>2 VA<br>120 VAC, 1 amp<br>4 to 20 mADC<br>Span error – 0.5%<br>Non-linearity – 0.03%<br>Loop supply voltage<br>7.5 to 36 Volts | 120 VOLT 50/60 HZ<br>2 VA<br>120 VAC, 1 amp<br>4 to 20 mADC                                                         | 120 VOLT 50/60 HZ<br>2 VA<br>120 VAC, 1 amp<br>4 to 20 mADC                                                         |
| Environmental:<br>Class<br>Temperature                                                                                               | NEMA 4<br>0 to 140 deg. F.                                                                                                                          | NEMA 4<br>0 to 140 deg. F.                                                                                          | NEMA 4<br>0 to 185 deg. F.                                                                                          |
| Optical:<br>Lens                                                                                                                     | Fused Silica                                                                                                                                        | Fused Silica                                                                                                        | Fused Silica                                                                                                        |
| Spectral Sensitivity<br>Wavelength (nanometers)                                                                                      | 180 – 230 (UV)                                                                                                                                      | 180 – 230 (UV)                                                                                                      | 400 – 1050 (IR)                                                                                                     |

BMU-IR infrared scanners will be available soon. Consult factory for availability.

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

### BMU\_Edit

In the tradition of PCC-III\_Edit and PWC\_Edit, the BurnerMate Universal is available with BMU\_Edit software that runs on your Windows-based PC and allows you to set the parameters of the BMU from your laptop. Communication between the BMU and your PC is done via a standard USB A/B (printer) cable.

Easy pull-down menus and text boxes allow parameter selections in your office to be written into the BMU chassis either before installation or during commissioning. Once commissioning is complete, BMU\_Edit allows you to read from the BMU chassis and save the latest parameter settings and curve data in the PC. This setting information can be used to setup additional BMUs or used as an archive if the BMU configuration becomes corrupted.

BMU\_Edit includes tools that allow the performance of a parameter check to make sure parameters haven't been set to incompatible values. The software will also convert setting data from one BMU version to another. In addition, BMU\_Edit can compare two BMU configurations and make a detailed list of the differences between the two configurations. This feature is important when more than one technician may work on the same boiler.



The compare function tracks any changes made to a BMU configuration for easy trouble-shooting.



The curve viewer function allows a technician to quickly view all the combustion related curves input in a BMU. This can be useful when diagnosing a problem. It can also be used to archive curve information quickly and easily. Parameter settings and fuel-air curves can be written back to the BMU, but the points must be verified before leaving commissioning mode.

| Model Description | Catalog Number |
|-------------------|----------------|
| BMU_Edit Software | BMU_Edit       |

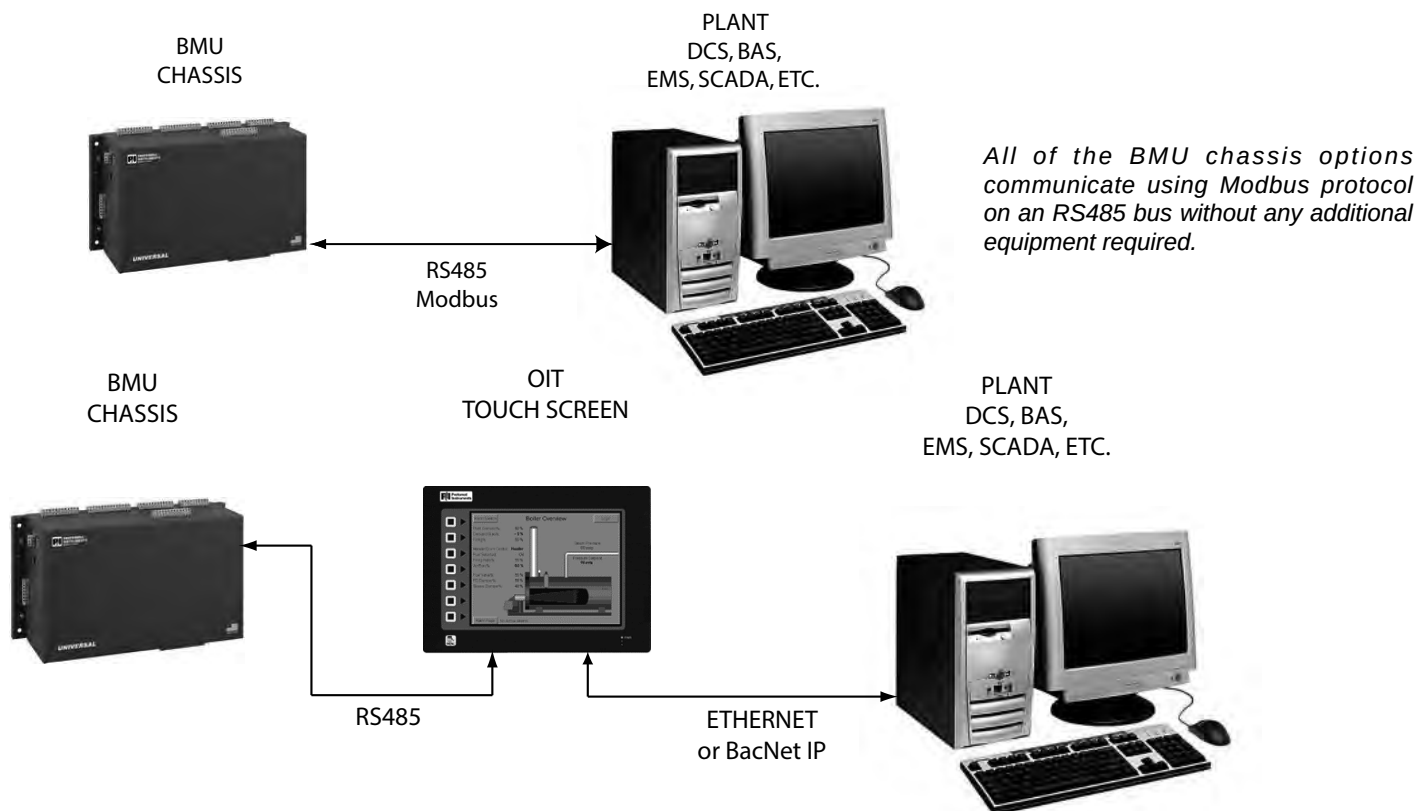
# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

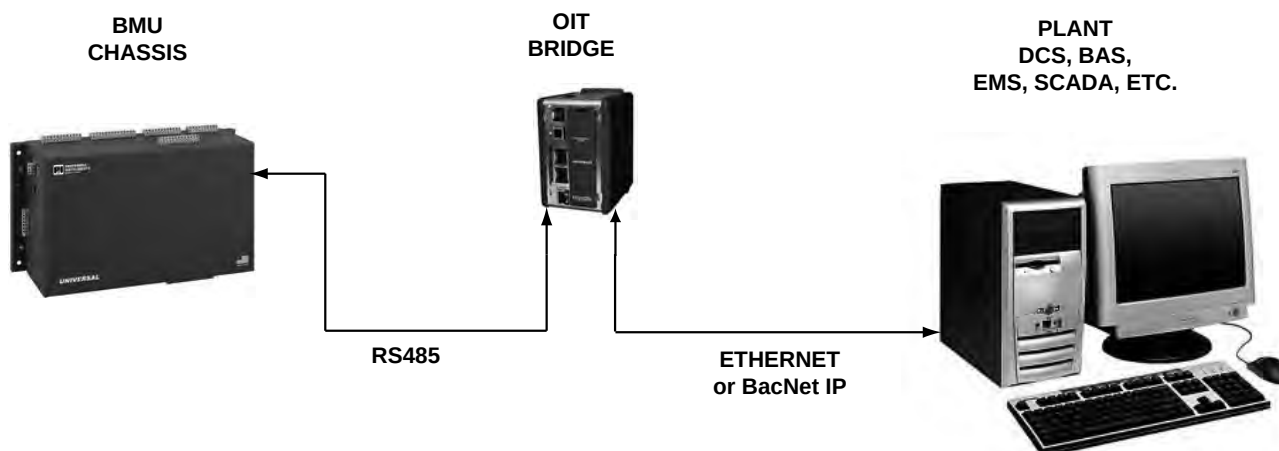
### Digital Communication Options

Many plant owners and engineers desire to monitor the status of the boiler room remotely. The BMU has Modbus addresses assigned for the status of many digital and analog inputs and outputs. This data is accessible by Modbus using the RS485 connection on the BMU chassis. The RS485 connection can

be converted to Ethernet using either the OIT touch screen or an OIT-Bridge. Generally, any data point displayed on the touch screen has a Modbus address and can be monitored remotely via Modbus. A PWC, PCC-III, or DCS-III loop controller can be used to make any other points available via Modbus.



*This is the most common digital communication scenario used with the BMU. The OIT touch screen is supplied for its graphics capability, and is also used to convert the RS485 bus to Ethernet. There are many terms for the control system the BMU typically interfaces with, including: Distributed Control System (DCS), Building Automation System, (BAS) Energy Management System (EMS) or Preferred Supervisory Control and Data Acquisition System (SCADA). Most of these systems can communicate via Modbus over Ethernet or have converters that can communicate via Modbus.*



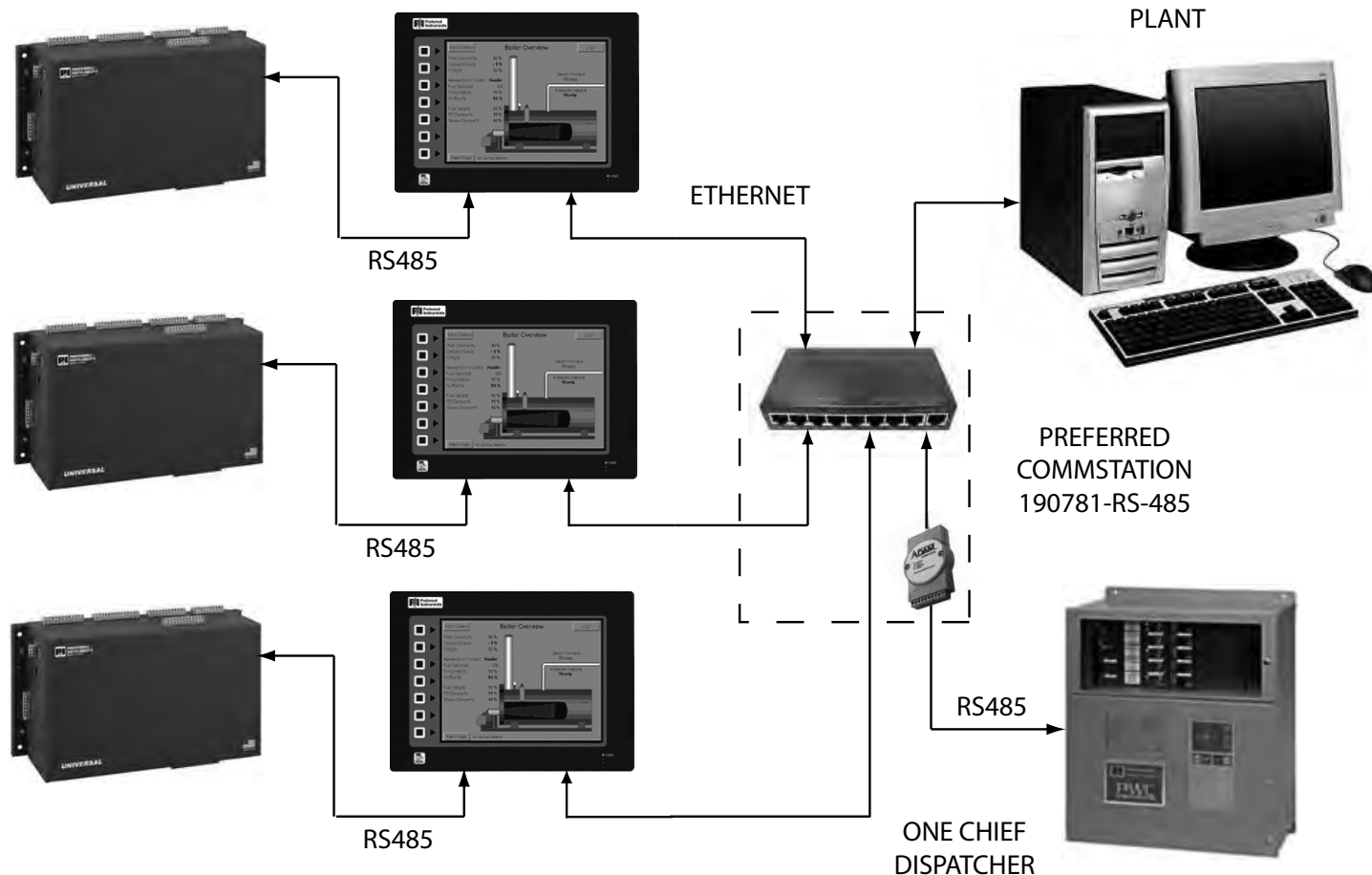
*As an economical alternative to the OIT touch screen, Preferred offers the OIT-Bridge that provides a pre-configured communication interface between the Modbus RS485 BMU chassis and Modbus over Ethernet. The OIT-Bridge is pre-configured to the Modbus addresses of the BMU. It offers the same communication capabilities as the OIT touch screen at a much lower price.*

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Ordering Information

### MULTIPLE BMUs IN ONE PLANT

### SINGLE ETHERNET CONNECTION TO PLANT



*This is the ultimate in-plant monitoring capability in an entirely pre-engineered package. Up to three boilers can be controlled and monitored using off-the-shelf BMU boiler masters, a Chief Dispatcher plant master, and the CommStation communication interface that provides a single Ethernet connection to the plant. Because the components of this system are completely pre-engineered, this is a very economic package that will typically be competing with a custom engineered PLC-based system.*

| Description                                                                                                                                                                                                                | Catalog Number  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Optional web browser remote communication module with pre-configured BMU operation and commission displays visible from a standard web browser. One Ethernet, one RS-485, and two RS-232 communication ports are built-in. | BMU-OIT-BRIDGE  |
| Historical memory 2 GB compact flash card for extended historical memory collection and export to MS Excel                                                                                                                 | 90283           |
| Communication expansion card. Provides one additional RS-232 and RS-485 port.                                                                                                                                              | 90284           |
| CommStation three boiler BMU/Chief Dispatcher Ethernet interface                                                                                                                                                           | 190781 – RS-485 |
| 120 VAC/ 24 VDC/ 2.5 A DIN rail-mounted power supply                                                                                                                                                                       | 92243           |



# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Suggested Specifications

### 1. Quality Assurance

The boiler control system shall be manufactured and supported in the United States by Preferred Instruments. The burner fuel-air-FGR ratio control system and the burner flame safeguard system shall be manufactured and labeled in accordance with U.L. 372, U.L. 1998, and CSA C22.2 #199. Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet as a whole must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL508A and CSA C22.1 #14. Inspection and labeling shall be supervised an OSHA approved Nationally Recognized Test Lab (NRTL). The system shall comply with NFPA 85 "Requirement for Independence," the flame safeguard system shall be provided with independent hardware shall be physically separated from the combustion control logic.

### 2. Parallel Positioning Combustion Control

A parallel positioning combustion control system with oxygen trim and (optional) VSD control shall be provided for each boiler. Each system shall be designed to provide continuous boiler operation within boiler design limits with a high level of safety and energy efficiency. As required the system shall provide continuous monitoring and control of steam pressure (or water temperature), water level, combustion air and fuel ratio & flue gas recirculation. The system shall be fully integrated to the burner management system to provide fully automatic, safe and reliable startup and shutdown. Position pacing shall be used to ensure up to eight servos will be continuously monitored and held "on curve" during boiler load changes.

### 3. Oxygen Trim System

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive type oxygen analyzers are not acceptable for combustion control. The probe shall be of a suitable length to sense the oxygen level in the middle third of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall:

- Include continuous self-diagnostics with diagnostic codes for at least 10 common faults.
- Automatically send the trim control to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault.
- The detector shall be field replaceable without removing the probe from the stack and shall not require special tools.
- The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift.
- Analyzer calibration shall be pushbutton semi-automatic (no trim pots) with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field re-calibration.

### 4. Flame Safeguard System (FSG)

Integral to the control system furnished shall be a Burner Management System (BMS) /Flame Safeguard System (FSG) controller. The system shall be designed to ensure the safe start-up, on-line operation, and shutdown of fuel firing equipment. Burner management system components shall be located in the combustion control cabinet and shall be fully integrated for automatic sequencing of light off and shutdown. For safety the BMS microprocessor and BMS VD shall be on a physically separate circuit board.

Microprocessor-based FSG shall provide: safety interlocks, flame monitoring protection, and timed sequences. Sequences shall include forced draft fan start and stop, furnace purge, burner light off and shutdown and post-purge. The FSG shall be capable of firing up to three fuels (two gas fuels, one oil fuel), one fuel at a time. Fuel changeover shall from oil to gas, or gas to oil firing shall be accomplished "on the fly" at low fire without boiler shutdown per NFPA.

A panel front-mounted English language, four line, twenty character LCD message display shall be provided to display flame signal strength, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and burner historical information. Historical information shall include the status of all limits and servos for the last ten lockouts.

To ensure boiler low water cutouts are working correctly, the controller shall be capable of performing a daily automatic water column blow-down test. The user shall select the time of day and duration of the water column blow-down test. The controller shall ensure the low water cutoff switches are functioning correctly, and alarm the operator or lockout the boiler if it detects a switch malfunction.

To prevent nuisance trips, the flame safeguard system shall accommodate two flame scanners with one required to prove flame. The controller shall provide 120 VAC or 24 VDC scanner power, and accept two analog inputs indicating flame strength. Flame safeguard system shall include oil gun post purge for oil firing. Assured low fire cutoff shall be provided.

For additional nuisance trip protection, field adjustable time delays shall be provided for F.D. fan start, fresh air damper, minimum air flow, low draft cut out, and fuel pressure limits. Five field selectable auxiliary relays shall be included for common alarm, auxiliary fan start, blow-down, flame on, fuel valve open, hot water pump or valve.

To protect against dry firing, an option shall be available for high flue gas temperature lockout.

To ensure air switches are functioning, a minimum air flow pressure switch and purge air flow pressure switch safe start check shall be included.

### 5. Feedwater Control

Provide a boiler water level controller capable of single-, two-, or three-element feedwater control with the ability to automatically switch between control strategies dependent on system demands.

### 6. Draft Control

The controller shall provide two-element draft control utilizing a Preferred Instruments JC-22XMTR draft transmitter. Burner firing rate shall be used as a feed forward for improved response to load changes. The control shall provide both automatic and manual damper control. All adjustments shall be made from the front panel display in engineering units.

# BURNERMATE UNIVERSAL BOILER CONTROLLER

## Suggested Specifications

### 7. Flue Gas Recirculation Valve Control

The controller shall have a characterizable setpoint curve output signal for the fan to vary or damper its speed. All the logic required to automatically signal pre-purge, postpurge, light-off, and burner modulate cycles shall be provided within the controller. Alternatively, the control will regulate FGR according to a preset windbox oxygen setpoint curve.

### 8. Windbox Oxygen FGR Control

The controller shall accept an analog input for burner windbox oxygen to be used as a measure of flue gas recirculation rate. During commissioning, a windbox oxygen vs. firing rate curve shall be established. The controller shall modulate the flue gas recirculation valve (or flue gas blower motor VSD) to maintain windbox oxygen on the pre-established curve despite changes in ambient conditions.

### 9. Atomizing Media Pressure Control

The controller shall accept an input for atomizing steam pressure or atomizing steam/ oil differential pressure. During commissioning, an atomizing steam pressure (or atomizing steam/oil differential pressure) curve shall be established. The controller will modulate an atomizing steam flow control valve to keep the atomizing steam pressure on curve at all firing rates.

### 10. Additional Control Requirements:

- Minimum number of f(x) Curves to be provided per servo: 6
- Minimum number of points per f(x) Curve to be provided: 11
- Cold FGR low fire cutback shall be provided when FGR is utilized for NOx reduction.
- Separate curves shall be provided for FD fan full speed bypass of VSD in case of VSD failure.
- Controller shall include the capability of receiving a remote firing rate input and remote set point input.
- Controller shall include dual outdoor reset setpoint curves (normal and setback)
- Controller shall include warm standby start / stop cycle.
- Controller shall include low fire hold, and cold start warm up ramping.
- All external or auxiliary power supplies necessary for electronic transmitters (or final control element) shall be included.
- Boiler control software shall be U.L. 372/ U.L. 1998 recognized and inaccessible to prevent tampering. Unit commissioning shall be by parameter selection, not requiring ladder logic or blockware programming.
- The controller shall accept standard 4-20 mA, 1-5 VDC, or thermistor inputs for analog inputs. No special sensors shall be required.
- Controller shall receive and display inputs for fuel flow, air flow, and steam flow. Controller shall be capable of future upgrades to fully metered combustion control.

### 11. OIT Color Touch Screen

Provide as an option a ten (10) inch Operator Interface Terminal (OIT) designed to provide local operation, graphic display of information, alarm message display, historical and real time trending, remote control tuning, x/ y plots of fuel-air curve data for intuitive commissioning, Ethernet connectivity and standard internet browser remote communication. The OIT shall contain a minimum of 75 graphic pages and be networked to the boiler control and burner management systems. The OIT shall provide graphic pages allowing step-by-step commissioning of the controller parameters using English language prompts and selections.

The system shall be an industrial hardened operator interface terminal. The terminal shall be enabled by the web and allow remote monitoring via a standard internet browser and support Modbus TCP/IP Master, TCP/IP Slave, RS-485 Modbus Master, and Ethernet communications.

### 12. High Torque Servo Features:

- Easy pushbutton set-up, not requiring the adjustment of internal or external potentiometers.
- Servo zero, span, and direction of travel shall be accomplished by push-button configuration.
- Totally enclosed, dust tight, and splash-proof covers.
- Provide a separate direct acting digital servo actuators for the fuel gas and fuel oil.
- Electrically isolated shaft position feedback potentiometer, integral brake, 90° rotation in 25 seconds.
- The actuator shall be capable of being stopped, started, or instantly reversed without loss of power or overloading.
- Servo actuator positioning accuracy: 0.1 degrees. Servo full stroke safe start check shall be provided.
- For high torque applications such as watertube boiler air dampers, servo torque shall be rated minimum 70 ft-lbs with 0.4 degree accuracy.
- No servo feedback adjustments shall be required with pushbutton zero setup. Adjustable travel limit switches shall be integral, with re-adjustment not requiring new fuel air ratio curve re-entry.
- Servos shall be cycled during each light-off cycle, and the feedback from each servo monitored to ensure safe actuator operation.
- Servos shall be Preferred Instruments, model BMU-SM or BMU-UM (high torque).

# BURNERMATE UNIVERSAL INDUSTRIAL BOILER CONTROLLER

## System Overview



### System Overview

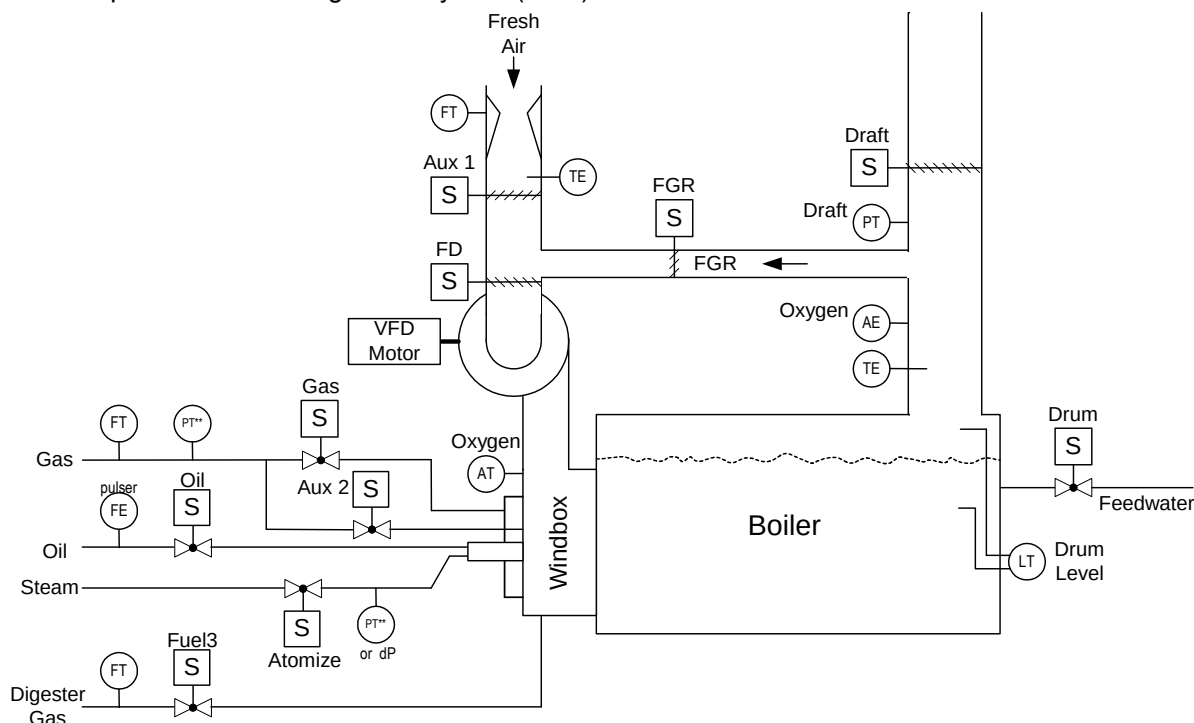
Fully Metered combustion control is now available “off the shelf” in an economical, pre-engineered, parameter-driven control package. The BurnerMATE Universal Industrial includes the following features:

- Patented “Predictive Full Metering” fuel-air ratio control
- Cross-limited Actuator, “Position Pacing”
- Single PID fuel-air, ratio tuning
- Air flow temperature compensation
- Gas flow pressure compensation
- Windbox O<sub>2</sub> FGR Trim + Flue O<sub>2</sub> Air Flow Trim

- Individual Interlock Annunciation with advanced Lockout Data storage
- Low Fire, Fuel Changeover
- Firing Rate, Feedwater and Draft control
- Oil Atomizing Pressure control with Setpoint Curve
- Large 10” color Touch Screen OIT with pre-programmed graphics (Note: 15” also available on custom applications)
- Modbus communications

The BurnerMATE Universal Industrial also includes all of the features in the Basic and Expanded versions of BMU:

- Precise high torque Servo Actuators ( 3 ft-lb -> 720 ft-lb, 8 sizes)
- FD, ID & FGR Fan and BFW Pump VFD drive control
- NFPA 85 compliant Burner Management System (BMS)



Typical Fully Metered BurnerMATE Universal Industrial P & ID.

# BURNERMATE UNIVERSAL INDUSTRIAL BOILER CONTROLLER

## System Overview

The BurnerMate Universal Industrial is available off-the-shelf for immediate delivery, requires only wiring and parameter setup to be operational and is NFPA 85 compliant and U.L. recognized.

### Predictive Metering Combustion Control

The BurnerMate Universal Industrial offers a patented metering fuel-air ratio combustion control technique using a unique control strategy referred to as “predictive metering”. The ideal combustion control strategy maintains a preset fuel-air ratio over the entire load range of a boiler despite changes in fuel supply, combustion air and draft conditions, and also provides rapid load change response.

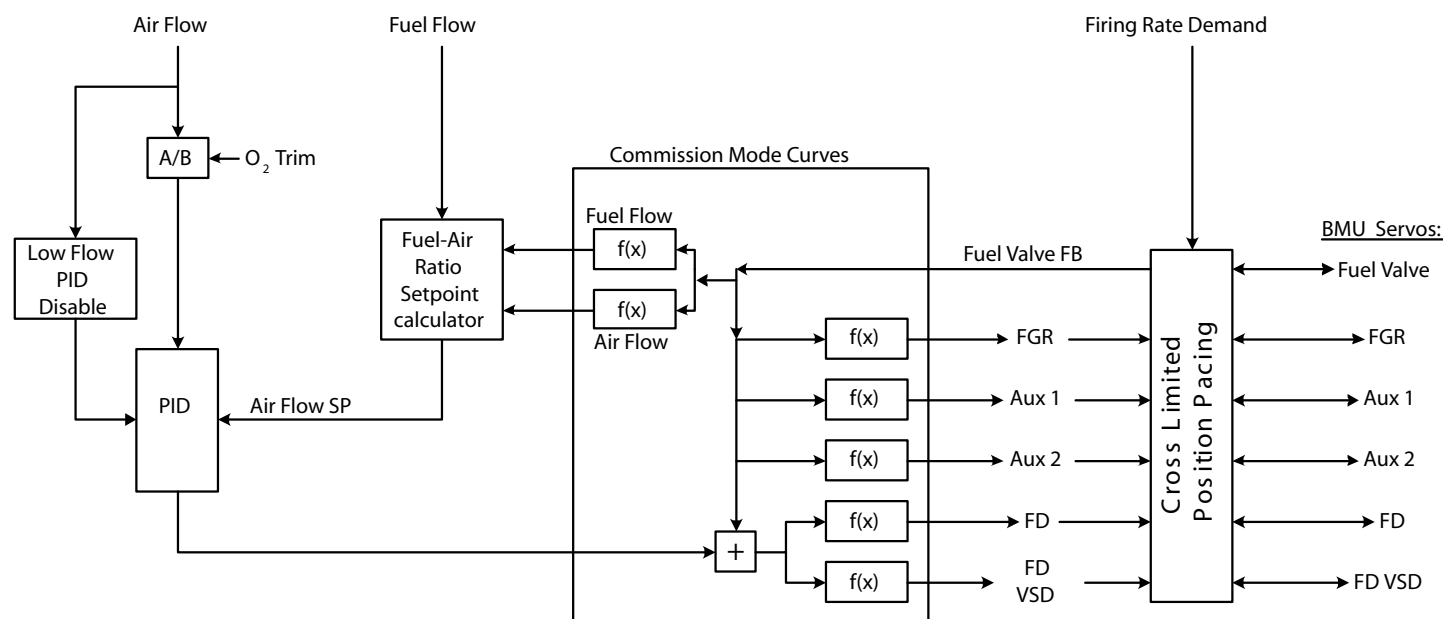
Traditional fully metered combustion control systems have the following weaknesses:

- Two PID loops are required, making tuning difficult
- Cross Limiting Lead-Lag causes Air Rich operation during Load changes
- Sluggish response to load changes caused by PID and Cross Limiting Lead-Lag interactions
- Air Flow meter inaccuracies at low flow rates limit Burner turndown capabilities
- Flow meter malfunctions disable the burner, or require manual operation until repaired
- Until now, Fully Metered control systems were “custom” so their benefits were not available “off-the-shelf”

Preferred’s patented “predictive metering” combustion control strategy combines multiple fuel, air, and FGR ‘as-commissioned’ feedforward curves (which predict Servo/VSD changes during a load change), with measured flow rate based PID fuel-air ratio control that incorporates a robust cross-limited position pacing algorithm. Predictive metering uses “as-commissioned” measured fuel flow rate and air flow rate curves to ensure that the PID fuel-air ratio remains at the “as-commissioned” fuel-air ratio setpoint for every firing rate.

Predictive metering, combined with “position pacing” logic, assures much more precise actuator positioning and assures that each servo remains “on curve” during load changes. This allows the controller to increase or decrease firing rate more quickly, without concern for “fuel rich” or “fuel lean” burner operation. These strategies are of particular importance when applied to sensitive low NOx burners with narrow limits of flammability.

Because “predictive metering” combustion control uses both the servo actuator position feedback and fuel and air flow meter inputs, metering combustion control can be selectively “turned” off at low firing rates where air flow meters may not be as accurate. Most importantly, if a flow meter malfunctions, by simple parameter selection the BMU Industrial controller can be directed to operate as a parallel positioning combustion control system with oxygen trim until the flow meter is repaired or replaced. Traditional fully metered systems can only be run in manual when there is a flow meter malfunction.



BurnerMate Universal Industrial Predictive Metering Control Schematic



# BURNERMATE UNIVERSAL INDUSTRIAL BOILER CONTROLLER

## System Overview

Because “predictive metering” is pre-programmed and only application-specific parameter setup is required to make the controller function, BurnerMate Universal Industrial is much easier to commission and operate than traditional fully metered combustion control systems. The single PID block (rather than the two required for traditional systems) requires that only one set of PID values need to be tuned during commissioning.

Inputs for “predictive metering” combustion control include:

- Combustion air flow
- Combustion air temperature
- Fuel 1 Oil flow (pulsar or 4-20 mA)
- Fuel 2 (natural) gas flow
- Fuel 2 (natural) gas pressure\*\*
- Fuel 3 (digester or other) gas flow\*\*

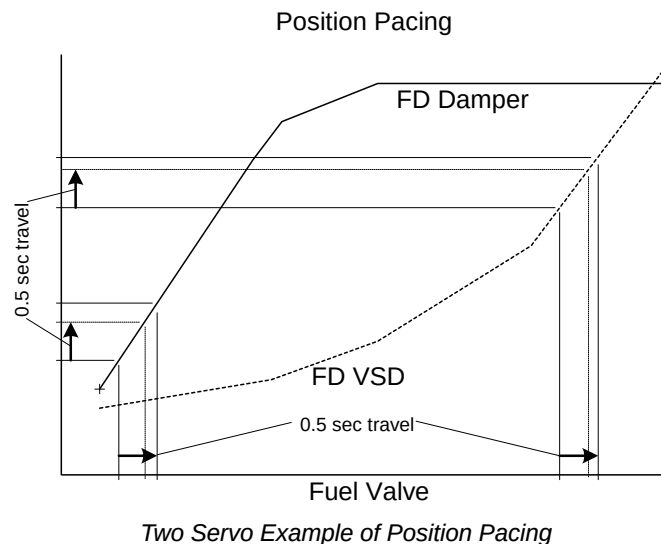
\*\*Note: The fuel 3 flow, gas pressure compensation, and atomizing pressure control transmitters all share a single BMU Industrial input. Only one of the three can be enabled (field selectable).

Fuel and steam flows are also totalized. Each of these flow rates and flow totals has a Modbus address for display on the local OIT Touch Screen or remotely via Modbus on Plant DCS system OITs.

BMU Industrial Fuel-Air-FGR Cross Limited Position Pacing “Position pacing” is a unique feature of the BurnerMate Universal Industrial that assures the positions of all fuel, air, and FGR Servos and related VSD speeds remain “on curve” during load swings. Position pacing helps avoid:

- Periods of lean combustion that can cause rumbling, vibration, or flame-outs during firing rate increases
- Fuel rich conditions that can cause smoking, burn-back, and excessive CO or unburned hydrocarbons during firing rate decreases

With traditional fully metered control systems, the solution to these problems is to slow down the response to firing rate changes, and to tighten “cross limiting lead-lag” to assure that the fuel and air flows remain “on curve.” For such systems, it is not unusual for low to high fire response times to be 4-8 minutes.



BMU Industrial “position pacing” assures that all servo actuators remain “on curve” in the following manner:

- All fuel, air, FGR servos and VSDs move together and “on curve” --there is no fuel or air “lead” or “lag”.
- Each Servo and VSD has precise position or speed feedback to insure that all devices are cross limited.
- The BMU Industrial “knows” how far each servo actuator and VSD can move in 0.5 seconds and uses “self-adaptive” position pacing to ensure that load changes never cause any servo or VSD to lag behind the others.
- Every 0.5 seconds, the BMU Industrial examines all curves to “find” the servo or VSD worst case 0.5 second “move” caused by a requested firing rate change.
- Based on the curves, all other servos or VSDs target positions are “scaled back” to ensure that ALL devices arrive “on curve” at the end of the next 0.5 second move.

BMU Industrial “position pacing” is fully automatic, provides for safer combustion control, drastically improved firing rate response times, and requires no user adjustments.

| Description                                                                                                                                                                             | Catalog Number |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| BurnerMate Universal Industrial chassis. Includes oxygen compensation inputs, and expanded processor with draft and feedwater control. LCD Keypad shipped loose for enclosure-mounting. | BMU-22N1       |

Note: BMU Industrial servos, scanners, oxygen analyzers and flow transmitters are required for a complete system.

# BURNERMATE UNIVERSAL INDUSTRIAL BOILER CONTROLLER

## Suggested Specifications

### 1. Quality Assurance

The boiler control system shall be manufactured and supported in the United States by Preferred Instruments. The burner fuel-air-FGR ratio control system and the burner flame safeguard system shall be manufactured and labelled in accordance with U.L. 372, U.L. 1998, and CSA C22.2 #199. Simply supplying UL recognized individual components is not sufficient. The assembled control cabinet as a whole must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL508A and CSA C22.1 #14. Inspection and labeling shall be supervised an OSHA approved Nationally Recognized Test Lab (NRTL). The system shall comply with NFPA 85 "Requirement for Independence," the flame safeguard system shall be provided with independent hardware, and shall be physically separated from the combustion control logic.

### 2. Predictive Metering Combustion Control

A fully metered combustion control system with oxygen compensation and (optional) VSD control shall be provided for each boiler. Each system shall be designed to provide continuous boiler operation within boiler design limits with a high level of safety and energy efficiency. Fuel flow, air flow, and servo position for up to eight servos will be continually monitored and held "on curve" during boiler load changes. For convenient setup and faster response to load changes, the fully metered combustion control logic shall contain only one PID loop. As required the system shall provide continuous monitoring and control of steam pressure (or water temperature), and water level. If a flow meter is out of range or inoperative, the control strategy can be switched to parallel positioning, by parameter selection. The system shall be fully integrated to the burner management system to provide fully automatic, safe and reliable startup and shutdown.

### 3. Oxygen Compensation System

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive type oxygen analyzers are not acceptable for combustion control. The probe shall be of a suitable length to sense the oxygen level in the middle third of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall:

- Include continuous self-diagnostics with diagnostic codes for at least 10 common faults.
- Automatically send the trim control to the 'null' position and trigger the alarm dry contacts in the if an oxygen analyzer faults.
- The detector shall be field replaceable without removing the probe from the stack and shall not require special tools.
- The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift.
- Analyzer calibration shall be pushbutton semi-automatic (no trim pots) with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field re-calibration.

### 4. Windbox Oxygen FGR Control

The controller shall accept an analog input for burner windbox oxygen to be used as a measure of flue gas recirculation rate. During commissioning, a windbox oxygen vs. firing rate curve shall be established. The controller shall modulate the flue gas recirculation valve (or flue gas blower motor VSD) to maintain windbox oxygen on the pre-established curve despite changes in ambient conditions.

### 5. Atomizing Media Pressure Control

The controller shall accept an input for atomizing steam pressure or atomizing steam/ oil differential pressure. During commissioning, an atomizing steam pressure (or atomizing steam/oil differential pressure) curve shall be established. The controller will modulate an atomizing steam flow control valve to keep the atomizing steam pressure on curve at all firing rates.

### 6. Flame Safeguard System (FSG)

Integral to the control system furnished shall be a Burner Management System (BMS)/ Flame Safeguard System (FSG) controller. The system shall be designed to ensure the safe start-up, on-line operation, and shutdown of fuel firing equipment. Burner management system components shall be located in the combustion control cabinet and shall be fully integrated for automatic sequencing of light off and shutdown. For safety the BMS microprocessor and BMS VD shall be on a physically separate circuit board.

Microprocessor-based FSG shall provide: safety interlocks, flame monitoring protection, and timed sequences. Sequences shall include forced draft fan start and stop, furnace purge, burner light off and shutdown and post-purge. The FSG shall be capable of firing up to three fuels (two gas fuels, one oil fuel), one fuel at a time. Fuel changeover shall be from oil to gas, or gas to oil firing shall be accomplished at low fire without boiler shutdown per NFPA.

A front-mounted panel with English language, four line, twenty character LCD message display shall be provided to display flame signal strength, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and burner historical information. Historical information shall include the status of all limits and servos for the last ten lockouts.

To ensure boiler low water cutouts are working correctly, the controller shall be capable of performing a daily automatic water column blow-down test. The user shall select the time of day and duration of the water column blow-down test. The controller shall ensure the low water cutoff switches are functioning correctly, and alarm the operator or lockout the boiler if it detects a switch malfunction.

To prevent nuisance trips, the flame safeguard system shall accommodate two flame scanners with one required to prove flame. The controller shall provide 120 VAC or 24 VDC scanner power, and accept two analog inputs for flame strength indications. Flame safeguard system shall include oil gun post purge for oil firing. Reliable low fire cutoff shall be provided.

For additional nuisance trip protection, field adjustable time delays shall be provided for F.D. fan start, fresh air damper, minimum air flow, low draft cut out, and fuel pressure limits. Five field selectable auxiliary relays shall be included for common alarm, auxiliary fan start, blow-down, flame on, fuel valve open, hot water pump or valve.

To protect against dry firing, an option shall be available for high flue gas temperature lockout.

To ensure air switches are functioning, minimum air flow pressure switch and purge air flow pressure switch shall be tested for safe starting.

# BURNERMATE UNIVERSAL INDUSTRIAL BOILER CONTROLLER

## Suggested Specifications

### 7. Feedwater Control

Provide a boiler water level controller capable of single-, two-, or three-element feedwater control with the ability to automatically switch between control strategies dependent on system demands.

### 8. Draft Control

The controller shall provide two-element draft control using a Preferred Instruments JC-22XMTR draft transmitter. Burner firing rate shall be used as a feed forward for improved response to load changes. The control shall provide both automatic and manual damper control. All adjustments shall be made from the front panel display in engineering units.

### 9. Flue Gas Recirculation Valve Control

The controller shall have a characterizable setpoint curve for damper or variable speed fan output signal. All the logic required to verify that pre-purge, post purge, light-off, and burner modulate cycles are automated shall be provided within the controller. Alternatively, the control will regulate FGR according to a preset windbox oxygen setpoint curve.

### 10. Additional Control Requirements:

- Minimum number of f(x) curves to be provided per servo: 6
- Minimum number of points per f(x) curve to be provided: 11
- Cold FGR low fire cutback shall be provided when FGR is utilized for NOx reduction.
- Separate curves shall be provided for FD fan full speed bypass of VSD in case of VSD failure.
- Controller shall include the capability of receiving a remote firing rate input and remote set point input.
- Controller shall include dual outdoor reset setpoint curves (normal and setback)
- Controller shall include warm standby start/ stop cycle.
- Controller shall include low fire hold, and cold start warm up ramping.
- All external or auxiliary power supplies necessary for electronic transmitters (or final control element) shall be included.
- Boiler control software shall be U.L. 372/ U.L. 1998 recognized and inaccessible to prevent tampering. Unit commissioning shall be by parameter selection, not requiring ladder logic or blockware programming.
- The controller shall accept standard 4-20 mA, 1-5 VDC, or RTD inputs for analog inputs. No special sensors shall be required.

### 11. OIT Color Touch Screen

Provide as an option a ten (10) inch Operator Interface Terminal (OIT) designed to provide local operation, graphic display of information, alarm message display, historical and real time trending, remote controller tuning, x/y plots of fuel-air curve data for intuitive commissioning, Ethernet connectivity and standard internet browser remote communication. The OIT shall contain a minimum of 75 graphic pages and be networked to the boiler control and burner management systems. The OIT shall provide graphic pages allowing step-by-step commissioning of the controller parameters using English language prompts and selections.

The system shall be an industrial hardened operator interface terminal. The terminal shall be web enabled and allow remote monitoring via a standard internet browser and support Modbus TCP/IP Master, TCP/IP Slave, RS-485 Modbus Master, BacNet IP, and Ethernet communications.

### 12. High Torque Servo Features:

- Easy pushbutton set-up, not requiring the adjustment of internal or external potentiometers.
- Servo zero, span, and direction of travel shall be accomplished by push-button configuration.
- Totally enclosed, dust tight, and splash-proof covers.
- Provide a separate direct acting digital servo actuator for the fuel gas and fuel oil.
- Electrically isolated shaft position feedback potentiometer, integral brake, 90° rotation in 25 seconds.
- The actuator shall be capable of being stopped, started, or instantly reversed without losing power or overloading.
- Servo actuator positioning accuracy: 0.1 degrees. Servo full stroke safe start check shall be provided.
- For high torque applications such as watertube boiler air dampers, servo torque shall be rated minimum 70 ft-lbs with 0.4 degree accuracy.
- No servo feedback adjustments shall be required with push-button zero setup. Adjustable travel limit switches shall be integral, with re-adjustment not requiring new fuel air ratio curve re-entry.
- Servos shall be cycled during each light-off cycle, and the feedback from each servo shall be monitored to ensure safe actuator operation.
- Servos shall be Preferred Instruments, model BMU-SM or BMU-UM (high torque).

## BURNERMATE TS BOILER CONTROL SYSTEM

### Overview

# BurnerMate® TS

**BurnerMate TS** is a custom-programmable boiler control and flame safeguard system that includes one or two DCS-III loop controllers and a flame safeguard microprocessor communicating via Modbus with a 10" or 15" OIT touch screen. The system provided includes an industrial enclosure with necessary pushbuttons, selector switches, power supplies, terminal blocks; factory wired and tested with other field devices for a complete system. Each system is programmed to the job specific requirements of the project.

### Advanced Combustion Control Options

- Single Point Positioning (Jackshaft) control. Effective control with remote monitoring for smaller boilers.
- Parallel Positioning control with Oxygen Trim and Variable Speed Fan Combustion Air Flow Control. Combined fuel and electrical savings for fast payback.
- Fully Metering control with Oxygen Trim and variable speed fan combustion air flow control creates superior control for Low NOx burner applications. Essential for simultaneous dual fuel firing, multiple burner boilers and balanced draft applications.
- Optional Drum Level, Draft and/ or Flue Gas Recirculation Control

### Integral Flame Safeguard

- Independent, industrial-hardened microprocessor.
- Automatic single burner, dual fuel, gas or oil firing, sequencing, ignition and flame monitoring protection.

### Easy to Order, Stock and Field Upgrade

- Factory wired and tested control system.

### Integrated Boiler Management

The BurnerMate TS is a combined combustion control, flame safeguard, and SCADA monitoring and control system. It incorporates Preferred's high quality DCS-III Multiple Loop Controller for boiler control functions, an industrial-hardened microprocessor for flame safeguard functions, and a PC-based SCADA workstation for graphic monitoring and operating. BurnerMate TS is a full scope control package that assures safe and efficient control with undivided system integration responsibility.

### Flexible & Expandable

A second, optional DCS-III Multiple Loop Controller can be supplied to provide draft and drum level control loops and balance of plant monitoring with up to 15 analog inputs, 6 analog outputs, 5 triac pair outputs, 6 relay outputs, 13 digital 120 VAC inputs, or combinations of these. BurnerMate TS is designed to be monitored and controlled by the optional SCADA/Flex Distributed Control System.



### BurnerMate TS Boiler Control

*Combustion Control Shown with Optional Flame Safeguard, Drum Level, Draft and FGR Control, Flue Gas Oxygen Analyzer, Flame Scanner, and SCADA/Flex Distributed Control System*

### Easy to Operate

BurnerMate TS with its large, industrial-grade color touch screens provides an intuitive, easily used control system that displays current boiler status, alarms, and historical logging. The system is password protected for security. Historical trending is standard. An optional flash card allows historical data to be exported to MS Excel. Scalable objects enable accurate process displays. X/ Y plots are provided for intuitive Fuel/ Air Curves display and commissioning. The NEMA 4X front panel eliminates the need for protective viewing doors. Easily used OIT\_Edit® configuration software can be used to customize graphic pages.

### Integral Oxygen Analyzer

The ZP Oxygen Probe is directly connected to the DCS-III controller (eliminating the need for a field mounted transmitter), which simplifies installation. The Model ZP with DCS-III-Zxxx is a full function analyzer which includes specific analyzer diagnostic codes for rapid trouble shooting and continuous monitoring of cell impedance for predicting cell health.

### Easy Commissioning

Using "Learn Mode" – F(x) characterizer curves are set by manually positioning fuel and air for safe and reliable operation and optimum Oxygen level and then pressing the "STORE" button. Air and oxygen setpoint curves are simultaneously setup. The process can be repeated for a maximum of 11 load points. Independent curves for each fuel are automatically selected.



# BURNERMATE TS BOILER CONTROL SYSTEM

## Specifications

### Remote Control and Monitoring

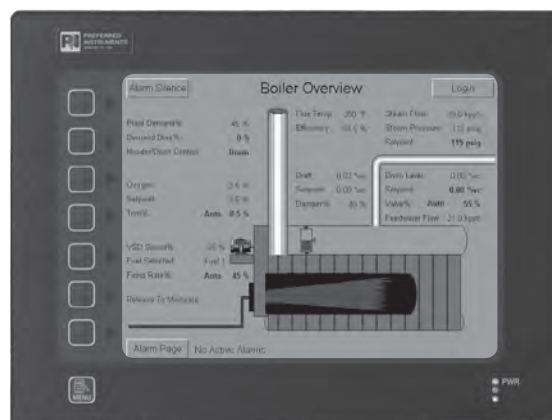
The optional SCADA/FLEX Distributed Control System provides remote operation, graphic display of information, alarm message displays, alarm printing, and remote boiler tuning capabilities. The system is networked to the boiler control and Flame Safeguard Systems.

### Standard Features

- Advanced Communication- 10 Base T/100 Base TX Ethernet
  - One RS-485, Second Optional
  - Two RS-232 Ports
  - Remote Web Access
  - Isolated, Simultaneous Modbus Master & Slave
- Real Time and Historical Trending Standard, optional Flash Card allows historical data to be exported to MS Excel.
- Scalable objects enable accurate process displays
- X/ Y Plots, for intuitive Fuel/ Air Curves display and commissioning
- NEMA 4X Front Panel eliminates the need for protective viewing doors.
- Easily used OIT\_Edit® Configuration Software

### Major Benefits

- Integration with DCS-III Controllers enables intuitive commissioning without the use of Laptops or PCC-III Controller Faceplate.
- BurnerMate TS Systems may be commissioned without the need for blockware training or laptops.



Typical Boiler Overview Screen is customized for the application

### Specifications

#### Mechanical

Enclosure Type: Windbox Mounted  
(optional Wall Mounted)  
Size: Typically - 30"H x 30"W x 12"D

#### Electrical

Input Power: 120 VAC

#### Environmental

Operating Temp: 32° F to 122° F (0° to 50° C)  
Storage Temp: -20° to 150° F (-28° to 65° C)  
Humidity Limits: 15 to 85% (noncondensing)  
Front Panel: NEMA 13/IP65

#### Communication

Network:  
Protocol: Modbus (ASCII or RTU mode)  
Speed: 1200 to 38,400 baud  
Type: RS485, optically isolated  
Configuration:  
Speed: 38,400 baud  
Type: RS232

#### Configuration, DCS-III Controller

Language: Function block style,  
60 functions, 160 blocks  
Laptop (optional): PC3\_Edit™ spread sheet based  
editor or PC3\_Draw™ graphical,  
object-oriented editor

#### OIT Touch Screen

#### Mechanical

10.4" TFT 256 Color VGA  
640 x 480 pixel LCD

#### Communication

10 Base T/100 Base TX Ethernet  
One RS-485, Second Optional  
Two RS-232 Ports  
Remote Web Access  
Isolated, Simultaneous Modbus  
Master & Slave



DCS-III Multiple Loop Controller

# BURNERMATE TS BOILER CONTROL SYSTEM

## Ordering Information

### Ordering Information

1. Specify BurnerMate TS Control System from the table (see the following pages for system descriptions)

Catalog Number: BMTS - ST - FMC

| Combustion Control                                                                    | Type        | Catalog Number     |
|---------------------------------------------------------------------------------------|-------------|--------------------|
| Steam or Hot Water Boiler                                                             | Steam       | ST                 |
|                                                                                       | Hot Water   | HW                 |
| Single Point Positioning Combustion Control                                           | Triac**     | SPT                |
|                                                                                       | Current*    | SPC                |
| Parallel Positioning Combustion Control                                               | Triac       | PPT                |
| Fully Metered Combustion Control                                                      | Current     | FMC                |
| Optional Features                                                                     | Output Type | Catalog Number     |
| Variable Speed Drive (VSD)<br>Combustion Air Fan Control<br>(PPT or FMC systems only) | Current     | add "-VSD" suffix  |
| Oxygen Trim Control                                                                   | --          | add "-ZP" suffix   |
| Flame Safeguard                                                                       |             | add "-FSG" suffix  |
| Draft Control                                                                         | Triac       | add "-DRT" suffix  |
|                                                                                       | Current     | add "-DRC" suffix  |
| Drum Level (Feedwater) Control "X" -<br>Feedwater (1, 2, or 3) Element                | Triac       | add "-FWT" suffix  |
|                                                                                       | Current     | add "-FWC" suffix  |
| Flue Gas Recirculation (FGR) Control                                                  | Triac       | add "-FGRT" suffix |
|                                                                                       | Current     | add "-FGRC" suffix |
| Wall Mounted style enclosure (instead of<br>Burner Windbox Mounted style)             |             | add "-WM" suffix   |

\* "Current" outputs provide a 4-20 mADC signal to drive electric or pneumatic actuators.

\*\* "Triac" outputs provide direct control of electric actuators such as the SM-15

### Additional Ordering Information (when required)

- Specify required pressure, temperature, or flow sensor ranges
- Specify Variable Speed Drive (VSD) motor data
- Specify In-Situ Oxygen Sensor probe length and cable length
- Specify SCADA/Flex Distributed Control requirements

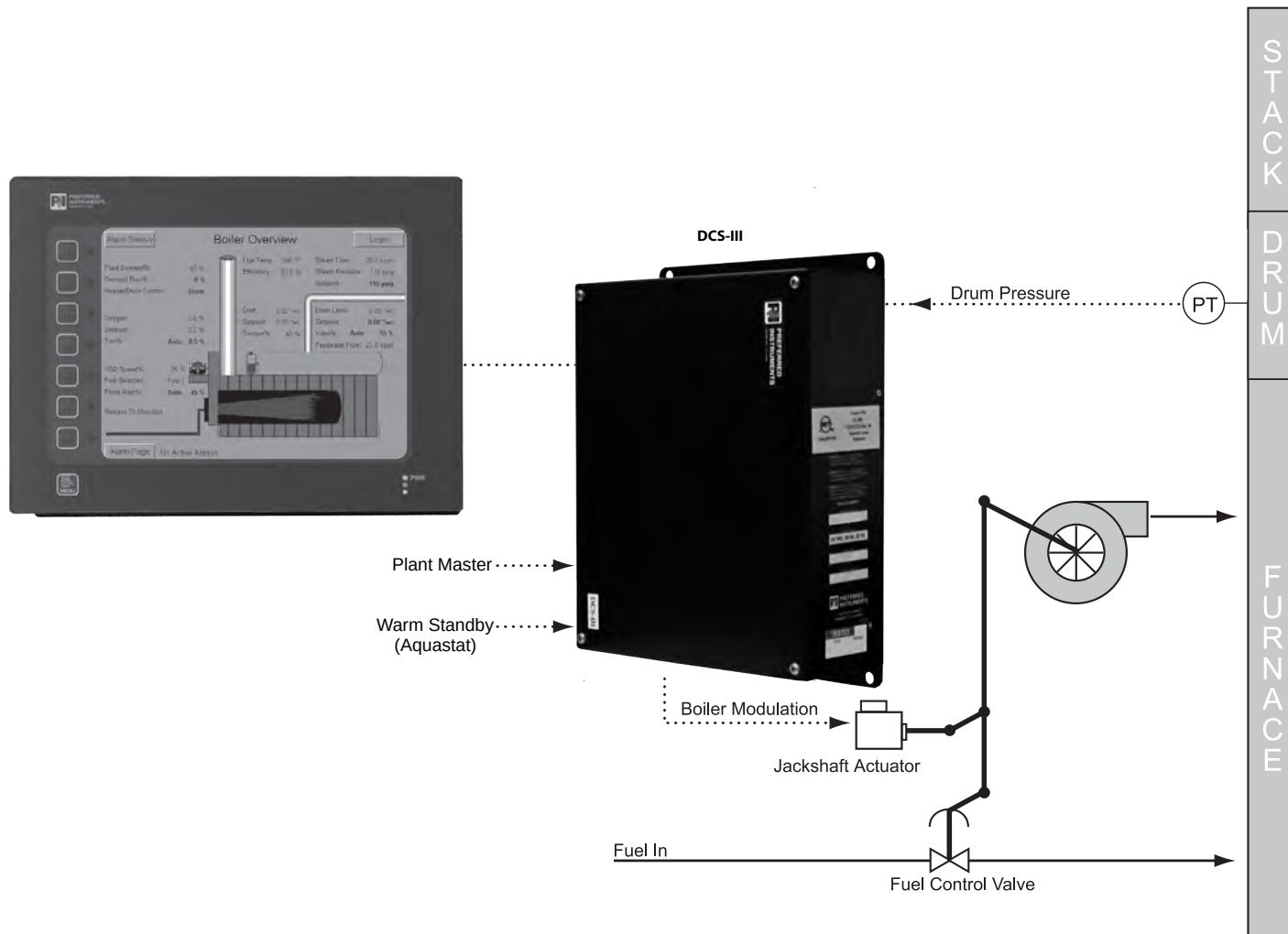
### Catalog Number Example:

BMTS-HW-FMC-VSD-ZP-FSG-DRT-2-FWC-FGRT: BurnerMate TS for Hot Water Generator with Fully Metered Combustion Control with current outputs, Variable Speed Drive (VSD) Combustion Air Fan Control, Oxygen Trim Control, Flame Safeguard, Draft Control with triac output, Two Element Feedwater Control with current output, and Flue Gas Recirculation Control with triac output.

Consult factory for VSD bypass or additional monitoring and control requirements.

## BURNERMATE TS MODEL BMTS-STSP

### Steam Boiler Single Point Positioning Combustion Control



Model BMTS-STSP Combustion Control System

#### Application

The BurnerMate TS Model BMTS-STSP provides automatic firing rate control for new or existing steam boilers using single point positioning, combustion control. In a single point positioning system the fuel valves and air control damper are mechanically linked, and are modulated by a single control actuator. Generally, the fuel valve has a characterizable flow versus position relationship that is used to establish the fuel/air ratio over the range of modulation. Single point positioning control is recommended when the boiler size or service hours do not justify the addition of Oxygen trim and variable speed fan control logic.

- Steam Drum Pressure is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating drum pressure "offset" (error)
- Responds to Plant Master Firing Rate and Sequencing Demand
- Warm Standby and Low Fire Hold – The boiler is periodically started and held at low fire until it returns to the warm standby temperature. (Aquastat supplied by fired equipment manufacturer)
- Oxygen Trim (optional) – Using the Link Trim Actuator (LTA) and ZP In-Situ Oxygen Sensor, Oxygen Trim can be added to the BMTS-STSP.

## BURNERMATE TS MODEL BMTS-STSP

### Suggested Specifications

#### Specifications

##### BurnerMate TS Control Panel

Touchscreen: OIT-10 or OIT-15  
Controller: DCS-III-0000  
Input Power: 120 VAC (+/- 15%)

##### Inputs

Drum Pressure: 4-20 mADC  
Plant Master: 4-20 mADC\*  
Warm Standby: 120 VAC, optically isolated\*

##### Outputs

Boiler Modulation: 4-20 mADC or Triac

\*These features are standard, but their use is selectable at time of start-up.

Consult Factory for Inputs and Outputs included with “-ZP” option.

#### Ordering Information

| Description                              | Catalog Number |
|------------------------------------------|----------------|
| Steam Boiler Control with Triac Output   | BMTS-STSP T    |
| Steam Boiler Control with Current Output | BMTS-STSP C    |

| Order Sensors Separately (Optional)                                                           | Catalog Number  |
|-----------------------------------------------------------------------------------------------|-----------------|
| Steam Pressure Transmitter, 4-20 mADC, 0 to 200 PSI, NEMA 4, Smart with single valve manifold | Consult Factory |

#### Suggested Specification

##### 1. Application

Supply a self-contained, Boiler Control System with 10" (or 15") color touch screen to provide process control of steam pressure, combustion air, and fuel flow. The control system shall be microprocessor-based and suitable for wall or windbox mounting. All the logic required to ensure that pre-purge, post-purge, light-off, and burner modulate cycles are automatic.

##### 2. Combustion Control

A PID-based single point positioning combustion control logic scheme shall be used to maintain steam drum pressure at setpoint. The fuel flow control valve shall be mechanically linked to the air flow control device to assure an air rich fuel/ air ratio. Mechanical linkage adjustment shall be required to adjust the fuel/ air ratio. A combustion control microprocessor failure shall not prevent the continued manual operation of the boiler. Fuel valve and air damper shall be modulated in response to an external plant master demand signal or measured boiler drum pressure compared to setpoint. At minimum, the control system shall display the following: steam pressure, steam pressure setpoint, boiler firing rate and alarm messages for low pressure, high pressure, and pressure setpoint deviation. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set up and commissioning screens, and boiler alarm.

##### 3. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and “first - out” annunciator, 120 VAC discrete inputs and outputs, and 4-20 mADC analog inputs and outputs. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if primary memory data is corrupted. All control logic, tuning, and fuel/ air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

##### 4. Communication

Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/ manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

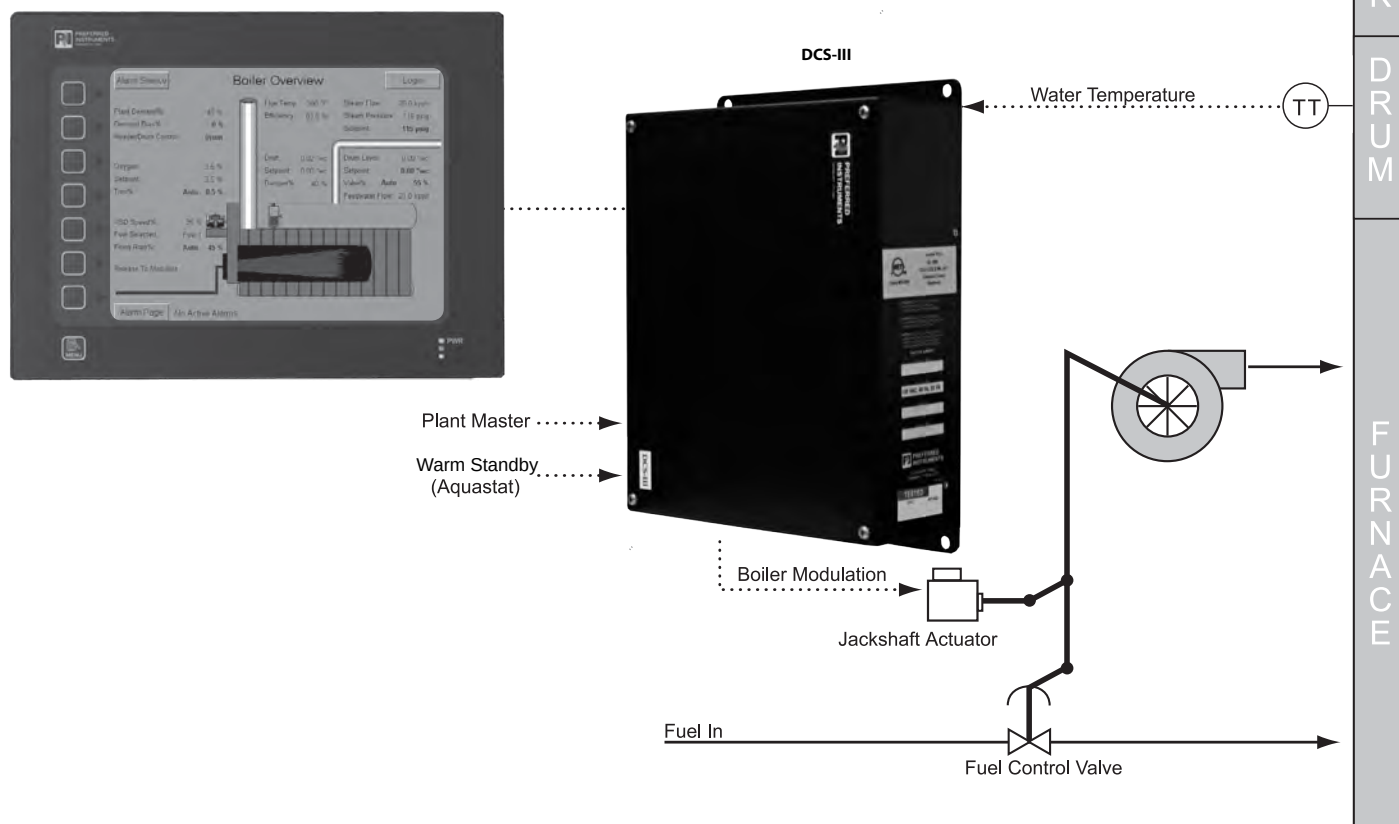
##### 5. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, **BurnerMate TS** Model BMTS-STSPx ('x' = "C" or "T" to denote a Current or Triac Control Output).



## BURNERMATE TS MODEL BMTS-HWSP

Hot Water Boiler Single Point Positioning Combustion Control



Model BMTS-HWSP Combustion Control System

### Application

The BurnerMate TS Model BMTS-HWSP provides automatic firing rate control for new or existing hot water boilers using single point positioning combustion control. In a single point positioning system the fuel valves and air control damper are mechanically linked, and are modulated by a single control actuator. Generally, the fuel valve has a characterizable flow versus position relationship that is used to establish the fuel/ air ratio over the range of modulation. Single point positioning control is recommended when the boiler size or service hours do not justify the addition of oxygen trim and variable speed fan control logic.

- Hot Water Temperature is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating temperature "offset" (error)
- Responds to Plant Master Firing Rate and Sequencing Demand
- Low Fire Hold – Firing rate may be held at low fire during warm-up, or base loaded at an optimum level in response to the lead/ lag controller
- Oxygen Trim (optional) – Using the Link Trim Actuator (LTA) and ZP In-Situ Oxygen Sensor, Oxygen Trim can be added to the BMTS-HWSP.

## BURNERMATE TS MODEL BMTS-HWSP

### Suggested Specifications

#### Specifications

##### BurnerMate TS Control Panel

Touchscreen: OIT-10 or OIT-15  
Controller: DCS-III-0000  
Input Power: 120 VAC (+/- 15%)

#### Inputs

Water Temperature: 4-20 mADC  
Plant Master: 4-20 mADC\*  
Warm Standby: 120 VAC, optically isolated (Optional)\*

#### Outputs

Boiler Modulation: 4-20 mADC or Triac

\*These features are standard, but their use is selectable at time of start-up.

Consult Factory for Inputs and Outputs included with “-ZP” option.

#### Ordering Information

| Description                                  | Catalog Number |
|----------------------------------------------|----------------|
| Hot Water Boiler Control with Triac Output   | BMTS-HWSPT     |
| Hot Water Boiler Control with Current Output | BMTS-HWSPC     |

| Order Sensors Separately (Optional)                                    | Catalog Number  |
|------------------------------------------------------------------------|-----------------|
| Hot Water Transmitter, 4-20 mADC, 0 to 500° F, NEMA 4, with 4.5" depth | Consult Factory |
| Thermowell, SS, 4.5" x ½ NPT                                           | Consult Factory |

#### Suggested Specification

##### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to provide process control of water temperature, combustion air and fuel flow. The control system shall be microprocessor-based and suitable for wall or windbox mounting. All the logic required to ensure that pre-purge, post-purge, light-off, and burner modulate cycles are automated shall be provided.

##### 2. Combustion Control

A PID based single point positioning combustion control logic scheme shall be used to maintain water temperature at setpoint. The fuel flow control valve shall be mechanically linked to the air flow control device to assure an air rich fuel/ air ratio. Mechanical linkage adjustment shall be required to adjust the fuel/air ratio. A combustion control microprocessor failure shall not prevent the continued manual operation of the boiler. Fuel valve and air damper shall be modulated in response to an external plant master demand signal or measured water temperature compared to setpoint. At minimum, the control system shall display the following: water temperature, temperature setpoint, firing rate and alarm messages for low temperature, high temperature, and temperature setpoint deviation. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm.

##### 3. Hot Water Temperature Setpoint

When the controller is in the automatic mode, the control system shall establish the setpoint based on day-night and outside air temperature. When in manual mode, the operator may set the setpoint via the front panel display.

##### 4. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and “first - out” annunciator, 120 VAC discrete inputs and outputs, and 4-20 mADC analog inputs and outputs. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if a primary memory data is corrupted. All control logic, tuning, and fuel/ air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

##### 5. Communication

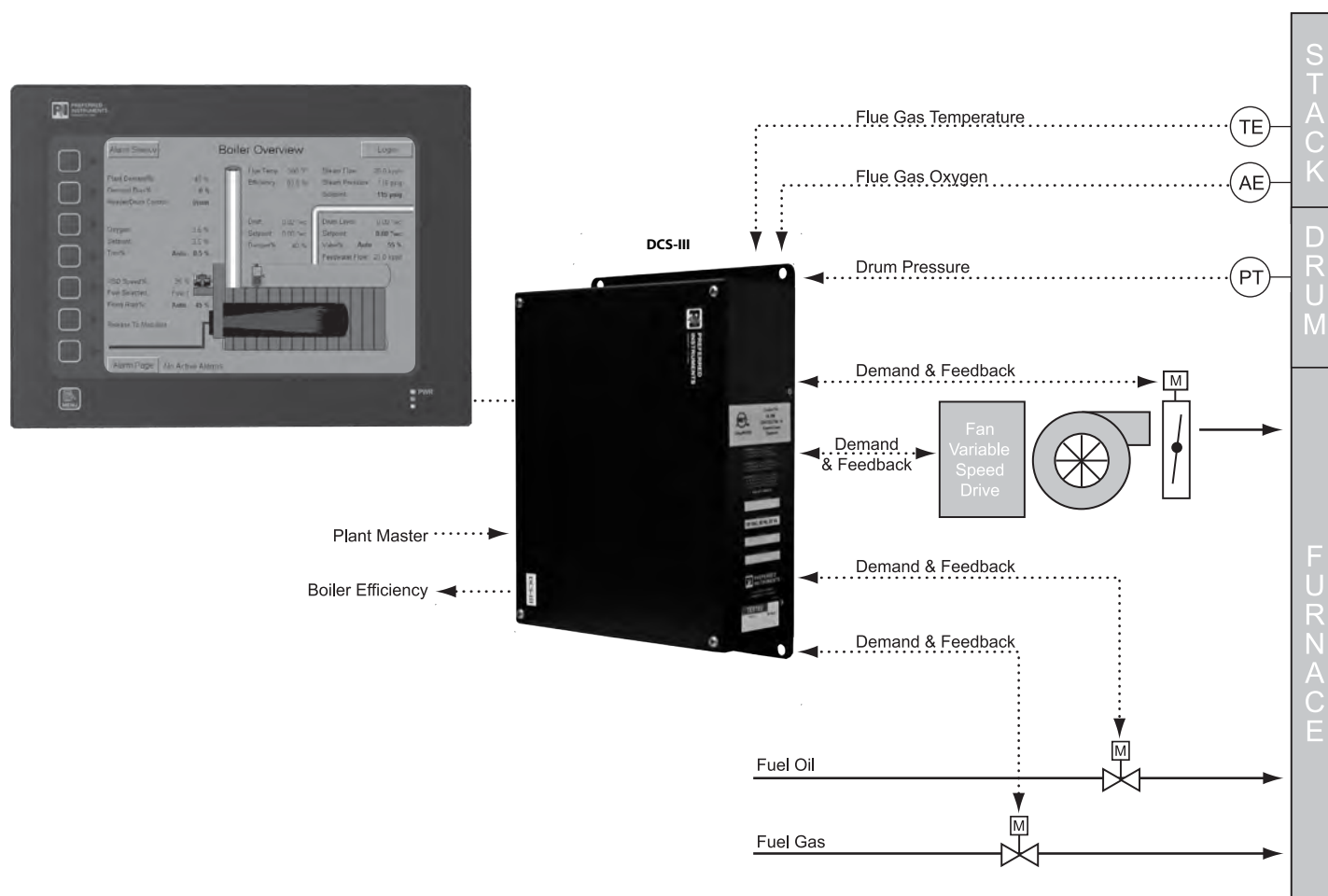
Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/ manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

##### 6. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The system shall be designed to insure the safe start-up, on-line operation and shutdown of fuel firing equipment. The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate TS Model BMTS-HWSPx (‘x’ = “C” or “T” to denote a Current or Triac Control Output).

## BURNERMATE TS MODEL BMTS-STPPT

### Steam Boiler Parallel Positioning Combustion Control



Model BMTS-STPPT Combustion Control System

#### Application

The BurnerMate TS Model BMTS-STPPT provides automatic firing rate control for new or existing steam or hot water boilers using parallel positioning combustion control with both oxygen trim and variable speed fan combustion air flow control. Separate controller outputs are provided for each fuel flow control valve, air control damper and Variable Speed Drive (VSD). Fuel/ air ratio is established and adjusted by use of a “soft” function curve of fuel valve position vs. air fan speed and damper position. Cross limiting using VSD and actuator position feedbacks is employed for safety and to prevent combustion or smoke during load changes.

- Steam Drum Pressure Is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating drum pressure “offset” (error). It also responds to plant master demand.
- Minimum Fuel Usage – Flue gas Oxygen is used to continuously adjust (trim) the fuel/ air ratio. Oxygen trim saves fuel by fine tuning the burner to operate safely and reliably, reducing excess air levels throughout the burner firing range
- Minimum Fan Power Usage – Fan speed control minimizes damper pressure drop related to fan power usage
- Real Time Boiler Efficiency Display – Allows the boiler operator to instantly identify inefficiencies and potential operating problems
- Safety – Flue gas temperature and oxygen are monitored. Warning alarms and burner safety shutdown interlocks are available. VSD speed and actuator position feedbacks are continuously monitored and the burner trips if any are out of position.

# BURNERMATE TS MODEL BMTS-STPPT

## Steam Boiler Parallel Positioning Combustion Control

### Specifications

#### BurnerMate TS Control Panel

Touchscreen: OIT-10 or OIT-15  
 Controller: DCS-III-GZS0  
 Input Power: 120 VAC (+/- 15%)

#### Inputs

Drum Pressure: 4-20 mADC  
 Flue Gas Temperature: T/C (Option "-ZP")  
 Flue Gas Oxygen: ZP Probe (Option "-ZP")  
 Plant Master: 4-20 mADC\*  
 Fuel Gas Actuator Feedback: Potentiometer  
 Fuel Oil Actuator Feedback: Potentiometer  
 Air Actuator Feedback: Potentiometer  
 VSD Speed Feedback: 4-20 mADC  
 (Option "-VSD")

#### Outputs

Boiler Efficiency: 4-20 mADC  
 Fuel Gas Valve Actuator: Triac  
 Fuel Oil Valve Actuator: Triac  
 Air Damper Actuator: Triac  
 VSD Speed Demand: 4-20 mADC  
 (Optional "-VSD")

\*These features are standard, but their use is selectable at time of start-up.

### Ordering Information

| Description          | Catalog Number |
|----------------------|----------------|
| Steam Boiler Control | BMTS-STPPT     |

#### Additional Ordering Information and Suggested Specifications

1. Model ZP In-Situ Oxygen Sensor
2. Variable Speed Drive (VSD)
3. Rotary Actuator (SM or UM)
4. Consult factory for low fire changeover, VSD bypass or pneumatic actuators

| Order Sensors Separately (Optional)                                                           | Catalog Number  |
|-----------------------------------------------------------------------------------------------|-----------------|
| Steam Pressure Transmitter, 4-20 mADC, 0 to 200 PSI, NEMA 4, Smart with single valve manifold | Consult Factory |



## BURNERMATE TS MODEL BMTS-STPPT

### Suggested Specifications

#### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to provide both electricity and fuel savings within the limits of stable burner operation. The control system shall be microprocessor-based and suitable for wall or windbox mounting. Provide all the logic required to ensure automated pre-purge, post-purge, light-off, and burner modulate cycles.

#### 2. Combustion Control

A PID-based, parallel positioning control strategy shall position the fuel valve(s), combustion air damper, and forced draft fan speed for minimum fan kWh usage, and shall continuously trim the fuel/air ratio based on measured flue gas oxygen levels for minimum fuel consumption. Systems that control forced draft fan speed based simply on burner windbox pressure are not acceptable. The system shall position the fuel and combustion air final control elements' movement and VSD speed with "position cross-limiting" to ensure that a safe fuel/air ratio is maintained under all load change conditions. Fuel/air ratio shall be established and adjusted by the use of a "soft" function curve relating fuel valve position to air damper position. Provide a PID based oxygen trim control strategy with automatic adaptive gain for stable operation. Flue gas oxygen setpoint shall vary automatically based on firing rate. Fuel valve and air damper shall modulate in response to an external plant master demand signal or measured boiler drum pressure compared to setpoint. At minimum, the control system shall display the following: boiler firing rate, steam pressure, steam pressure setpoint, boiler efficiency, trim percent, flue gas oxygen setpoint, flue gas oxygen, flue gas temperature, fuel valve position, air damper position, and VSD speed and alarm messages for low pressure, high pressure, high flue gas temperature, low oxygen, low oxygen trip, fuel trip, damper trip, VSD trip, and oxygen cell fault. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm.

The control system shall include a dedicated, normally energized, fail safe relay output contact in the "running" interlock circuit of the flame safeguard that will cause a fired equipment shutdown in the event of: low oxygen, air damper actuator fault, fuel valve actuator fault, VSD fault, or controller fault.

#### 3. Boiler Efficiency Display

Real time boiler efficiency shall be calculated and displayed, thereby allowing the boiler operator to instantly identify inefficiencies and potential operational problems. The calculation shall be based on the ASME "by losses" method and must utilize real time inputs of boiler firing rate, flue gas oxygen, flue gas temperature and fuel selected. Two sets of adjustable fuel chemistry data parameters shall be included, and firing rate scaled radiation losses shall be used for maximum accuracy. Calculations that rely on fixed constants, or manually inputted values for these conditions, are not acceptable. NOTE: Flue gas temperature transmitters must be provided and installed at each boiler outlet.

#### 4. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and "first-out" annunciator displays. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if primary memory data is corrupted. All control logic, tuning, and fuel/air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

#### 5. Flue Gas Oxygen Analyzer

Provide a boiler breeching mounted in-situ, zirconium oxide Oxygen analyzer for each boiler. Extractive or "wet cell" type oxygen analyzers are not acceptable. The probe shall be of a suitable length for sensing the oxygen level in the middle 1/3 of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults. The system shall automatically send the trim actuator to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift. Analyzer calibration shall be pushbutton semi-automatic (no trim pots), with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field recalibration.

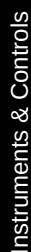
#### 6. Communication

Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 7. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate Model BMTS-STPPT-ZP-VSD.

## Hot Water Boiler Parallel Positioning Combustion Control



### Model BMTS-HWPPT Combustion Control System

## Application

The BurnerMate TS Model BMTS-HWPPT provides automatic firing rate control for new or existing hot water boilers using parallel positioning combustion control with both oxygen trim and variable speed fan combustion air flow control. Separate controller outputs are provided for each fuel flow control valve, air control damper and variable speed drive (VSD). Fuel/ air ratio is established and adjusted by use of a “soft” function curve of fuel valve position vs. air fan speed and damper position. Cross limiting using VSD and actuator position feedbacks is employed for safety and to prevent combustibles or smoke during load changes.

- Hot Water Temperature is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating drum pressure “offset” (error). Also responds to Plant Master demand
- Minimum Fuel Usage – Flue gas oxygen is used to continuously adjust (trim) the fuel/ air ratio. oxygen trim saves fuel by fine tuning the burner to operate safely and reliably at reduced excess air levels throughout the burner firing range
- Minimum Fan Power Usage – Fan speed control minimizes damper pressure drop related to fan power usage
- Real Time Boiler Efficiency Display – Allows the boiler operator to instantly identify inefficiencies and potential operational problems
- Safety – Flue gas temperature and oxygen are monitored. Warning alarms and burner safety shutdown interlocks are available. VSD speed and actuator position feedbacks are continuously monitored, and the burner trips if any are out of position.

## BURNERMATE TS MODEL BMTS-HWPPT

### Hot Water Boiler Parallel Positioning Combustion Control

#### Specifications

##### BurnerMate TS Panel

Touchscreen: OIT-10- or OIT-15  
 Controller: DCS-III-GZS0  
 Input Power: 120 VAC (+/- 15%)

##### Inputs

Water Temperature: 4-20 mADC  
 Flue Gas Temperature: T/C (Option "-ZP")  
 Flue Gas Oxygen: ZP Probe (Option "-ZP")  
 Plant Master: 4-20 mADC\*  
 Fuel Gas Actuator Feedback: Potentiometer  
 Fuel Oil Actuator Feedback: Potentiometer  
 Air Actuator Feedback: Potentiometer  
 VSD Speed Feedback: 4-20 mADC  
 (Option "-VSD")

##### Outputs

Boiler Efficiency: 4-20 mADC  
 Fuel Gas Valve Actuator: Triac  
 Fuel Oil Valve Actuator: Triac  
 Air Damper Actuator: Triac  
 VSD Speed Demand: 4-20 mADC  
 (Option "-VSD")

\*These features are standard, but their use is selectable at time of start-up.

#### Ordering Information

| Description              | Catalog Number |
|--------------------------|----------------|
| Hot Water Boiler Control | BMTS-HWPPT     |

#### Additional Ordering Information and Suggested Specifications

1. Model ZP In-Situ Oxygen Sensor
2. Variable Speed Drive (VSD)
3. Actuator (SM or UM)
4. Consult factory for low fire changeover and VSD bypass

| Order Sensors Separately (Optional)                                                     | Catalog Number  |
|-----------------------------------------------------------------------------------------|-----------------|
| Hot Water Temperature Transmitter, 4-20 mADC, 0 to 500° F, NEMA 4, Smart with 4½" depth | Consult Factory |
| Thermowell, SS, 4½" x ½ NPT                                                             | Consult Factory |

## BURNERMATE TS MODEL BMTS-HWPPT

### Suggested Specifications

#### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to provide both electricity and fuel savings within the limits of stable burner operation. The control system shall be microprocessor-based and suitable for wall or windbox mounting. Provide all the logic required to ensure automated pre-purge, post-purge, light-off, and burner modulate cycles.

#### 2. Combustion Control

A PID based, parallel positioning control strategy shall position the fuel valve(s), combustion air damper, and forced draft fan speed for minimum fan kWh usage, and shall continuously trim the fuel/air ratio based on measured flue gas oxygen levels to minimize fuel consumption. Systems that control forced draft fan speed based simply on burner windbox pressure are not acceptable. The system shall position the fuel and combustion air final control elements' movement and VSD speed with "position cross-limiting" to insure that a safe fuel/air ratio is maintained under all load change conditions. Fuel/air ratio shall be established and adjusted by the use of a "soft" function curve relating fuel valve position to air damper position. Provide a PID based oxygen trim control strategy with automatic adaptive gain for stable operation. Flue gas oxygen setpoint shall vary automatically based on firing rate. Fuel valve and air damper shall modulate in response to an external plant master demand signal or measured hot water temperature compared to setpoint. At minimum, the control system shall display the following: boiler firing rate, hot water temperature, hot water temperature setpoint, boiler efficiency, trim percent, flue gas oxygen setpoint, flue gas oxygen, flue gas temperature, fuel valve position, air damper position, and VSD Speed and alarm messages for low temperature, high temperature, high flue gas temperature, low oxygen, low oxygen trip, fuel trip, damper trip, VSD trip, and oxygen cell fault. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm.

The control system shall include a dedicated, normally energized, fail safe relay output contact in the "running" interlock circuit of the flame safeguard that will cause a fired equipment shutdown in the event of: low oxygen, air damper actuator fault, fuel valve actuator fault, VSD fault, or controller fault.

#### 3. Hot Water Temperature Setpoint

When the controller setpoint is in automatic mode the control system shall establish the setpoint based on outside air temperature. When in manual mode, the operator may adjust the setpoint via the front panel display.

#### 4. Boiler Efficiency Display

Real time boiler efficiency shall be calculated and displayed, thereby allowing the boiler operator to instantly identify inefficiencies and potential operating problems. The calculation shall be based on the ASME "by losses" method and must utilize real time inputs of boiler firing rate, flue gas Oxygen, flue gas temperature and fuel selected. Two sets of adjustable fuel chemistry data parameters shall be

included, and firing rate scaled radiation losses shall be used for maximum accuracy. Calculations that rely on fixed constants, or manually entered values for these conditions, are not acceptable. NOTE: Flue gas temperature transmitters must be provided and installed at each boiler outlet.

#### 5. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and "first-out" annunciator displays. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if a primary memory data is corrupted. All control logic, tuning, and fuel/air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

#### 6. Flue Gas Oxygen Analyzer

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive or "wet cell" type oxygen analyzers are not acceptable. The probe shall be of a suitable length for sensing the oxygen level in the middle 1/3 of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults. The system shall automatically send the trim actuator to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift. Analyzer calibration shall be push-button semi-automatic (no trim pots), with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field recalibration.

#### 7. Communication

Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

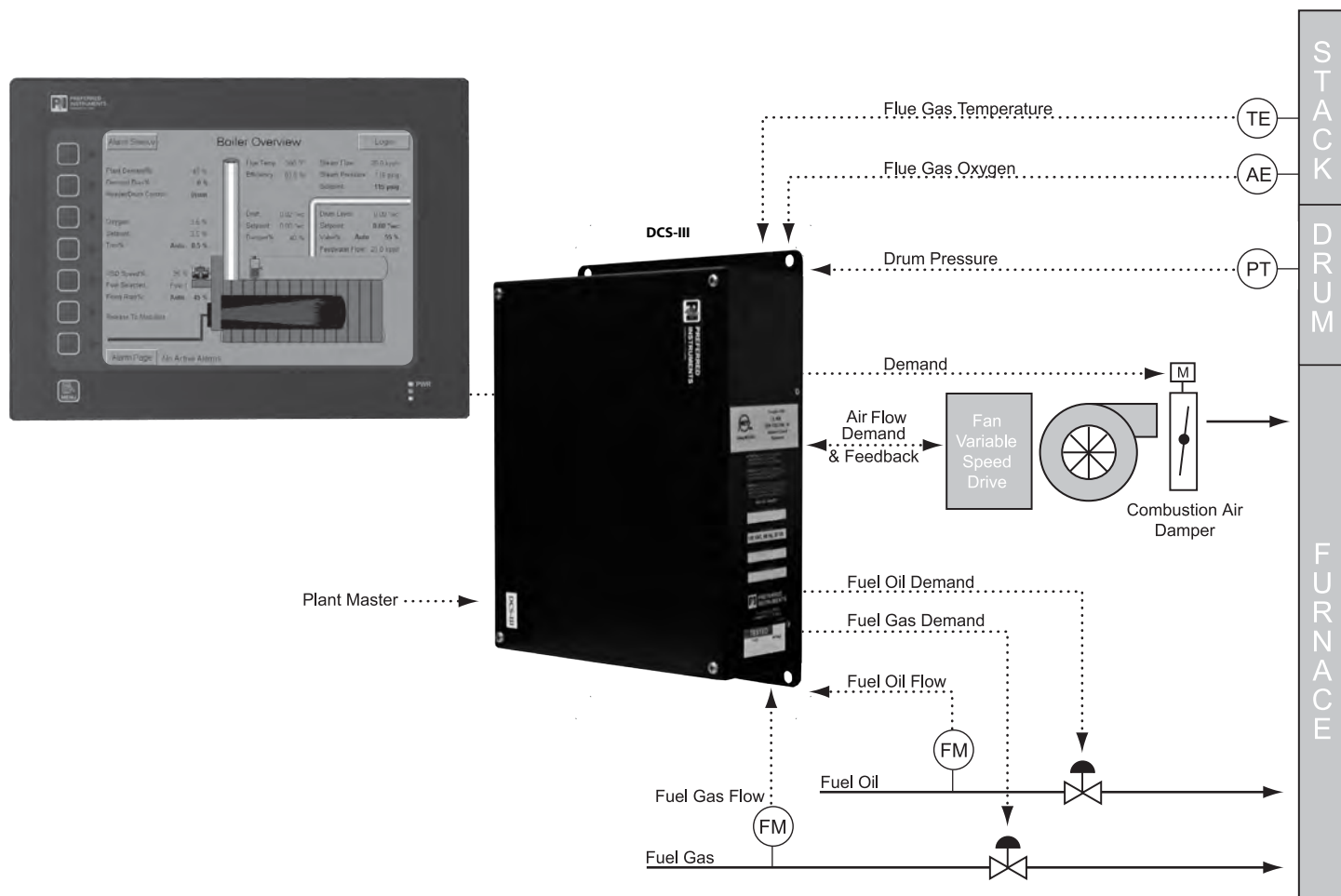
#### 8. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate Model BMTS-HWPPT-ZP-VSD.



## BURNERMATE TS MODEL BMTS-STFMC

### Steam Boiler Fully Metered Combustion Control



Model BMTS-STFMC Combustion Control System

#### Application

The BurnerMateTS Model BMTS-STFMC provides automatic firing rate control for new or existing steam boilers using fully metered combustion control. Both the fuel flow and the air flow are accurately measured. Measured temperature or pressure is used to generate a setpoint for fuel flow and air flow. The fuel flow setpoint is compared against actual fuel flow to control the fuel metering valves and the actual air flow is compared against the air flow setpoint to control the air control damper. Cross limiting using measured fuel and combustion air flow is employed for safety and to prevent combustibles or smoke during load changes. Fully metered control with oxygen trim minimizes excess air.

- Steam Drum Pressure is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating drum pressure "offset" (error). Also responds to plant master demand.
- Minimum Fuel Usage – Measured fuel, air flow and flue gas oxygen is used to continuously adjust (trim) the fuel/air ratio. Oxygen trim saves fuel by fine tuning the burner to operate safely and reliably at reduced excess air levels throughout the burner firing range.
- Minimum Fan Power Usage – Fan speed control minimizes damper pressure drop related to fan power usage.
- Real Time Boiler Efficiency Display – Allows the boiler operator to instantly identify inefficiencies and potential operational problems.
- Safe and Dependable Boiler Control – Flue gas temperature and oxygen are monitored. Warning alarms and burner safety shutdown interlocks are available.

## BURNERMATE TS MODEL BMTS-STFMC

### Steam Boiler Fully Metered Combustion Control

#### Specifications

##### BurnerMate TS Panel

Touchscreen: OIT-10 or OIT-15  
Controller: DCS-III-FZ00  
Input Power: 120 VAC (+/- 15%)

##### Inputs

Drum Pressure: 4-20 mADC  
Flue Gas Temperature: T/C (Option "-ZP")  
Flue Gas Oxygen: ZP Probe (Option "-ZP")  
Plant Master: 4-20 mADC\*  
Fuel Gas Flow: 4-20 mADC\*  
Fuel Oil Flow: 4-20 mADC\*  
Air Flow: 4-20 mADC  
VSD Speed Feedback: 4-20 mADC (Option "-VSD")

##### Outputs

Fuel Oil Valve Actuator: 4-20 mADC\*  
Fuel Gas Valve Actuator: 4-20 mADC\*  
Air Damper Actuator: 4-20 mADC  
VSD Speed Demand: 4-20 mADC (Option "-VSD")

\*These features are standard, but their use is selectable at time of start-up.

#### Ordering Information

| Description          | Catalog Number |
|----------------------|----------------|
| Steam Boiler Control | BMTS-STFMC     |

#### Additional Ordering Information and Suggested Specifications

1. Model ZP In-Situ Oxygen Sensor
2. Variable Speed Drive (VSD)
3. Actuator
4. Consult factory for low fire fuel changeover and VSD bypass

| Order Sensors Separately (Optional)                                                           | Catalog Number  |
|-----------------------------------------------------------------------------------------------|-----------------|
| Steam Pressure Transmitter, 4-20 mADC, 0 to 200 PSI, NEMA 4, Smart with single valve manifold | Consult Factory |
| Oil Flow, Oval Gear type, 4-20 mADC, NEMA 4                                                   | Consult Factory |
| Gas Flow, Thermal Insertion Mass Flow, 4-20 mADC, NEMA 4                                      | Consult Factory |
| Air Flow, differential pressure transmitter, 4-20 mADC, NEMA 4, Smart with 3 valve manifold   | Consult Factory |

## BURNERMATE TS MODEL BMTS-STFMC

### Suggested Specifications

#### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to minimize consumption of both electricity and fuel within the limits of stable burner operation. The system shall use a flow meter cross-limited full metering combustion control logic scheme with oxygen trim and variable speed combustion air fan control to maintain main steam header pressure at the selected value. Positioning systems that depend on actuator feedback pots for cross limiting are not acceptable. The control system shall be microprocessor-based and suitable for wall or windbox mounting. All the logic provides pre-purge, post-purge, light-off, and burner modulate cycles are automated shall be provided.

#### 2. Combustion Control

The fuel flow control loop shall be cross-limited with the air flow control loop so that fuel demand cannot be increased until an air flow increase is proven by the air flow measurement loop and air demand cannot be decreased until a fuel flow decrease is proven by the fuel flow measurement loop. In addition, fuel demand cannot be increased beyond a certain amount above the measured air flow, and air demand cannot be decreased beyond a certain amount below the measured fuel flow. Fuel/ air ratio shall be established and adjusted by the use of a "soft" function curve, relating fuel flow setpoint to air flow setpoint. Oxygen trim shall be accomplished by varying the fuel/ air ratio and shall include separate characterizable oxygen setpoint curves for both oil and gas fuels. Fuel valve and air damper shall be modulated in response to an external plant master demand signal or measured steam pressure compared to setpoint. Provision shall be made to automatically switch the control mode from metering to positioning control of the air control damper whenever the firing rate of the unit is below the turndown range of the air flow transmitter. This control system shall require the burner to be shut down to change fuels. At minimum, the control system shall display the following: boiler firing rate, steam pressure, steam pressure setpoint, gas flow, oil flow, flue gas oxygen, fuel valve position, air flow, air damper position and VSD speed. The following color touch screen graphic pages shall be provided: boiler overview, Flame Safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm.

The control system shall include a dedicated, normally energized, fail safe relay output contact in the "running" interlock circuit of the flame safeguard that will cause a fired equipment shutdown in the event of: low oxygen, low fuel flow, high flue gas temperature, VSD fault, or controller fault.

#### 3. Boiler Efficiency Calculation

Real time boiler efficiency shall be calculated. The calculation shall be based on the ASME "by losses" method and must utilize real time inputs of boiler firing rate, flue gas oxygen, flue gas temperature and fuel selected. Two sets of adjustable fuel chemistry data parameters shall be included, and firing rate scaled radiation losses shall be used for maximum accuracy. NOTE: Flue gas temperature transmitters must be provided and installed at each boiler outlet.

#### 4. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and "first-out" annunciator displays. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if primary memory data is corrupted. All control logic, tuning, and fuel/ air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

#### 5. Flue Gas Oxygen Analyzer

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive or "wet cell" type oxygen analyzers are not acceptable. The probe shall be of a suitable length for sensing the oxygen level in the middle 1/3 of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults. The system shall automatically send the trim actuator to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift. Analyzer calibration shall be push-button semi-automatic (no trim pots), with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field recalibration.

#### 6. Communication

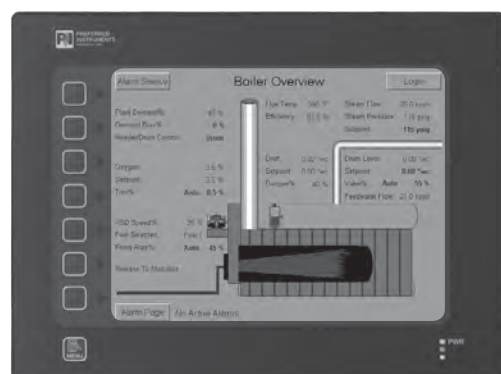
Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: Auto/Manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 7. Quality Assurance

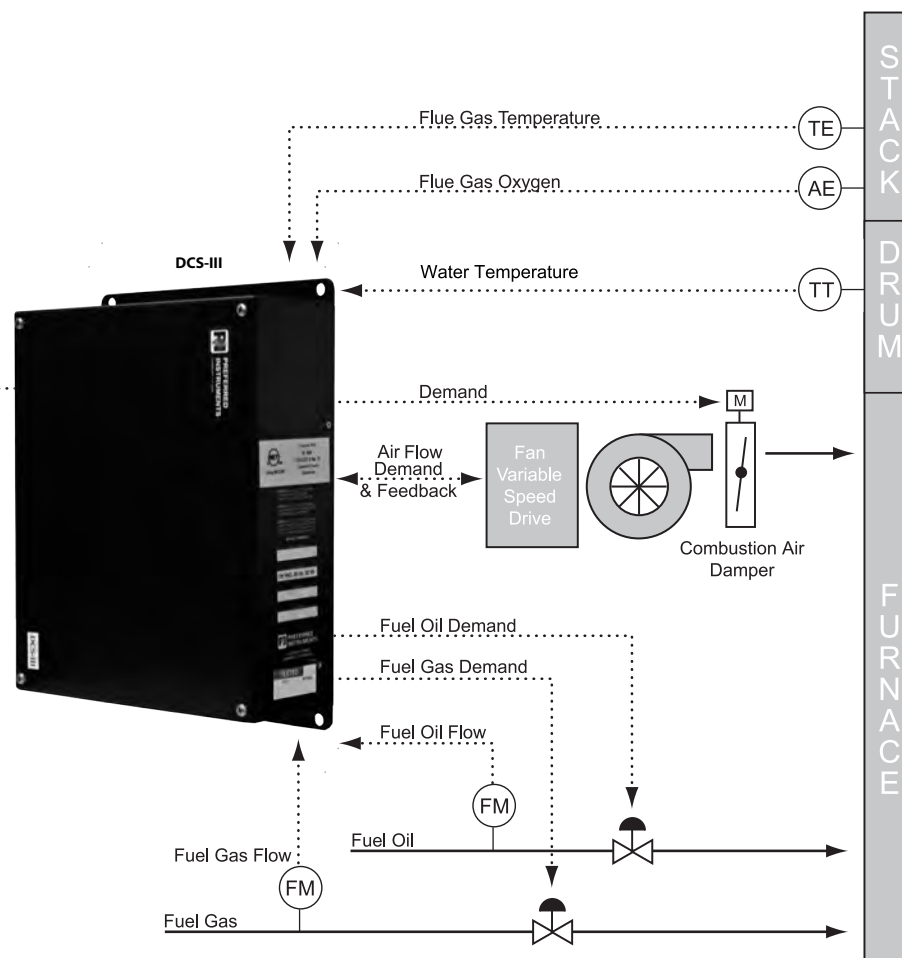
The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate TS Model BMTS-STFMC-ZP-VSD.

## BURNERMATE TS MODEL BMTS-HWFC

### Hot Water Boiler Fully Metered Combustion Control



Plant Master .....



Model BMTS-HWFC Combustion Control System

#### Application

The BurnerMate TS Model BMTS-HWFC provides automatic firing rate controls for new or existing hot water boilers using fully metered combustion control. Both the fuel flow and the air flow are accurately measured. Measured temperature or pressure is used to generate a setpoint for fuel flow and air flow. The fuel flow setpoint is compared against actual fuel flow to control the fuel metering valves and the actual air flow is compared against the air flow setpoint to control the air control damper. Cross limiting using measured fuel and combustion air flow is employed for safety and to prevent combustibles or smoke during load changes. Fully metered control with oxygen trim minimizes extra excess air.

- Hot Water Temperature is Maintained using local PID setpoint control. PID control provides efficient, accurate control by eliminating drum pressure “offset” (error). Also responds to plant master demand.
- Minimum Fuel Usage – Measured fuel, air flow and flue gas oxygen is used to continuously adjust (trim) the fuel/air ratio. Oxygen trim saves fuel by fine tuning the burner to operate safely and reliably at reduced excess air levels throughout the burner firing range.
- Minimum Fan Power Usage – Fan speed control minimizes damper pressure drop related to fan power usage.
- Real Time Boiler Efficiency Display – Allows the boiler operator to instantly identify inefficiencies and potential operational problems.
- Safe and Dependable Boiler Control – Flue gas temperature and oxygen are monitored. Warning alarms and burner safety shutdown interlocks are available.



## BURNERMATE TS MODEL BMTS-HWPMC

Hot Water Boiler Fully Metered Combustion Control

### Specifications

#### BurnerMate TS Control Panel

Touchscreen: OIT-10 or OIT-15  
Controller: DCS-III-FZ00  
Input Power: 120 VAC (+/- 15%)

#### Inputs

Water Temperature: 4-20 mADC  
Flue Gas Temperature: T/C (Option "-ZP")  
Flue Gas Oxygen: ZP Probe (Option "-ZP")  
Plant Master: 4-20 mADC\*  
Fuel Gas Flow: 4-20 mADC\*  
Fuel Oil Flow: 4-20 mADC\*  
Air Flow: 4-20 mADC  
VSD Speed Feedback: 4-20 mADC (Option "-VSD")

#### Outputs

Fuel Oil Valve Actuator: 4-20 mADC\*  
Fuel Gas Valve Actuator: 4-20 mADC\*  
Air Damper Actuator: 4-20 mADC  
VSD Speed Demand: 4-20 mADC (Option "-VSD")

\*These features are standard, but their use is selectable at time of start-up.

### Ordering Information

| Description              | Catalog Number |
|--------------------------|----------------|
| Hot Water Boiler Control | BMTS-HWPMC     |

### Additional Ordering Information and Suggested Specifications

1. Model ZP In-Situ Oxygen Sensor
2. Variable Speed Drive (VSD)
3. Actuator
4. Consult factory for low fire fuel changeover and VSD bypass

| Order Sensors Separately (Optional)                                                         | Catalog Number  |
|---------------------------------------------------------------------------------------------|-----------------|
| Hot Water Temperature Transmitter, 4-20 mADC, 0 to 500° F, NEMA 4, Smart with 4½" depth     | Consult Factory |
| Thermowell, SS, 4½" x ½ NPT                                                                 | Consult Factory |
| Oil Flow, Oval Gear type, 4-20 mADC, NEMA 4                                                 | Consult Factory |
| Gas Flow, Thermal Insertion Mass Flow, 4-20 mADC, NEMA 4                                    | Consult Factory |
| Air Flow, Differential Pressure Transmitter, 4-20 mADC, NEMA 4, Smart with 3 valve manifold | Consult Factory |

## BURNERMATE TS MODEL BMTS-HWPMC

### Suggested Specifications

#### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to minimize consumption of both electricity and fuel within the limits of stable burner operation. The system shall use a flow meter cross-limited full metering combustion control logic scheme with oxygen trim and variable speed combustion air fan control to maintain water temperature at the selected value. Positioning systems that depend on actuator feedback pots for cross limiting are not acceptable. The control system shall be microprocessor-based and suitable for wall or windbox mounting. All the logic required to ensure that pre-purge, post-purge, light-off, and burner modulate cycles are automated shall be provided.

#### 2. Combustion Control

The fuel flow control loop shall be cross-limited with the air flow control loop so that fuel demand cannot be increased until an air flow increase is proven by the air flow measurement loop and air demand cannot be decreased until a fuel flow decrease is proven by the fuel flow measurement loop. Additionally, fuel demand cannot be increased beyond a certain amount above the measured air flow and air demand cannot be decreased beyond a certain amount below the measured fuel flow. Fuel/ air ratio shall be established and adjusted by the use of a "soft" function curve relating fuel flow setpoint to air flow setpoint. Oxygen trim shall be accomplished by varying the fuel/ air ratio and shall include separate characterizable oxygen setpoint curves for both oil and gas fuels based on firing rate. Fuel valve and air damper shall be modulated in response to an external plant master demand signal or measured steam pressure compared to setpoint. Provision shall be made to automatically switch the control mode from metering to positioning control of the air control damper whenever the firing rate of the unit is below the turndown range of the air flow transmitter. This control system shall require the burner to be shut down to change fuels. At minimum, the control system shall display the following: boiler firing rate, hot water temperature, hot water temperature setpoint, gas flow, oil flow, air flow, flue gas oxygen, fuel valve position, air damper position and VSD Speed. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm.

The control system shall include a dedicated, normally energized, fail safe relay output contact in the "running" interlock circuit of the flame safeguard that will cause a fired equipment shutdown in the event of: low oxygen, low fuel flow, high flue gas temperature, VSD fault, or controller fault.

#### 3. Boiler Efficiency Calculation

Real time boiler efficiency shall be calculated. The calculation shall be based on the ASME "by losses" method and must utilize real time inputs of boiler firing rate, flue gas Oxygen, flue gas temperature and fuel selected. Two sets of adjustable fuel chemistry data parameters shall be included, and firing rate scaled radiation losses shall be used for maximum accuracy. NOTE: Flue gas temperature transmitters must be provided and installed at each boiler outlet.

#### 4. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and "first-out" annunciator displays. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory if primary memory data is corrupted. All control logic, tuning, and fuel/ air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop computer per facility.

#### 5. Flue Gas Oxygen Analyzer

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive or "wet cell" type oxygen analyzers are not acceptable. The probe shall be of a suitable length for sensing the oxygen level in the middle 1/3 of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults. The system shall automatically send the trim actuator to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift. Analyzer calibration shall be pushbutton semi-automatic (no trim pots), with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field recalibration.

#### 6. Communication

Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/ manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 7. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate TS Model BMTS-HWPMC-ZP-VSD.

## BURNERMATE TS MODEL BMTS-AC

Drum Level (Feedwater) Control, Draft Control, and/or Flue Gas Recirculation Control

### Application

The BurnerMate TS Model BMTS-AC provides automatic control for drum level, boiler draft and flue gas recirculation (FGR) for new or existing boilers. A feedwater valve that is swinging from closed to open will cause the steam header pressure to swing up and down, even when the plant load is absolutely constant. This will in turn cause the burner firing rate to swing up and down. Burner load swings cause combustion control systems to operate the burner with extra excess air, thus lowering efficiency. Draft controllers modulate the boiler outlet damper in order to maintain a constant pressure in the combustion chamber. Any boiler that will be operated at a negative draft should have a draft control system. Positioning burner control systems can operate with less excess air if the furnace pressure is constant. At a given F.D. fan inlet damper position, the air flow through a burner will increase when the boiler draft goes more negative.

### Key Features

- **Precise Draft Control** - "GAP" PID Draft Control and firing rate feedforward assure stable draft even during load changes. This is especially important for outlet draft control on boilers with induced flue gas recirculation (FGR) NOx reduction.
- **Single Element Drum Level Control** - A drum level sensor causes the feedwater valve to open or close in proportion to the deviation from desired drum level. Suitable for firetube boilers with moderate load swings and watertube boilers with slowly changing loads. Variations in the feedwater supply pressure will cause the drum level to change when the load is steady. This control strategy does not respond well to shrink and swell.
- **Two Element Drum Level Control** - A drum level sensor is the primary controller input, a steam flow sensor is a feedforward controller input. The steam flow signal allows the controller to respond properly during shrink and swell. Feedwater pressure variations also upset the drum level. Suitable for watertube boilers with substantial load swings if the feedwater pressure is consistent.
- **Three Element Drum Level Control** - A feedwater flow sensor is added to allow the controller to compensate for variations in feedwater supply pressure. Suitable for watertube boilers with substantial load swings and inconsistent feedwater pressure.
- **Flue Gas Recirculation (FGR) Control** - FGR flow rate is controller in response to boiler load.

### Ordering Information

| Optional Features                                                     | Add Suffix to BurnerMate TS Catalog Number |
|-----------------------------------------------------------------------|--------------------------------------------|
| Draft Control                                                         | add "-DR*" suffix                          |
| Drum Level (Feedwater) Control<br>"X" = Feedwater (1,2, or 3) Element | add "-x-FW*" suffix                        |
| Flue Gas Recirculation (FGR) Control                                  | add "-FGR*" suffix                         |

\*Add "C" or "T" to denote a Current (4-20 mADC) or Triac Control Output

Refer to the Plant Engineering Data section for the "Control Signal" diagrams

| Order Sensors Separately (Optional)                                        | Catalog Number  |
|----------------------------------------------------------------------------|-----------------|
| E-link Draft Damper Assembly                                               | Consult Factory |
| Draft Transmitter, 4-20 mADC, NEMA 4, Smart with three valve manifold      | Consult Factory |
| Drum Level Transmitter, 4-20 mADC, NEMA 4, Smart with three valve manifold | Consult Factory |
| Steam Flow, Vortex Shedding type, 4-20 mADC                                | Consult Factory |
| Feedwater Flow Meter, Turbine type                                         | Consult Factory |

## BURNERMATE TS MODEL BMTS-AC

### Suggested Specifications

#### 1. Application

Supply a self-contained Boiler Control System with 10" (or 15") color touch screen to provide drum level, boiler outlet draft and flue gas recirculation control. The control components shall be located in the combustion control cabinet and shall be fully integrated for automatic sequencing of light-off and shutdown.

#### 2. Drum Level (Feedwater) Control (when required)

The Drum Level control system shall be designed to maintain boiler drum level. Drum level shall be controlled by modulating the feedwater control valve in either a single element or three element mode. In the single element mode only drum level measurement is used. In the three element mode drum level, steam flow and feedwater flow measurements are used.

#### 3. Draft Control (when required)

Boiler Draft shall be controlled in response to changing furnace pressure, and a feed-forward signal of boiler load. The controller shall have a characterizable set-point curve for the feed-forward signal. Alarm shall be provided for low draft. All the logic required to insure that pre-purge, postpurge, light-off, and burner modulate cycles are automated shall be provided within the controller.

#### 4. Flue Gas Recirculation Control (when required)

Flue gas recirculation (FGR) flow rate shall be controlled in response to boiler load. The controller shall have a characterizable setpoint curve for damper output signal. All the logic required to insure that pre-purge, postpurge, light-off, and burner modulate cycles are automated shall be provided within the controller.

#### 5. Boiler Controllers

To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple loop controller system shall be provided. The controller shall include process variable and "first-out" annunciator displays. Configuration and calibration data shall be stored on redundant non-volatile EEPROM memory modules. The backup memory module shall automatically download into the primary memory in the event of primary memory data corruption. All control logic, tuning, and fuel/ air ratio curves shall be field configurable. If required to allow field modifications to the controller logic, provide one configuration tool or laptop personal computer per facility. The following color touch screen graphic pages shall be dedicated to each boiler control loop including drum level control, draft control, and FGR control, when applicable.

#### 6. Communication

Each controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow: auto/ manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 7. Quality Assurance

A single control system manufacturer with a minimum of 10 years experience manufacturing similar combustion control systems shall provide the specified control system complete with oxygen analyzers, variable speed drive, transmitters, and actuators. The manufacturer's authorized representative shall provide experienced combustion control technicians that have been trained by the manufacturer for variable speed fan oxygen trim systems start-up and operator training. The system shall be factory manufactured and tested according to UL508A requirements (CSA C22.2 #14 for use in Canada). The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate TS Model BMTS-AC [-DRx] [-1, -2, or -3] [-FWx] [-FGRx] ('x' = "C" or "T" to denote a Current or Triac Control Output).

#### Specifications

##### BurnerMate TS Control Panel

|                          |                               |
|--------------------------|-------------------------------|
| Touchscreen:             | OIT-10 or OIT-15              |
| Controller:              | DCS-III                       |
| Input Power:             | 120 VAC (+/- 15%)             |
| <b>Inputs</b>            |                               |
| Draft                    | 4-20 mADC (optional)          |
| Firing Rate              | 4-20 mADC (optional)          |
| Drum Level               | 4-20 mADC (optional)          |
| Drum Pressure            | 4-20 mADC (optional)          |
| Feedwater Flow           | 4-20 mADC (optional)          |
| Steam Flow               | 4-20 mADC (optional)          |
| Outlet Damper Feedback   | Potentiometer (optional)*     |
| FGR Damper Feedback      | Potentiometer (optional)*     |
| Feedwater Valve Feedback | Potentiometer (optional)*     |
| <b>Outputs</b>           |                               |
| Outlet Damper            | Triac or 4-20 mADC (optional) |
| FGR Damper               | Triac or 4-20 mADC (optional) |
| Feedwater Valve          | Triac or 4-20 mADC (optional) |

\* These signals are only required if Triac output is selected.



## BURNERMATE TS MODEL BMTS-FSG

### Flame Safeguard System

#### Application

The BurnerMate TS Model BMTS-FSG Flame Safeguard System provides automatic flame safety monitoring and control for new or existing steam or hot water boilers. The system is engineered to be in compliance with the latest factory mutual and NFPA 85 standards. The systems are manufactured, tested and labeled according to UL508A standards.

#### Key Features

- **Microprocessor-based Controller** – The Flame Safeguard System is microprocessor-based, with self-diagnostics and non-volatile memory.
- **Flame Scanners** – An infrared (IR) flame scanner is provided as a standard for water-wall furnaces. An ultraviolet (UV) self checking flame scanner is an available option for refractory lined furnaces. The Flame Safeguard System provides the proper burner sequencing, ignition and flame monitoring protection on single burner, automatically ignited oil or gas fired boilers.
- **The system uses a fail-safe “de-energize” to trip design.** Upon the loss of system power the fuel safety shutoff valves are automatically closed and ignition components are de-energized.
- **Message Display** – An externally-mounted LCD backlit display has two lines of sixteen characters each. The display provides burner status and historical information. Operation, troubleshooting and maintenance information is at the boiler front, where it is needed. On a safety shutdown, the message display will advise the operator that the control is in “lockout” and will indicate the specific cause and the state in the operating sequence where the shutdown occurred.
- **Combustion Control Sequence Interlocks** – Combustion control system interfaces are provided to ensure safe automatic fuel and air sequencing for purge, light-off and shutdown.
- **Drum level conductivity probe relays** are incorporated for an auxiliary low water cutout safety interlock, low water alarm and high water alarm.

#### Specifications

##### Operator Control Panel

Touchscreen: OIT-10 or OIT-15  
 Display: 2 line x 16 character LCD display  
 Pushbutton: Membrane, tactile feedback

**IR Flame Scanner:** Infrared, 1/2" 90° angle mount, 96" cable

**UV Flame Scanner:** Ultraviolet 1" NPT mount, 72" lead

#### Ordering Information

| Optional Features | Add Suffix to BurnerMate TS Catalog Number |
|-------------------|--------------------------------------------|
| Flame Safeguard   | Add “-FSG” suffix                          |

*Consult Factory for suggested specifications and ordering information for Low Fire Fuel Change Over “LFCO,” Simultaneous Dual Fuel Firing, and Automatic Atomizer Post Purge functions.*

## BURNERMATE TS MODEL BMTS-FSG

### Suggested Specifications

#### 1. Application

Integral to the control system shall be a Burner Management System (BMS) / Flame Safeguard System (FSG) with 10" (or 15") color touch screen. The system shall be designed to ensure the safe start-up, on-line operation and shutdown of fuel firing equipment. Burner management system components shall be located in the combustion control cabinet and shall be fully integrated for automatic sequencing of light-off and shutdown. Numbered terminal strips shall also be provided to permit termination of all field wiring.

#### 2. Microprocessor

An industrial duty microprocessor-based FSG shall provide: safety interlocks, flame monitoring protection and timed sequences. Sequences shall include forced draft fan start and stop, furnace purge, burner light-off and shutdown and post-purge. The FSG shall be capable of firing two fuels, one fuel at a time. Fuel changeover shall require boiler shutdown. FSG components shall be located in the combustion control enclosure and shall be fully integrated for automatic sequencing of light-off and shutdown. The following color touch screen graphic pages shall be provided: boiler overview, flame safeguard overview, control panel faceplate with real time and historical trending, set-up and commissioning screens, and boiler alarm. Graphic pages shall display flame signal strength, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and burner historical information. Historical information shall include the last six lockout conditions, number of burner cycles and burner hours. The system shall include a "system reset" pushbutton and "FD fan "hand-off-auto", "burner off - fuel select gas - oil" control switches and alarm horn. Drum level conductivity probe relays for low level cutout, low level and high level alarms shall be provided. Provision shall be made to allow for water column blowdown without tripping the boiler. Provide one (1) flame scanner for each burner.

#### 3. Communications

The flame safeguard controller shall be equipped with an optically isolated RS485 modbus communications data highway connection to the color touch screen. The touch screen shall communicate with the plant BAS, EMS, or DCS by a Modbus over Ethernet communications data highway and shall allow reading of the following information: flame signal intensity, sequence of operation messages, diagnostic messages, "first out" cause of lockout messages, last six lockout conditions, number of burner cycles and burner operating hours. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 4. Quality Assurance

The system shall be factory manufactured and tested according to UL508A requirements. The system shall be designed to ensure the safe start-up, on-line operation and shutdown of fuel firing equipment. The system shall comply with NFPA 85. Per NFPA 85 "1.9.3.2.3 Requirement for Independence", the flame safeguard system shall be provided with independent logic and power supplies and shall be physically separated from the combustion control logic. The control system shall be a Preferred Instruments, Danbury, CT, BurnerMate TS Model BMTS-FSG.

#### Specifications

##### BurnerMate TS Control Panel

|              |                   |
|--------------|-------------------|
| Touchscreen: | OIT-10 or OIT-15  |
| Input Power: | 120 VAC (+/- 15%) |

##### Inputs

|                                 |               |
|---------------------------------|---------------|
| Recycling High Steam Pressure   | Dry Contact   |
| Flame Scanner                   | Scanner Input |
| *High Drum Level                | Water Probe   |
| *Low Water Level                | Dry Contact   |
| Emergency Stop Pushbutton       | Dry Contact   |
| Low Draft Switch                | Dry Contact   |
| Low Water Cutout                | Dry Contact   |
| Auxiliary Low Water Cutout      | Dry Contact   |
| Blowdown Pushbutton             | Dry Contact   |
| Excessive High Steam Pressure   | Dry Contact   |
| Purge Air Flow Switch           | Dry Contact   |
| Minimum Air Flow Switch         | Dry Contact   |
| *Low Instrument Air Pressure    | Dry Contact   |
| Fan Motor Started               | Dry Contact   |
| *VSD Running and No Alarms      | Dry Contact   |
| Fuel Oil Temperature Low        | Dry Contact   |
| *Fuel Oil Temperature High      | Dry Contact   |
| Fuel Oil Pressure Low           | Dry Contact   |
| Low Atomizing Medium Flow       | Dry Contact   |
| Low Atomizing Medium Pressure   | Dry Contact   |
| Fuel Gas Pressure High          | Dry Contact   |
| Fuel Gas Pressure Low           | Dry Contact   |
| Low Fire Air Switch             | Dry Contact   |
| Air Damper Proof of Open        | Dry Contact   |
| *Draft Damper Proof of Open     | Dry Contact   |
| *FGR Damper Proof of Closure    | Dry Contact   |
| Fuel Gas SSOV Proof of Closure  | Dry Contact   |
| Fuel Oil SSOV Proof of Closure  | Dry Contact   |
| Fuel Gas Control Valve Low Fire | Dry Contact   |
| Fuel Oil Control Valve Low Fire | Dry Contact   |

##### Outputs

|                            |         |
|----------------------------|---------|
| Energize Igniter           | 120 VAC |
| Open/Close Igniter SSOV    | 120 VAC |
| Open/Close Gas SSOV        | 120 VAC |
| Open/Close Oil SSOV        | 120 VAC |
| Open/Close Atomizing Valve | 120 VAC |
| Limits (to Lead/Lag)       | 120 VAC |
| Lockout (to Lead/Lag)      | 120 VAC |

\*These features are standard, but their use is selectable at time of start-up.

# BOILER ENERGY SAVINGS PROGRAM

- Provides an accurate way to assess the financial impact of boiler size and loading variations, burner excess air, combustion air fan variable speed drive, and fuel and electrical cost changes.

**Boiler Data**

Boiler Rating: 20 (klbs/hr)

Fuel Cost: 5.50 (\$ / 1000 ft<sup>3</sup>)

Fuel Type: Natural Gas

Electricity Cost: 6 (cents / kWh)

Combustion Air Fan Motor Rating: 30 (Hp)

Replace Existing Motor? (Yes or No): No

Inlet Vortex Damper? (Yes or No): No

O<sub>2</sub> Measurement Entered Below: % O<sub>2</sub> Wet

"Payback Analysis" Sheet  
(showing "blow up")

- Savings estimate is based on boiler size, motor HP, air damper type, current operating O<sub>2</sub> levels, projected operating O<sub>2</sub> levels, flue gas temperature, seasonal loading data, fuel cost, and electrical cost.

**Boiler EnergySaver Payback Analysis**

PREFERRED INSTRUMENTS  
11-55 South St., Rockville, CT 06866  
Tel: (860) 743-6741, Fax: (860) 743-7313  
www.preferred-instruments.com

**Customer Data**

Customer: University Place  
Location: U.S.A.  
Sales Representative: Preferred Representative  
Boiler Number: Boiler 1  
Notes:

Peak at 100% Rate during the Summer and 40% during the winter. Peak 24 hours a day 7 days a week.

**Boiler Data**

Boiler Rating: 20  
Fuel Cost: 5.50  
Fuel Type: Natural Gas  
Electricity Cost: 6 (cents / kWh)  
Combustion Air Fan Motor Rating: 30 (Hp)  
Replace Existing Motor? (Yes or No): No  
Inlet Vortex Damper? (Yes or No): No  
O<sub>2</sub> Measurement Entered Below: % O<sub>2</sub> Wet

Boiler data required for all "nonshaded" boxes. "shaded" boxes are calculated fields.

| Boiler Firing Rate                                       | 0%       | 20%      | 40%      | 60%      | 80%      | 100% | Total                |
|----------------------------------------------------------|----------|----------|----------|----------|----------|------|----------------------|
| % of year (should add up to 100%)                        | 0%       | 10%      | 30%      | 20%      | 30%      | 10%  | 100%                 |
| Boiler Firing Rate                                       | 0.0      | 4.0      | 8.0      | 12.0     | 16.0     | 20.0 | (klbs/hr)            |
| Stack Oxygen: (existing)                                 | 4.5      | 5.0      | 4.5      | 4.5      | 4.5      | 4.5  | % O <sub>2</sub> Wet |
| Stack Temperature: (existing)                            | 475      | 475      | 475      | 475      | 475      | 475  | (F)                  |
| Projected Stack Oxygen: (w/O <sub>2</sub> Trim)          | 5.0      | 4.0      | 3.5      | 3.0      | 3.0      | 3.0  | % O <sub>2</sub> Wet |
| Projected Stack Temperature: (w/O <sub>2</sub> Trim)     | 464      | 464      | 464      | 464      | 464      | 464  | (F)                  |
| Combustion Efficiency: (existing)                        | 79.1     | 80.2     | 80.5     | 80.5     | 80.5     | 80.5 | (%)                  |
| Projected Combustion Efficiency: (w/O <sub>2</sub> Trim) | 80.5     | 80.9     | 81.2     | 81.5     | 81.5     | 81.4 | (%)                  |
| Electrical energy used per year: (existing)              | 14,336.4 | 53,781.4 | 43,009.1 | 69,898.8 | 25,088.6 |      | (kWh)                |
| Electrical energy used per year: (w/VFD)                 | 896.0    | 10,752.3 | 14,336.4 | 37,633.0 | 23,296.6 |      | (kWh)                |
| Days Off-Line:                                           | 0.0      |          |          |          |          |      | (Days)               |
| Average Annual Boiler Load:                              | 12       |          |          |          |          |      | (klbs/hr)            |

**Savings**

|                                                  | Existing  | Projected | Total Savings per Year |
|--------------------------------------------------|-----------|-----------|------------------------|
| Annual Fuel Cost:                                | \$718,990 | \$711,270 | \$7,720                |
| Annual Fan Electrical Energy Cost:               | \$9,727   | \$6,429   | \$3,298                |
| <b>CO<sub>2</sub> Credit Based on Fuel Saved</b> |           |           | 232,916 (lbs/year)     |

Total Preferred Control System Cost With Installation: \$22,000 (\$)

Utility Energy Rebate (% or \$ amount): 5.0 %

Calculated Utility Energy Rebate: \$1,100 (\$)

System Cost (Less Rebate): \$20,900 (\$)

**Simple Payback:** 1.9 (Years)

**Simple Return On Investment (ROI):** 52.7 (%)

"Payback Analysis" Sheet  
(showing full sheet)

File Edit View Insert Format Tools Data Window Help Adobe PDF

Boiler Data

Boiler Rating: 20 (klbs/hr)

Fuel Cost: 5.50 (\$ / 1000 ft<sup>3</sup>)

Fuel Type: Natural Gas

Electricity Cost: 6 (cents / kWh)

Combustion Air Fan Motor Rating: 30 (Hp)

Replace Existing Motor? (Yes or No): No

Inlet Vortex Damper? (Yes or No): No

O<sub>2</sub> Measurement Entered Below: % O<sub>2</sub> Wet

Boiler data required for all "nonshaded" boxes. "shaded" boxes are calculated fields.

| Boiler Firing Rate                                       | 0%       | 20%      | 40%      | 60%      | 80%      | 100% | Total                |
|----------------------------------------------------------|----------|----------|----------|----------|----------|------|----------------------|
| % of year (should add up to 100%)                        | 0%       | 10%      | 30%      | 20%      | 30%      | 10%  | 100%                 |
| Boiler Firing Rate                                       | 0.0      | 4.0      | 8.0      | 12.0     | 16.0     | 20.0 | (klbs/hr)            |
| Stack Oxygen: (existing)                                 | 4.5      | 5.0      | 4.5      | 4.5      | 4.5      | 4.5  | % O <sub>2</sub> Wet |
| Stack Temperature: (existing)                            | 475      | 475      | 475      | 475      | 475      | 475  | (F)                  |
| Projected Stack Oxygen: (w/O <sub>2</sub> Trim)          | 5.0      | 4.0      | 3.5      | 3.0      | 3.0      | 3.0  | % O <sub>2</sub> Wet |
| Projected Stack Temperature: (w/O <sub>2</sub> Trim)     | 464      | 464      | 464      | 464      | 464      | 464  | (F)                  |
| Combustion Efficiency: (existing)                        | 79.1     | 80.2     | 80.5     | 80.5     | 80.5     | 80.5 | (%)                  |
| Projected Combustion Efficiency: (w/O <sub>2</sub> Trim) | 80.5     | 80.9     | 81.2     | 81.5     | 81.5     | 81.4 | (%)                  |
| Electrical energy used per year: (existing)              | 14,336.4 | 53,781.4 | 43,009.1 | 69,898.8 | 25,088.6 |      | (kWh)                |
| Electrical energy used per year: (w/VFD)                 | 896.0    | 10,752.3 | 14,336.4 | 37,633.0 | 23,296.6 |      | (kWh)                |
| Days Off-Line:                                           | 0.0      |          |          |          |          |      | (Days)               |
| Average Annual Boiler Load:                              | 12       |          |          |          |          |      | (klbs/hr)            |

**Savings**

|                                                  | Existing  | Projected | Total Savings per Year |
|--------------------------------------------------|-----------|-----------|------------------------|
| Annual Fuel Cost:                                | \$718,990 | \$711,270 | \$7,720                |
| Annual Fan Electrical Energy Cost:               | \$9,727   | \$6,429   | \$3,298                |
| <b>CO<sub>2</sub> Credit Based on Fuel Saved</b> |           |           | 232,916 (lbs/year)     |

Total Preferred Control System Cost With Installation: \$22,000 (\$)

Utility Energy Rebate (% or \$ amount): 5.0 %

Calculated Utility Energy Rebate: \$1,100 (\$)

System Cost (Less Rebate): \$20,900 (\$)

**Simple Payback:** 1.9 (Years)

**Simple Return On Investment (ROI):** 52.7 (%)

"Payback Analysis" Sheet  
(showing lower half of the sheet)

- Actual operating boiler loads are used to allow accurate operating cost calculation.
- Electrical usage estimates are based on leading AC motor manufacturing data.
- Fuel use estimates are based on combustion efficiency calculated using the ASME "by losses" method.
- Summary information calculates existing and projected fuel and electrical operating cost, energy savings rebate (% or \$), and a Return on Investment (ROI).
- "CO<sub>2</sub> credit" is calculated based on fuel savings.

**Ordering Information**  
Consult Factory



# HAWK REPLACEMENT SYSTEM

## Product Overview

The Preferred **Hawk Replacement System** is a BurnerMate TS configured to be a replacement for obsolete CB Hawk and Honeywell BCS 7700 boiler controllers.

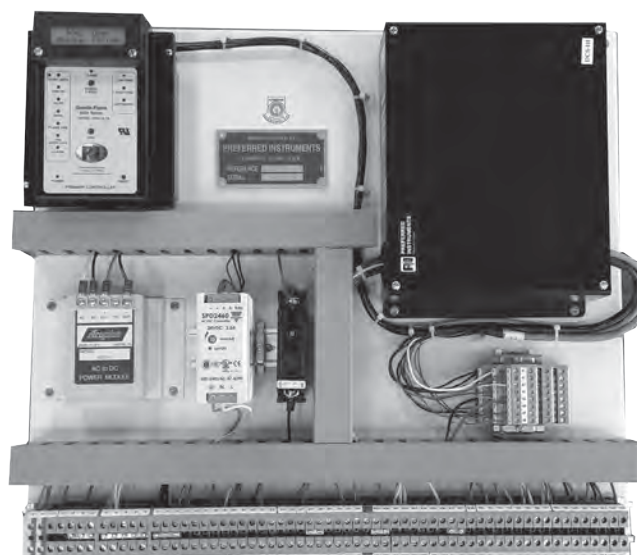
### Major Features Include:

- Direct replacement for existing boiler control panel sub-panel. Terminals provided for reconnecting existing reusable wires
- Existing control panel, entrance box, control switches, indications, flame scanner and operating limits are reused
- Automatic burner sequencing and flame supervision
- Firing rate control with thermal shock protection
- Simple touch screen operation with alarm and event summaries, real time and historical trending
- Remote monitoring through standard WEB browser
- Remote interface via Ethernet TCP/ IP communication

### Minimized Installation Cost

Existing wiring, sensors and control cabinets are reused to the **maximum extent possible**. Only additional limit devices (gas and oil pressure switches) are included to meet the guidelines of the National Fire Protection Association (NFPA). Typical installation time for this system is 24 man-hours and an additional 2 hours for commissioning.

- 10.4" Touch Screen Operator Interface Terminal
- Fully wired and tested sub-panel replacement:
  - DCS-III Programmable Controller
  - Quanta-Flame 5004-M-85 Flame Safeguard
  - Power Supplies, interposing terminations and connectors to door-mounted color touch screen operator terminal



*Hawk Replacement Sub-Panel Fits Existing Hawk Enclosures*

### New Field Equipment Required

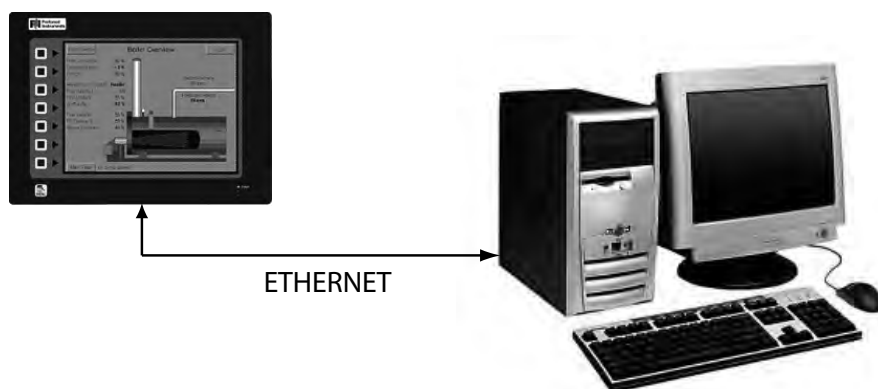
- Steam pressure or water temperature transmitter
- New damper servo motor actuator with feedback and limit switches
- Low and high gas pressure switches
- Low oil pressure switch

### Improved Accuracy

Outdated modulating motor is replaced with a state of the art, accurate Preferred Instruments SM-15 actuator.

OIT  
TOUCH SCREEN

PLANT  
DCS, BAS,  
EMS, SCADA, ETC.



*Preferred Hawk Replacement System Communicates Digitally by Modbus Ethernet OPC.*



# HAWK REPLACEMENT SYSTEM

## Product Overview

### Advanced Communication Interfacing

An Ethernet (TCP/IP) communication port is easily assigned an IP address and connected to a facility wide network. Building Automation Systems and SCADA Systems are interfaced via industry standard MODBUS Ethernet.

### Real Time and Historical Trends

Easily used, multiple pen charts allow quick system assessment and maintenance monitoring.

### Web Browser Remote Operation

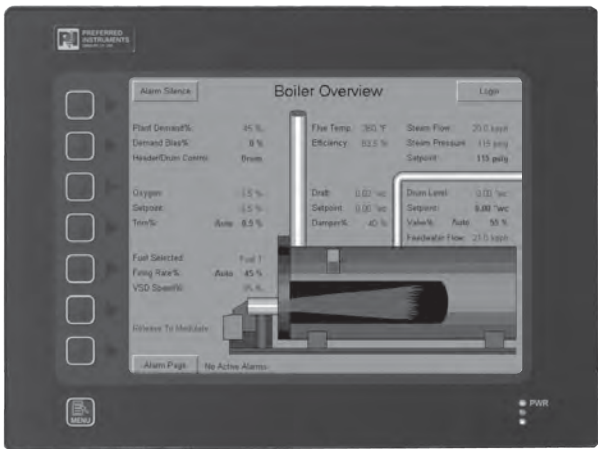
Any PC that is connected via the Ethernet port can view displays using a standard Web browser. Historical alarm and event data can be imported to spreadsheet applications such as Microsoft Excel® (with optional flash card).

### Simple Touch Screen Operator Terminal

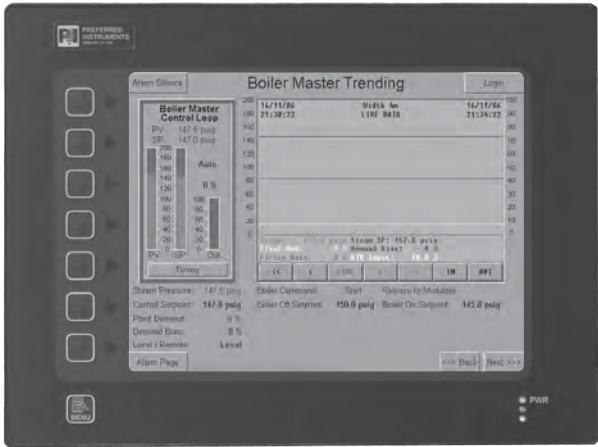
Monitor and control boiler operation, setpoints, process data, boiler faults and status from one convenient display. Commissioning and trouble shooting activities are laid out in an easy to follow step by step procedure, eliminating the need for knowledge of individual controller menus and programming languages.

### Improved Spare Parts Availability

Industry standard controllers, actuator and limit devices are used. Replacement parts are in stock.



Boiler Overview Screen



Pre-Engineered Graphics Pages Allow Quick Commissioning

### Ordering Information:

| Description                                                                                                                                                                                                       | Catalog Number   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Boiler Control Panel Upgrade Kit with assembled, pre-wired and tested subpanel assembly, gas only firing, 10" OIT, DCS-III, 5004-M-85, SM-15 actuator, power supplies and terminals.                              | BM-Kit-G-OIT10   |
| Boiler Control Panel Upgrade Kit with assembled, pre-wired and tested subpanel assembly, gas and oil firing, 10" OIT, DCS-III, 5004-M-85, SM-15 actuator, power supplies, gas/ oil selector switch and terminals. | BM-Kit-GO-OIT10  |
| UV Flame Scanner Amplifier                                                                                                                                                                                        | add "-UV" suffix |
| IR Flame Scanner Amplifier                                                                                                                                                                                        | add "-IR" suffix |
| 30 Second Purge Card                                                                                                                                                                                              | add "-30" suffix |
| 60 Second Purge Card                                                                                                                                                                                              | add "-60" suffix |
| 90 Second Purge Card                                                                                                                                                                                              | add "-90" suffix |

Note: Existing Hawk gas and oil pressure sensors must be replaced by pressure switches. (Not included in the kits)

## 5002-01 ULTRAVIOLET SELF-CHECKING SCANNER

### Product Overview

#### Description

The Quanta-Flame Series 5002 is intended for monitoring all gas, oil and coal-fired burners. The control is the basis for industrial or commercial burner management systems using microprocessors, PLC or relay-based hardware. All essential circuits are supervised. The 5002-01 scanner is not an approved flame safeguard controller, so it must be used in conjunction with an approved flame safeguard controller.

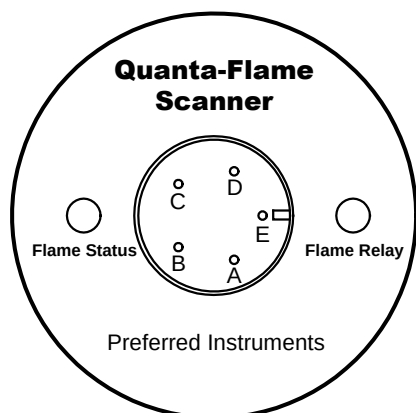
- 5002-01 interfaces with Preferred, Fireye, Honeywell, and PCI flame safeguard controllers. Model numbers ending in "-C" provide contact closure and 4-20 mA outputs to interface with PLC-based and DCS-based flame safeguard systems
- Internal microcomputer controls internal functions as well as supervising the relay contacts to verify they are always operating correctly
- High quality fused silica quartz lens
- Machined alloy housing with seals
- Detectors and signal processor automatically checked every 10 seconds
- Replacement scanner can be installed without disturbing wiring
- No scheduled replacement parts
- Flame relay contacts and load circuit supervised
- Status LEDs
- Flame intensity
- Output on indicator
- Self-check indicator

#### LED Indicators

A Flame Status LED and Flame Relay LED provide useful diagnostic information on the front of the scanner.

#### Flame Status LED

The Flame Status LED (FSL) is a dual-color LED that acts as a multifunctional indicator.



Connector view of 5002-01 scanner showing cable pinouts



5002-01 Series Ultraviolet Self-Checking Scanner

When a flame is detected, the FSL will illuminate with a red color. This light will vary in intensity proportional to the level of flame signal (flame strength) detected. Every 10 seconds, the self-checking mechanism will interrupt the light coming from the flame. This is done to verify that the UV sensing element is still functioning properly. When this check is being performed, the FSL will momentarily turn to a yellow color (when flame present) or green color (when flame is not present). Should the UV sensing element fail to function, the scanner will lockout all the outputs to indicate the failure and the FSL will remain green without blinking for one minute.

After one minute, the control will automatically reset itself. The scanner's microcomputer will then continue to check the sensing element every ten seconds. Should the sensing tube be in a permanent "runaway" condition, the scanner will immediately lock out again for another period of one minute.

#### Flame Relay LED

The Flame Relay LED (FRL) is a single color LED. When a flame of sufficient intensity is detected the 5002-01 scanner will activate the output signal. This output may be any one of the possible output forms described above. While the output is activated, the FRL will illuminate. Should the flame signal fall below the minimum threshold, or should one of the internal circuits or sensing elements tests fail, the output will deactivate, and the FRL will shut off.

#### Specifications

##### Mechanical

|                             |                              |
|-----------------------------|------------------------------|
| <b>Length Overall:</b>      | 7" (177.8 mm)                |
| <b>Diameter:</b>            | 3.25" (82.5 mm)              |
| <b>Housing:</b>             | Machined 5052 Aluminum Alloy |
| <b>Finish:</b>              | Clear Anodized               |
| <b>Sight Tube Entrance:</b> | 1" Pipe Thread               |

## 5002-01 ULTRAVIOLET SELF-CHECKING SCANNER

### Product Overview

**Purge Air Entrance:** 3/8" Pipe Thread  
**Electrical**  
**Supply Voltage:** 120 VAC 50/60Hz,  
 230 VAC 50/60Hz  
 24 VDC  
 (depending on model)  
**Required power:** 2 VA  
**Output Contact Rating:** 230 VAC, 1 A  
**Available Outputs:**  
 (-C Models) Relay Contact &  
 4 to 20 mA

Other models interface with Preferred and other flame safeguard amplifiers. (see wiring examples)

Specifications for 4 to 20 mA output  
 (two-wire current loop)

**Span error:** 1%  
**Non-linearity:** 0.1%  
**Supply required to the loop:** 12 to 30 VDC

**Environmental**

**Class:**

**Temperature:**

NEMA 4  
 (0° F to 140° F).

**Optical**

**Lens Material:**

Fused Silica

**Spectral Sensitivity**

**Ultraviolet:**

180-230 nanometers

**Product Certification**

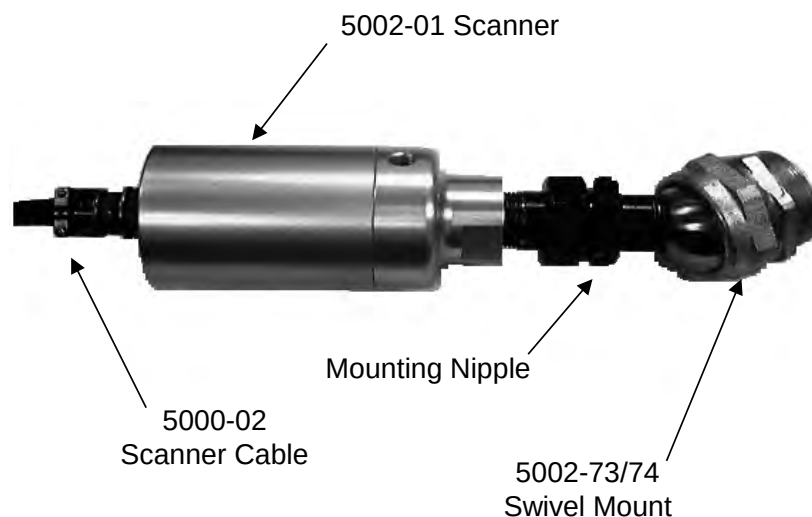
Microcomputer controlled UV Scanner (120VAC) Relay &  
 Flame Amplifier Output FM / UL / CSA / CSAUS

UL file Number: E233069

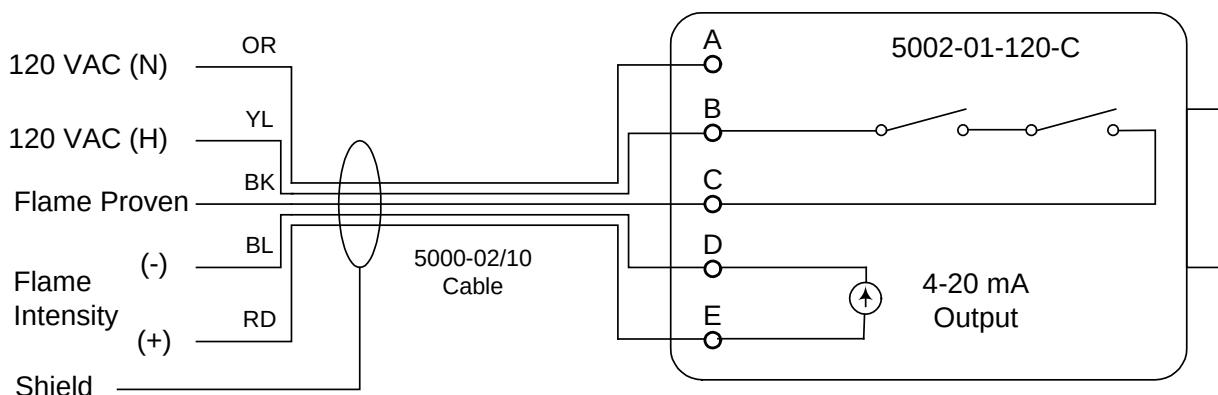
CSA Certification: File No. 204571 –Project Number  
 1181621 and 1298906 update to add PCI and Eclipse  
 controls. See attached CSA Certificate of Compliance  
 FM Approved Report Number: 3009512 and 3013648 (for  
 use specifically with Eclipse Combustion Inc and Protection  
 Controls Combustion Safeguards)

Applicable Requirements: CSA 0.8-M1986, 199-M89, UL  
 372, UL1998, FM Class 7610

Note: Flame scanners must be used in conjunction with an  
 approved flame safeguard controller.



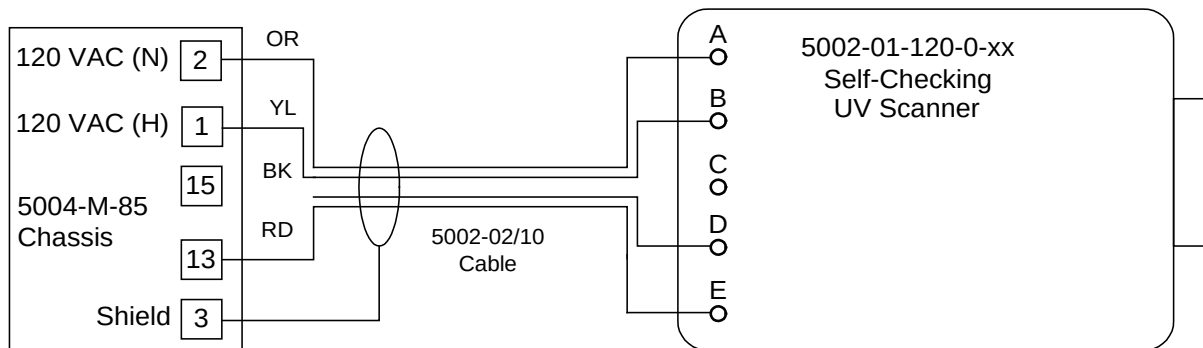
Typical Scanner Mounting



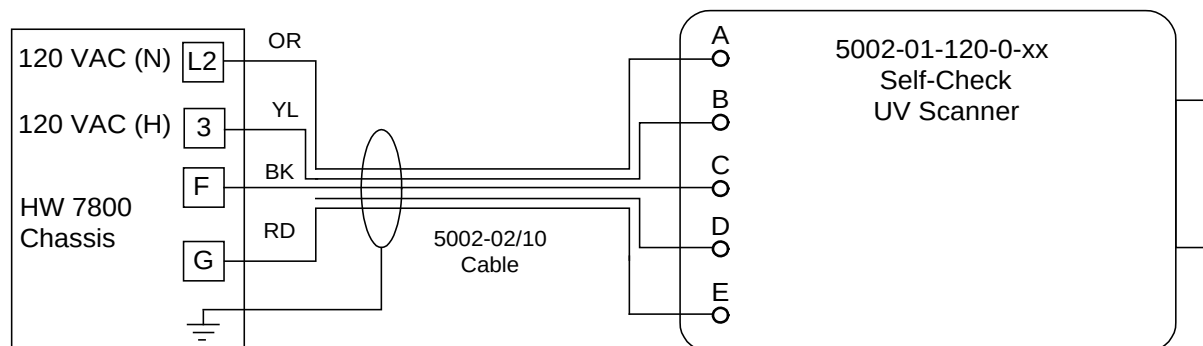
Internal Wiring and Typical Field Wiring of the 5002-01-120-C UV Self-check Scanner with 4-20 mA Output Option

## 5002-01 ULTRAVIOLET SELF-CHECKING SCANNER

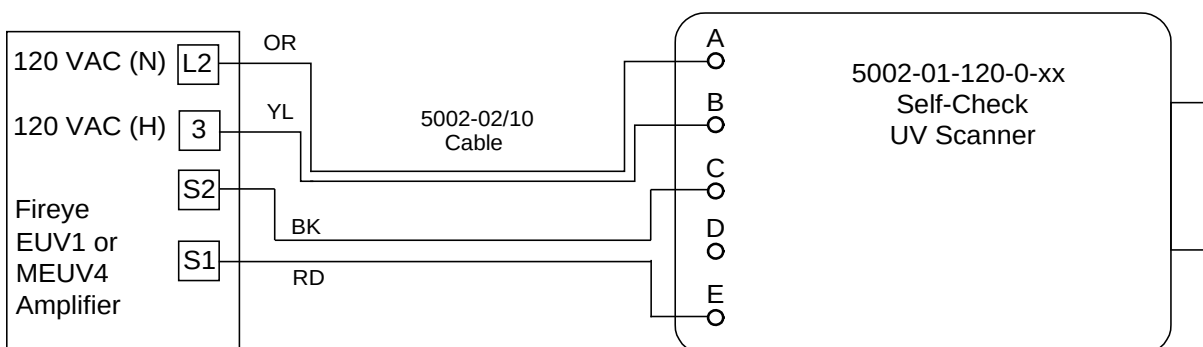
### Typical Wiring



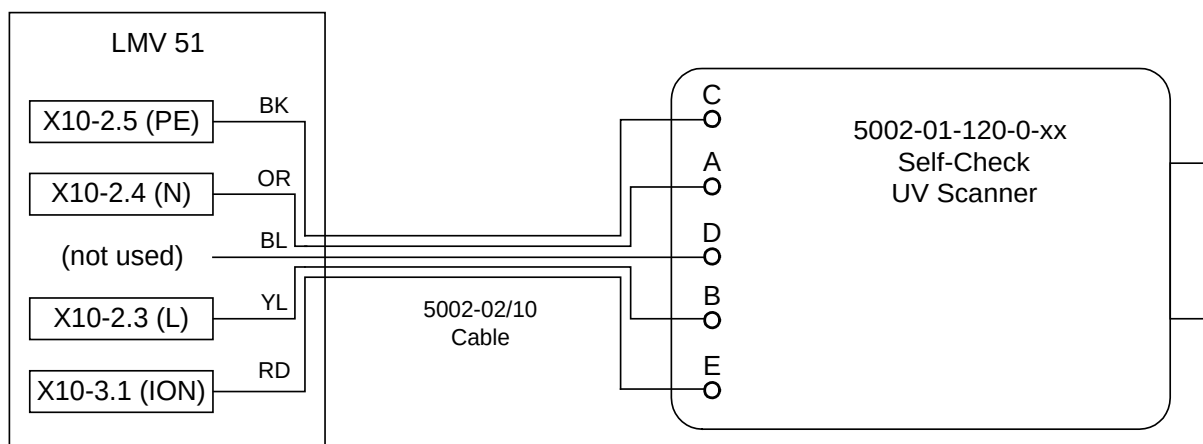
Typical Wiring Schematic--UV Self-check Scanner to Preferred Instruments 5004-M-85 Flame Safeguard Controller



Typical Wiring Schematic--UV Self-check Scanner to HW 7800 Series Flame Safeguard Controller



Typical Wiring Schematic--UV Self-check Scanner to Fireye EUV1 or MEUV4 Flame Safeguard Controller

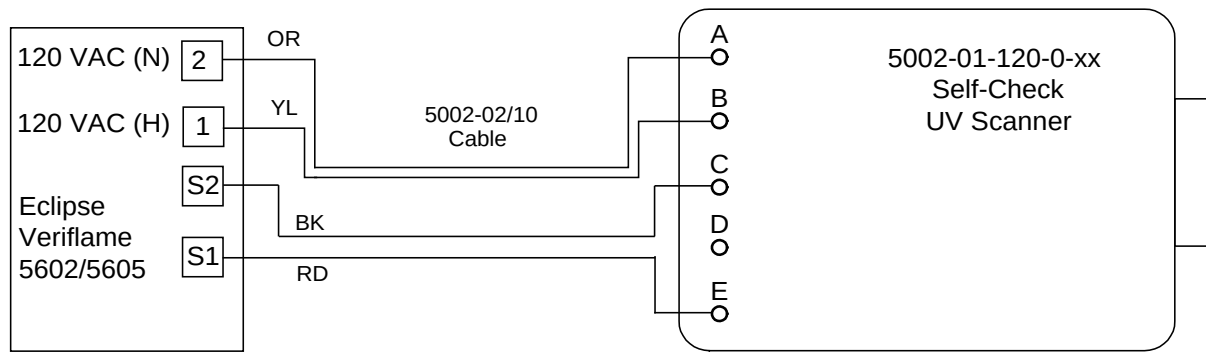


Typical Wiring Schematic--UV Self-check Scanner to Siemens LMV Controllers



## 5002-01 ULTRAVIOLET SELF-CHECKING SCANNER

### Suggested Specification



Typical Wiring Schematic--UV Self-check Scanner to Eclipse Veriflame Controllers

Suggested Specification:

#### 1. Self-checking UV Scanner

Ultraviolet self-checking flame scanner shall be U.L. listed, FM approved, and CSA certified. Scanner housing shall be made of rugged anodized aluminum, have two status LEDs, and connect by means of a military-style quick disconnect fitting.

#### 2. Physical Description

Scanner shall be made of high strength anodized aluminum and mount by means of industry standard 1" NPTF connection and include:

- 3/8" Purge connection
- 5 Pin military-style quick disconnect cable fitting

#### 3. Electrical Characteristics

Scanner shall be powered by 120 VAC, 230 VAC, or 24 VDC input power. A 120/230 VAC relay contact shall be provided to prove flame while a 4-20 mA output shall correspond to flame signal strength (-C models). Alternatively, the 5002-01-(120 or 240)-0-xx shall interface with most existing flame amplifiers.

#### 4. Manufacturer

Self-checking ultraviolet scanner shall be Model 5002-01 series manufactured by Preferred Utilities of Danbury, CT.

## 5002-01NC ULTRAVIOLET SCANNER

### Product Overview

#### Description

The Quanta-Flame Series 5002 is intended for monitoring all gas, oil and coal-fired burners. The control is the basis for industrial or commercial burner management systems using microprocessors, PLC or relay-based hardware. All essential circuits are supervised.

- 5002-01NC interfaces with Preferred, Fireye, Honeywell, and PCI flame safeguard controllers or it is available with contact closure and 4-20 mA outputs interface with PLC-based and DCS-based flame safeguard systems
- High quality fused silica quartz lens
- Machined alloy housing with seals
- Replacement scanner can be installed without disturbing wiring
- No scheduled replacement parts
- Status LEDs
- Flame intensity
- Output On indicator
- Self-Check indicator

#### LED Indicators

A Flame Status LED and Flame Relay LED provide useful diagnostic information on the front of the scanner.

#### Flame Status LED

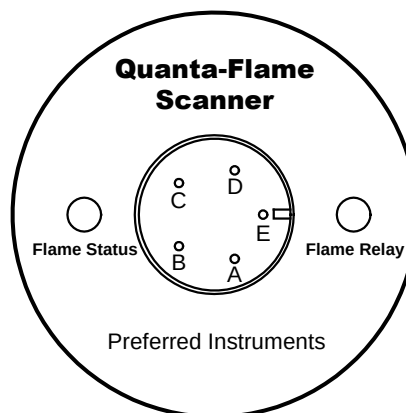
The Flame Status LED (FSL) is a dual color LED that acts as a multifunctional indicator. When a flame is detected, the FSL will illuminate with a red color. This light will vary in intensity proportional to the level of flame signal (flame strength) detected.

#### Flame Relay LED

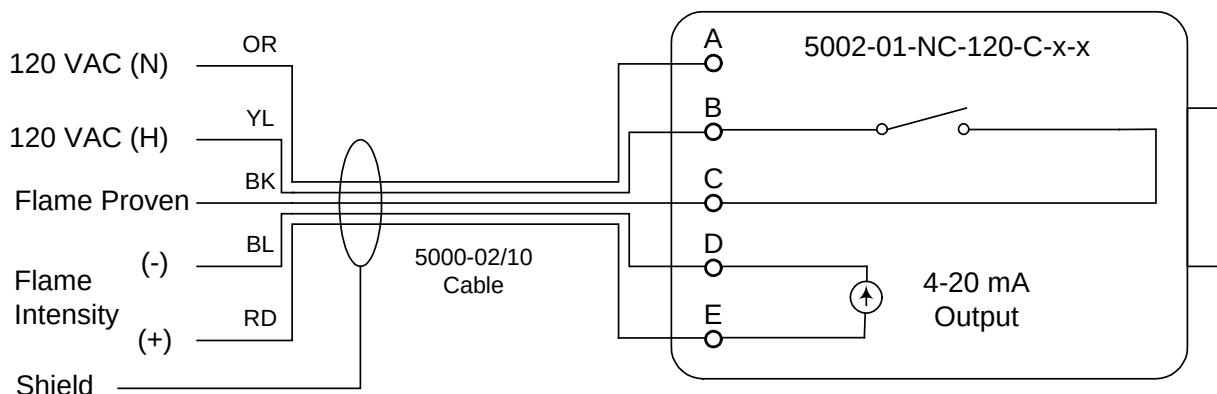
The Flame Relay LED (FRL) is a single-color LED. When a flame of sufficient intensity is detected, the 5002 control will activate the output signal. This output may be any one of the possible output forms described above.



5002-01NC Series Ultraviolet Scanner



Connector view of 5002-01NC scanner showing cable pinouts



Internal Wiring and Typical Field Wiring of the 5002-01-NC-120-C-x-x Ultraviolet Scanner.

## 5002-01NC ULTRAVIOLET SCANNER

### Product Overview

While the output is activated, the FRL will illuminate. Should the flame signal fall below the minimum threshold, or should one of the internal circuits or sensing elements tests fail, the output will deactivate, and the FRL will shut off.

#### Specifications:

##### Mechanical

**Length Overall:** 3.5" (88.9 mm)  
**Diameter:** 2.25" (57.2 mm)  
**Housing:** Machined 5052 Aluminum Alloy  
**Finish:** Clear  
**Sight Tube Entrance:** 1/2" Pipe Thread

##### Electrical

**Supply Voltage:** 120 VAC 50/60 Hz, 24 VDC (depending on model)  
**Required power:** 2 VA  
**Output Contact Rating:** 230 VAC, 1 A  
**Available Outputs:** Relay Contact & 4 to 20 mA (-C Models)

Specifications for 4 to 20 mA output (two-wire current loop)

**Span error:** 1%  
**Non-linearity:** 0.1%  
**Supply required to the loop:** 12 to 30 VDC

##### Environmental

**Class:** NEMA 4  
**Temperature:** (0° F to 140° F).

##### Optical

**Lens Material:** Fused Silica

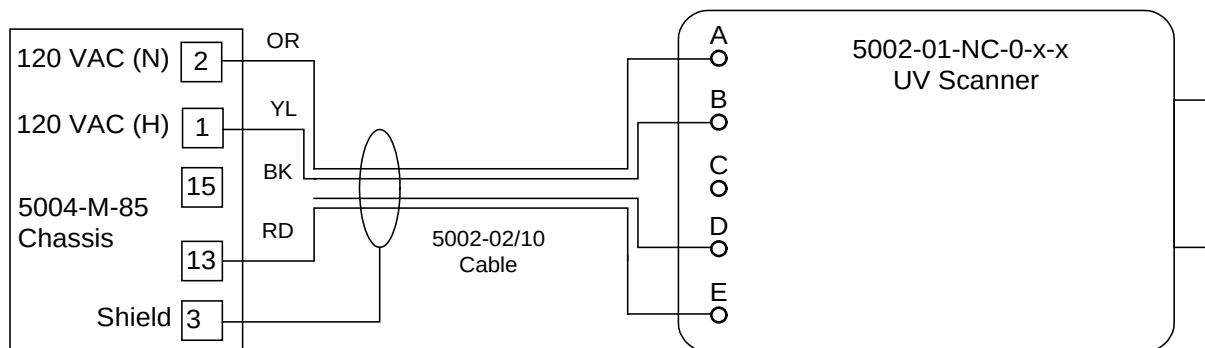
##### Spectral Sensitivity

**Ultraviolet:** 180-230 nanometers

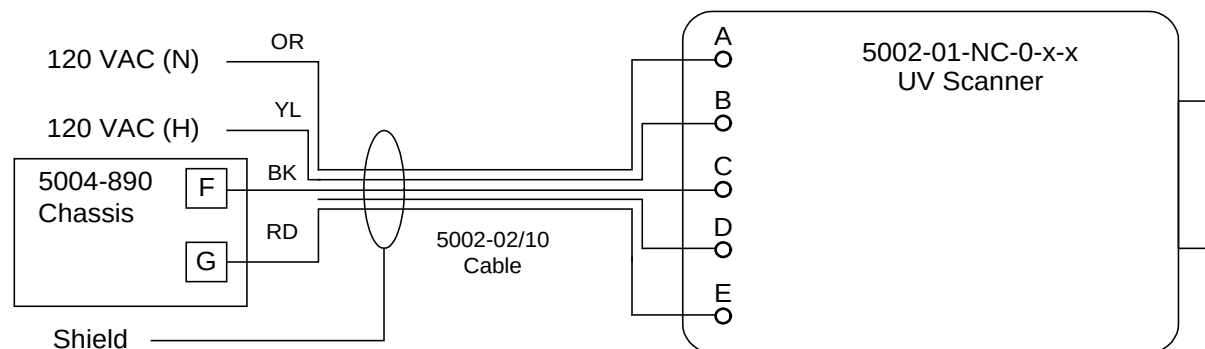
##### Product Certification

UL file number: E233069

Other models interface with Preferred and other flame safeguard amplifiers. (see wiring examples)



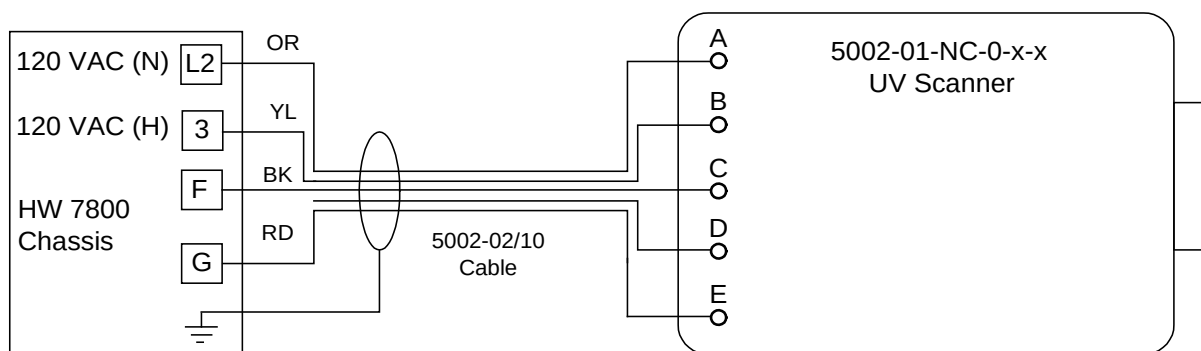
Typical Wiring Schematic: UV Scanner to Preferred Instruments 5004-M-85 Flame Safeguard Controller



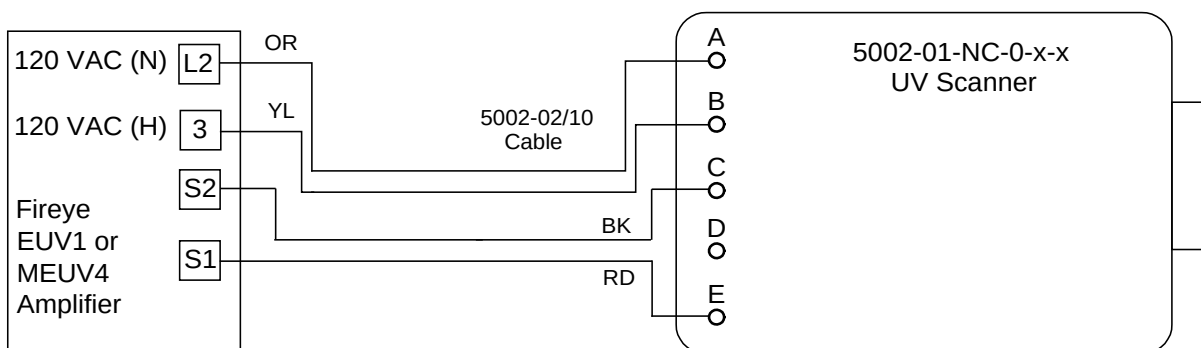
Typical Wiring Schematic: UV Scanner to Preferred Instruments 5004-890 Flame Safeguard Controller

## 5002-01NC ULTRAVIOLET SCANNER

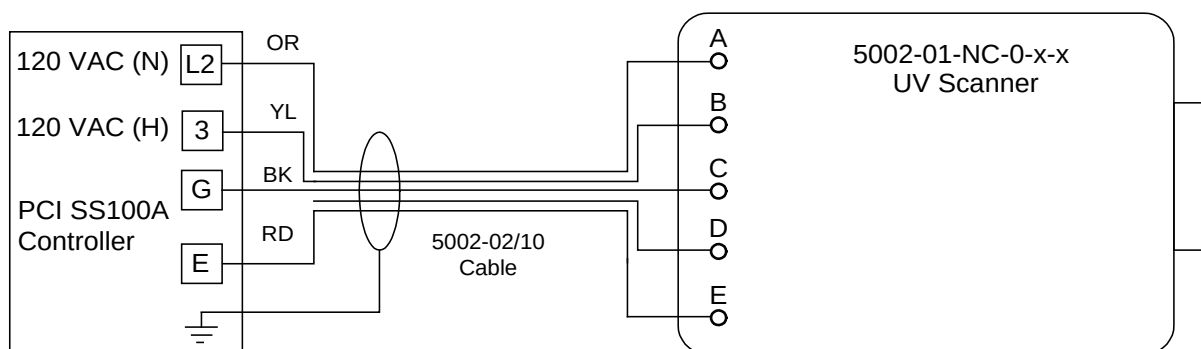
### Typical Wiring



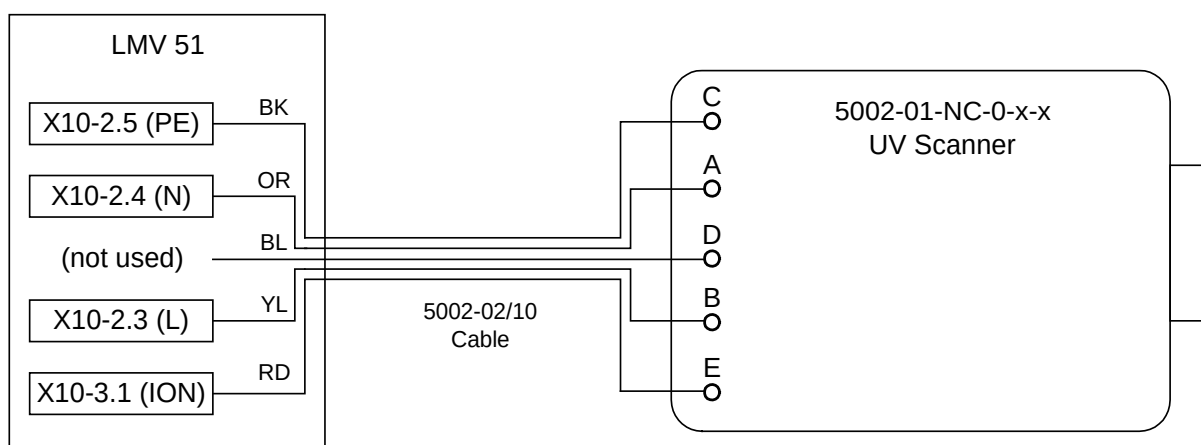
Typical Wiring Schematic: UV Scanner to Honeywell 7800 Series Flame Safeguard Controllers



Typical Wiring Schematic: UV Scanner to Fireye Flame Safeguard Controllers



Typical Wiring Schematic: UV Scanner to PCI Flame Safeguard Controllers

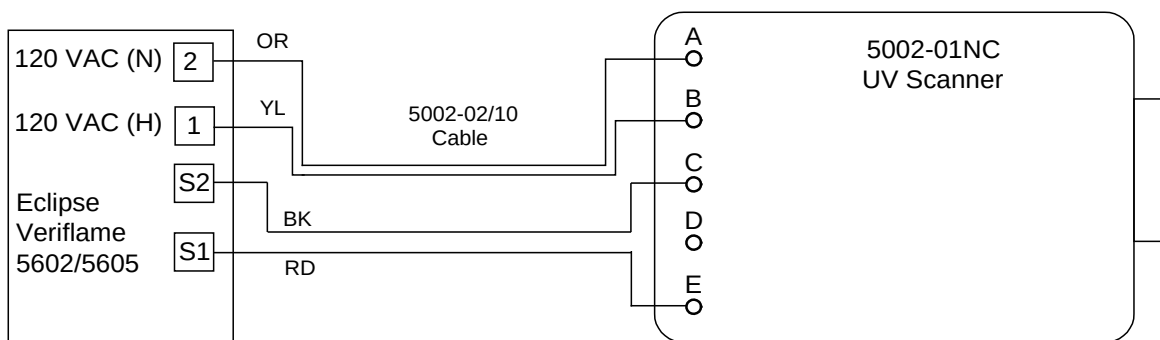


Typical Wiring Schematic: UV Scanner to Siemens LMV Flame Safeguard Controllers



## 5002-01NC ULTRAVIOLET SCANNER

### Suggested Specification



*Typical Wiring Schematic 5002-01NC Scanner to Eclipse Veriflame Controllers*

#### Suggested Specifications

##### 1. UV Scanner

Flame scanner shall be U.L. recognized. Scanner housing shall be made of rugged anodized aluminum, have two status LEDs, and connect by means of a military-style, "quick-disconnect" fitting.

##### 2. Physical Description

Scanner shall be made of high strength anodized aluminum and mount by means of industry standard 1/2" NPTF connection including:

- 3/8" Purge connection
- 5 Pin military-style quick disconnect cable fitting

##### 3. Electrical Characteristics

Scanner shall be powered by 120 VAC, 230 VAC, or 24 VDC input

power. A 120/230 VAC relay contact shall be provided to prove flame while a 4-20 mA output shall correspond to flame signal strength (-C models). Alternatively, the 5002-01-(120 or 240)-0-xx shall interface with most existing flame amplifiers.

##### 4. Manufacturer

Scanner shall be model 5002-01NC manufactured by Preferred Instruments of Danbury, CT.

## FLAME SCANNERS

### Ordering Information

#### UV Non Self-Check Scanners

| Description                                                             | Catalog Number |
|-------------------------------------------------------------------------|----------------|
| 5004-01 UV Scanner with 90 degree angle mount, no cable included        | 5004-01-0-0    |
| 5004-01 UV Scanner with 90 degree angle mount, 5 feet of cable included | 5004-01-0-C    |
| 5004-01 UV Scanner with straight mount, no cable included               | 5004-01-S-0    |
| 5004-01 UV Scanner with straight mount, 5 feet of cable included        | 5004-01-S-C    |
| 5 feet of cable with connector                                          | 5004-00        |

#### UV Self-Check Scanners

| Description                           | Catalog Number   |
|---------------------------------------|------------------|
| Aluminum Alloy Body                   |                  |
| UV or Flame Rod output; 120 VAC input | 5002-01-120-0-00 |
| 4-20 mA DC output; 120 VAC input      | 5002-01-120-C-00 |
| UV or Flame Rod output; 24 VDC input  | 5002-01-024-0-00 |
| 4-20 mA DC output; 24 VDC input       | 5002-01-024-C-00 |
| UV or Flame Rod output; 240 VAC input | 5002-01-240-0-00 |
| 4-20 mA DC output; 240 VAC input      | 5002-01-240-C-00 |
| Stainless Steel Body                  |                  |
| UV or Flame Rod output; 120 VAC input | 5002-01-120-0-SS |
| 4-20 mA DC output; 120 VAC input      | 5002-01-120-C-SS |
| UV or Flame Rod output; 24 VDC input  | 5002-01-024-0-SS |
| 4-20 mA DC output; 24 VDC input       | 5002-01-024-C-SS |
| UV or Flame Rod output; 240 VAC input | 5002-01-240-0-SS |
| 4-20 mA DC output; 240 VAC input      | 5002-01-240-C-SS |

## FLAME SCANNERS

### Ordering Information

#### Infrared Flame Scanners

| Description                                                  | Catalog Number         |
|--------------------------------------------------------------|------------------------|
| <b>Aluminum Alloy Body</b>                                   |                        |
| Contact closure output only                                  | 5002-11-NC-xxx-R-00-00 |
| 4-20 mA DC signal & contact closure output                   | 5002-11-NC-xxx-C-00-00 |
| UV/Flame Rod signal only                                     | 5002-11-NC-xxx-F-00-00 |
| Contact closure output only. High Sensitivity                | 5002-11-NC-xxx-R-00-HS |
| 4-20 mA DC signal & contact closure output. High Sensitivity | 5002-11-NC-xxx-C-00-HS |
| UV/Flame Rod signal only. High Sensitivity.                  | 5002-11-NC-xxx-F-00-HS |
| <b>Stainless Steel Body</b>                                  |                        |
| Contact closure output only                                  | 5002-11-NC-xxx-R-SS-00 |
| 4-20 mA DC signal & contact closure output                   | 5002-11-NC-xxx-C-SS-00 |
| UV/Flame Rod signal only                                     | 5002-11-NC-xxx-F-SS-00 |
| Contact closure output only. High Sensitivity                | 5002-11-NC-xxx-R-SS-HS |
| 4-20 mA DC signal & contact closure output. High Sensitivity | 5002-11-NC-xxx-C-SS-HS |
| UV/Flame Rod signal only. High Sensitivity.                  | 5002-11-NC-xxx-F-SS-HS |

"-xxx-" Suffix: "-012-" 12 VDC input; "-024-" 24 VDC input; "-120-" 120 VAC input;

#### Scanner Accessories

| Description                                                                                                | Catalog Number   |
|------------------------------------------------------------------------------------------------------------|------------------|
| Replacement quartz lens for mtg nipple 5000-01-00.                                                         | 5000-01-00L      |
| Swivel mount, 2" NPT x 1" NPTF, Stainless steel.                                                           | 5000-73/74-SS    |
| Single piece nipple, 1" NPT x 4" long with quartz lens and purge connection.                               | 5000-475         |
| Mounting nipple for 5000-001 scanner including quartz lens, 1" NPT x 4" long. Stainless steel.             | 5000-01-00-SS    |
| Mounting nipple for 5000-001 scanner including glass lens, 1" NPT x 4" long. Stainless steel.              | 5000-11-00-SS    |
| Stainless Steel mtg. nipple for 5000-001 scanner with insert quartz lens for higher pressure applications. | 5000-01-00A      |
| Mtg nipple for scanners with 1" threads, carbon Teflon for 450 deg. F service. 1" NPT x 4" long.           | 5000-01-04-CT    |
| Scanner Cable 5 feet – with connector                                                                      | 5000-02-05       |
| Scanner Cable 10 feet – with connector                                                                     | 5000-02-10       |
| Scanner Cable – Specify Length – connector not included.                                                   | 5000-02-xx       |
| 5002 scanner line filter                                                                                   | 5000-01UFL       |
| <b>1/2" NPT Scanner Nipples with Quartz Lenses</b>                                                         |                  |
| Insulator with Flat Quartz Lens; no Purge connection; 200°F Rating                                         | 7077-17-FP-0-200 |
| Insulator with Flat Quartz Lens; with Purge connection; 200°F Rating                                       | 7077-17-FP-P-200 |
| Insulator with Flat Quartz Lens; no Purge connection; 450°F Rating                                         | 7077-17-FP-0-450 |
| Insulator with Flat Quartz Lens; with Purge connection; 450°F Rating                                       | 7077-17-FP-P-450 |
| Insulator with Magnifying Quartz Lens; no Purge connection; 200°F Rating                                   | 7077-17-MP-0-200 |
| Insulator with Magnifying Quartz Lens; with Purge connection; 200°F Rating                                 | 7077-17-MP-P-200 |
| Insulator with Magnifying Quartz Lens; no Purge connection; 450°F Rating                                   | 7077-17-MP-0-450 |
| Insulator with Magnifying Quartz Lens; with Purge connection; 450°F Rating                                 | 7077-17-MP-P-450 |
| <b>1/2" NPT Scanner Nipples without Quartz Lenses</b>                                                      |                  |
| Nipple, 1/2" NPT; with Purge connection; 200°F Rating                                                      | 7077-17PN-200    |
| Nipple, 1/2" NPT; no Purge connection; 200°F Rating                                                        | 7077-17EN-200    |
| Nipple, 1/2" NPT; with Purge connection; 450°F Rating                                                      | 7077-17PN-450    |
| Nipple, 1/2" NPT; no Purge connection; 450°F Rating                                                        | 7077-17EN-450    |

## 5004-M-85 FLAME SAFEGUARD CONTROLLER

### System Overview

#### Quanta-Flame 5004-M-85

A state-of-the-art flame safeguard controller designed for single burner and boiler applications with one or two scanners. Unlike other flame safeguard controllers that require a multitude of amplifiers, programmers, and purge timers, the Preferred 5004-M-85 has just one processor with a built-in universal amplifier that accepts UV, IR, and self-checking UV scanner inputs, as well as flame rod inputs. In addition, Purge times and Main Trial For Ignition (MTFI) times are field-selectable.

#### Features Include

- Every unit interfaces to infrared, ultraviolet, ultraviolet self-check or flame rod sensors. Sensor specific plug-in amplifiers are not required
- Single or Dual Flame Sensors
- Field Selectable Purge Time
- Field Selectable Pilot Trial for Ignition (PTFI) Time
- Selectable running interlock short test
- DIP switch settings are burned into memory after four hours of operation
- RS485 Modbus Communication
- Local LCD display for status and troubleshooting
- Optional Remote Display (5004-216RN)
- Sequence Status Lights
- Jacks for direct flame strength measurement 0-5VDC
- Low Panel Profile
- Plug-in Field Wiring Terminals
- Field Selectable Check for Power Failure
- Field Selectable 10/15 sec Interrupted Pilot
- Field Selectable check for limits bypassed function
- Early Spark Termination
- Pilot Test Mode
- Optional 16 Point Annunciator (QA16)
- Remote/ Local reset from lockout state
- Optional QA5004-216 Remote Display

#### Controller Functions

**False Flame Detection** - The controller will lockout if flame is detected during Standby or Purge.

**Safe Start Check** - During every burner startup sequence, the controller performs hardware and software self-tests to verify it's internal circuitry is functioning properly. The controller verifies the safety relay, ignition relay, pilot relay, and the main fuel valve relays are functioning properly. If the "check for power failure" function is selected and power was interrupted during a firing cycle, upon power up the control will lockout.

**Check for Limits Bypassed** - If the "check for limits bypassed" function is selected, before beginning purge, the controller ensures the "limits made" input is de-energized, and waits for up to 60 seconds for the "limits made" input to be de-energized. (The fan motor starter interlock and minimum air pressure switch should not be made before the fan is powered. This function will detect if these limits have been bypassed.)



Quanta-Flame 5004-M-85 Flame Safeguard Controller Chassis

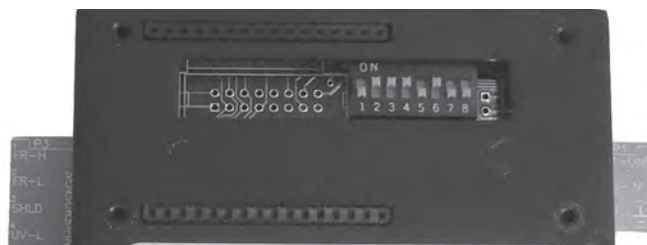
**Proof of Valve Closure (POVC)** - The controller will lockout if the main fuel valves are not proven closed during standby, purge and Pilot Trial for Ignition (PTFI). The controller will also lockout if the main fuel valves close when the burner is firing.

**Proven High Fire / Purge**- Proves that the high fire position and purge air flow interlocks are made before purge can begin, and requires these interlocks to be made throughout the purge period. If these interlocks open during the purge period for more than 30 seconds (cumulative), the controller will lockout. If running interlocks are not made continuously throughout the purge period, the control will lockout after 5 minutes. This ensures a proper purge cycle.

**Proven Low Fire/ Ignition** - Proves the low fire position prior to Ignition and light off of the burner. If low fire proving switch is not made within 5 minutes. The control will lockout.

**Selectable Pilot Trial for Ignition (PTFI) Time** - DIP switches allow selection of a 3, 5, or 10 second timing.

**Early Spark Termination / Pilot Verification** - The ignition transformer spark is de-energized at the end of PTFI while the pilot valve continues to be energized for 5 seconds before the main fuel valves are energized.



DIP switches used to configure the controller are located underneath the LCD display.



## 5004-M-85 FLAME SAFEGUARD CONTROLLER

### System Overview

This ensures the sensor is not recognizing spark as a (false) flame and the pilot flame is stable without a spark, before energizing the main fuel valves.

**Selectable Main Trial for Ignition (MTFI) Time** - The default MTFI time is 10 seconds. Some No. 6 oil burners may require a 15 second MTFI to allow extra time for the cold oil to flow to the burner. Energizing terminal 27 changes the MTFI time from 10 seconds to 15 seconds.

**Pilot Test Mode** - In this mode, after the completion of PTFI, the ignition transformer is de-energized, the pilot valve remains energized, and the controller will not attempt to open the main fuel valves. If the flame sensor stops detecting a flame, the controller will lockout. This mode permits the technician to examine and adjust the pilot flame.

#### Specifications:

**Mechanical:** 7" L x 5" W x 2" D

**Weight:** 2 lbs

**Operating Temp:** -40° F to +140° F  
(-40° C to +60° C)

**Electrical:** UV scanners -20° C to 60° C,  
IR scanner -30° C to 65° C  
Voltage: 120 VAC +10% - 15%,  
50/60 Hz

**Power consumption:** 2 VA

**Flame Failure**

**Response Time:** 2.5 to 3.5 seconds

**Purge Time:** 30, 60, 90, 150, 180, 300, 450,  
or 900 seconds  
(DIP switch selectable)

**Pilot Trial for**

**Ignition Time:** 3, 5, or 10 seconds  
(DIP switch selectable)

#### Flame Sensor

**Inputs (2):** Infrared, Ultraviolet, Flame Rod

#### Controller Configuration:

Configuration of the controller is done by setting the DIP switches located under the LCD display.

DIP switch No. 1 sets the power-up response of the controller.

| Switch 1 |                                                                        |
|----------|------------------------------------------------------------------------|
| ON       | Controller locks out if power is interrupted after Trial for Ignition. |
| OFF      | Controller recycles if power is interrupted after Trial for Ignition.  |

DIP switches 2 through 4 set the purge timing.

DIP switches 5 and 6 set the desired Pilot Trial for Ignition (PTFI) time.

DIP switch 7 activates the Limits Bypassed check.

When DIP switch 7 is ON, the controller waits up to 60 seconds for the Limits Made input to de-energize. After 60 seconds, the control will lockout.

| Purge Timer Configuration |          |          |               |                |
|---------------------------|----------|----------|---------------|----------------|
| Switch 2                  | Switch 3 | Switch 4 | Purge Seconds | Explanation    |
| ON                        | ON       | ON       | 30            | 30 x 1 x 1 x 1 |
| OFF                       | ON       | ON       | 60            | 30 x 2 x 1 x 1 |
| ON                        | OFF      | ON       | 90            | 30 x 1 x 3 x 1 |
| ON                        | ON       | OFF      | 150           | 30 x 1 x 1 x 5 |
| OFF                       | OFF      | ON       | 180           | 30 x 2 x 3 x 1 |
| OFF                       | ON       | OFF      | 300           | 30 x 2 x 1 x 5 |
| ON                        | OFF      | OFF      | 450           | 30 x 1 x 3 x 5 |
| OFF                       | OFF      | OFF      | 900           | 30 x 2 x 3 x 5 |

# 5004-M-85 FLAME SAFEGUARD CONTROLLER

## System Overview

| Switch 5 | Switch 6 | Pilot Trial Seconds |
|----------|----------|---------------------|
| OFF      | OFF      | 3                   |
| ON       | OFF      | 5                   |
| ON       | ON       | 10                  |

| Switch 7 |                                                                                               |
|----------|-----------------------------------------------------------------------------------------------|
| ON       | Controller goes into Lockout if Limits Made input is energized when Start command is powered. |
| OFF      | Controller does not check to see if the Limits made input is powered at start-up.             |

When DIP switch 7 is OFF, the control will continue into purge even if the limits made input is energized when the start input is energized.

DIP switch 8 is used for configuring Modbus.

During normal operation: DIP Switch 8 MUST be OFF.

### Note:

After 4 hours of continuous operation, all current DIP switch settings will be recorded in non-volatile memory. Subsequent DIP switch changes will be ignored.

### Output Terminal Load Ratings:

Terminals 9 – 12

Modulation Sequencing:

2 A resistive

Terminals 18 – 19

Fan:

10 A resistive: ½ HP inductive

Terminal 21

Ignition Transformer:

10 A resistive, ¼ HP inductive

Terminal 22

Pilot Valve:

10 A resistive, ¼ HP inductive

Terminal 23

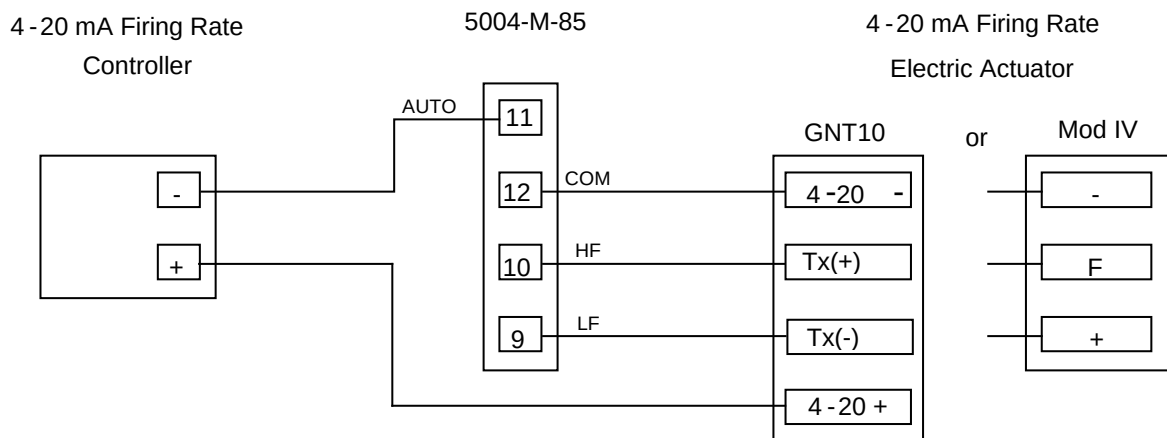
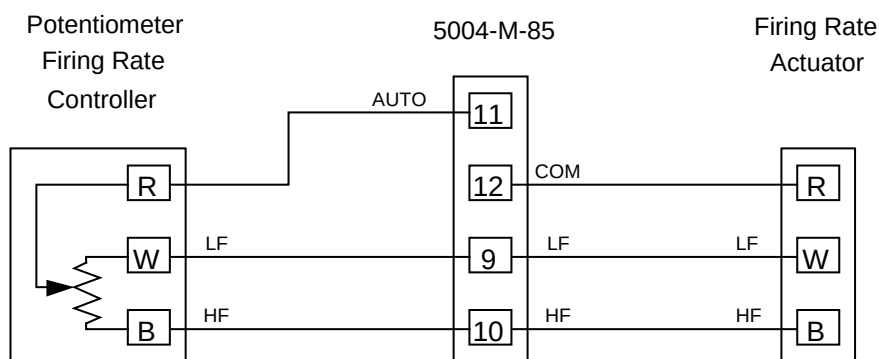
Main Fuel Valve:

10 A resistive, ¼ HP inductive

Terminal 29 – 30

Alarm Relay:

2 A resistive



5004-M-85 Wiring for 0-135 Ohm, and 4-20 mA Firing Rate Outputs

# 5004-M-85 FLAME SAFEGUARD CONTROLLER

## System Overview

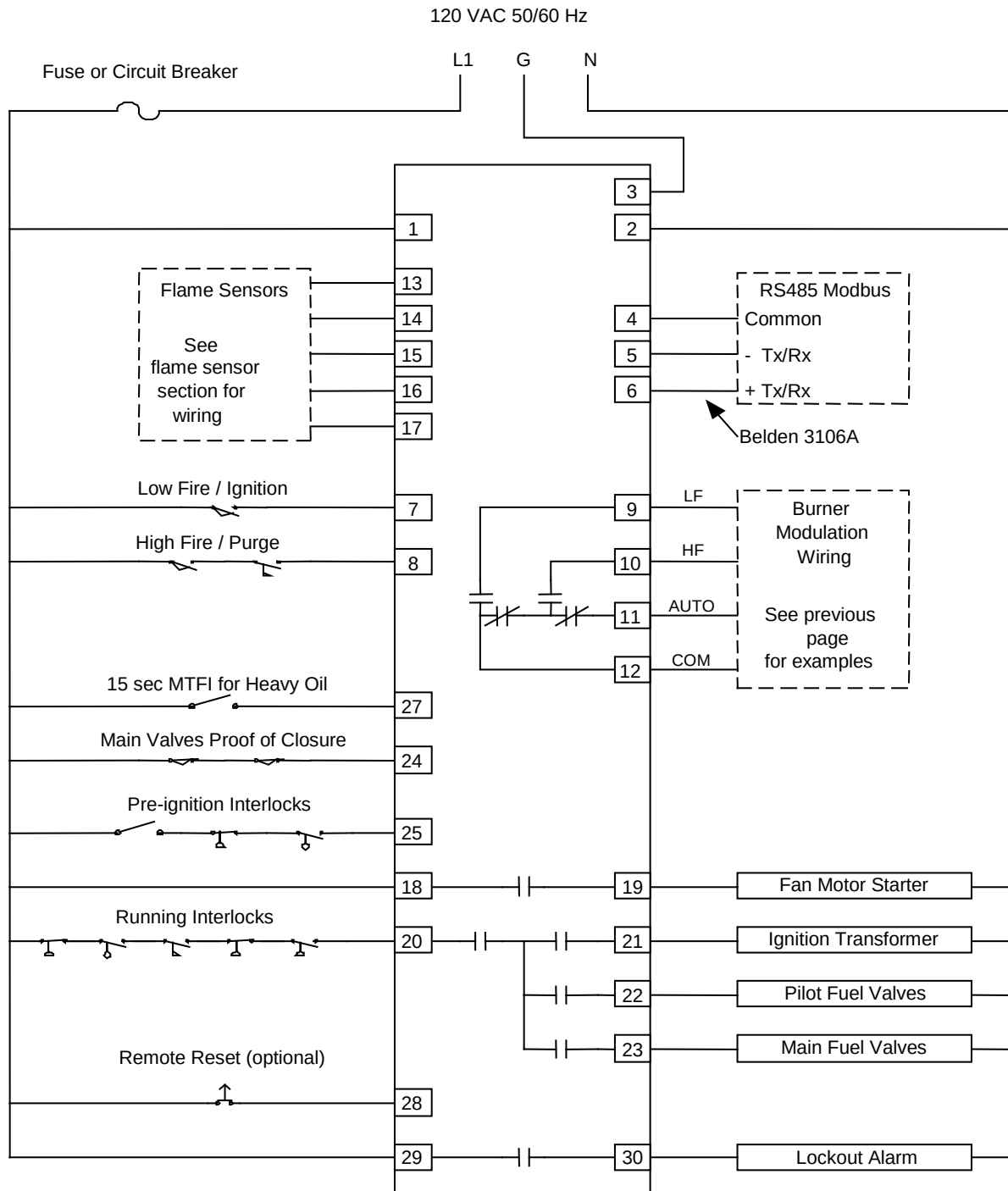
**Total connected 120 VAC load must not exceed 15 A.**

### Compatible Flame Sensors:

|                                |                 |
|--------------------------------|-----------------|
| Flame Rod                      |                 |
| Ultraviolet, non self-checking | Model 5004-01   |
| Infrared, non self-checking    | Model 5004-11   |
| Ultraviolet, non self-checking | Model 5002-01NC |
| Ultraviolet, self-checking     | Model 5002-01   |
| Infrared                       | Model 5002-11NC |

### Modbus Communications

The operation of the 5004-M-85 can be monitored via the RS485 Modbus communications link. Modbus also provides access to the Historical Data in the 5004-M-85: The last 6 Lockout reasons, burner run hours, and burner start cycles.



5004-M-85 External Wiring

## 5004-M-85 FLAME SAFEGUARD CONTROLLER

### Suggested Specification

#### Modbus Description:

Electrical: 2 Wire RS485 half-duplex,  
non-isolated  
Protocol: RTU  
Baud Rate: 4800  
Start Bits 1  
Stop Bits 1  
Data Bits 8  
Parity None  
Modbus Point Type: Holding Register (400xx  
series)  
Maximum Registers  
Requested/Poll 6  
Modbus Functions  
supported: Function 03: Read Multiple  
Holding Registers

#### Ordering Information

| Description                                                                                                                                                    | Catalog Number |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| <b>5004-M-85 Boiler FSG Controller</b>                                                                                                                         |                |
| FSG Controller w/ Integral Display. Universal UV, IR, UV Self-Check, and Flame Rod Input. DIP switch selectable purge, MTFI time, RS-485 Modbus Communications | 5004-M-85      |

#### Suggested Specification:

##### 1. Microprocessor Flame Safeguard Controller

Controller shall be U.L. recognized for single burner boiler applications. It shall accept inputs from one or two flame detectors without external circuitry. The controller shall be capable of accepting inputs from ultraviolet, infrared, self-checking ultraviolet, and flame rod detectors without changing controller hardware. purge timing, Pilot Trial for Ignition (PTFI) timing, and other control functions shall be DIP switch selectable.

##### 2. Flame Safeguard Controller Hardware

Controller and included flame amplifier circuitry shall be microprocessor-based and include the following as a minimum:

- Removable LCD display for status information and troubleshooting
- Optional remote display
- Sequence status LEDs on the controller faceplate including Start Limits (green), Fan On (yellow), Pilot (yellow), Main (yellow), Flame Fail (red), Safety Interlock (red), Alarm (red) Power (red), Flame (red), Low Fire (green), High Fire (red), Automatic (yellow)
- Plug-in field wiring terminals
- Test jacks for direct flame intensity measurement (0-5 VDC)

##### 3. Flame Safeguard Functions

The controller shall cycle the burner from standby, through purge, supervised Pilot Trial for Ignition, main flame trial for ignition

and release to modulate states. De-energization of pre-ignition interlocks, running interlocks, or loss of flame signal shall result in the safe shutdown of the burner. Additional control functions shall include:

- False Flame detection during Standby and Purge modes.
- Field selectable check for limits bypassed during startup.
- Field selectable Lockout or Recycle on loss of AC power.
- Field selectable Purge timing from 30 to 900 seconds (by DIP switch).
- Field selectable Pilot Trial for Ignition (PTFI) timing from 3 to 10 seconds (by DIP switch)
- Field selectable Main Trial for Ignition (MTFI) timing (by powering digital input)

##### 4. Digital Communication

The flame safeguard controller shall be capable of Modbus RTU communications via RS-485 bus.

##### 5. Manufacturer

The flame safeguard controller shall be model 5004-M-85 manufactured by Preferred Utilities Mfg. of Danbury, CT.



# 5004-M-78 FLAME SAFEGUARD REPLACEMENT CHASSIS

## Product Overview



Quanta-Flame 5004-M-78 Flame Safeguard

The **5004-M-78 Flame Safeguard Replacement Chassis** consists of the electronics of the 5004-M-85 flame safeguard controller, designed to mount into an existing Q7800A1005, Q7800B1003, or CB 780 (833-2725) wiring sub base. **It is a direct replacement for most RM7800E, RM7800L, and CB780 flame safeguard controllers.**

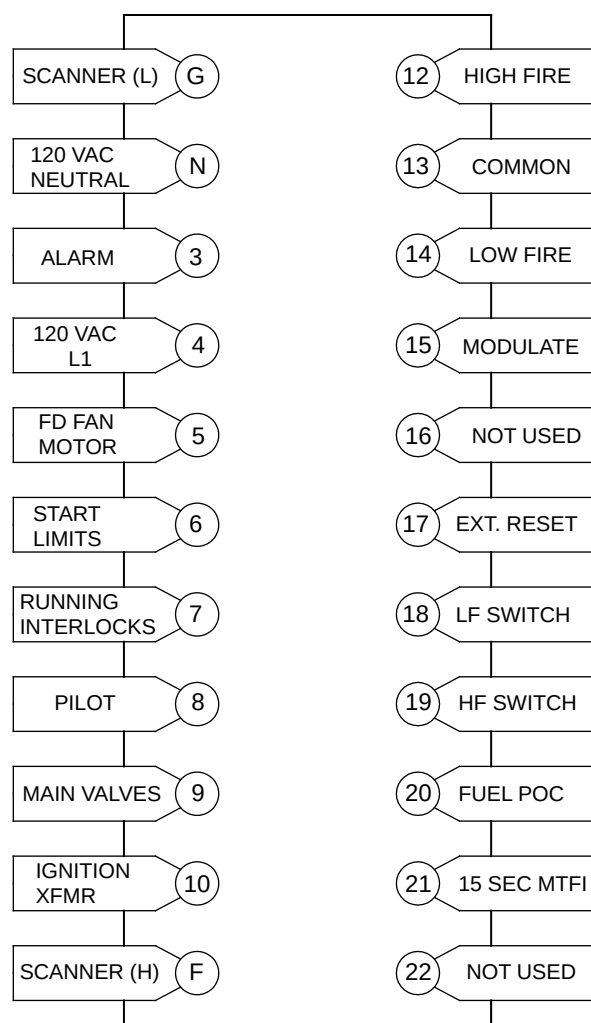
- Existing scanners can be reused or replaced with Preferred UV, IR, or UV self-checking scanners.

One model number (5004-M-78) replaces an existing:

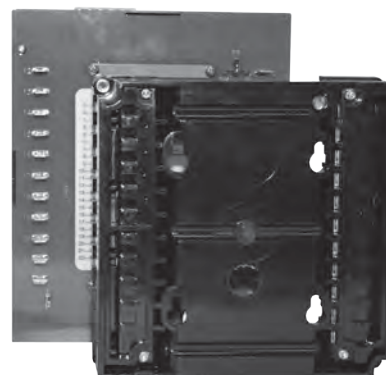
- Control chassis
- Display module
- Purge timer
- Flame amplifier

As with the 5004-M-85, the flame amplifier inputs are universal. Purge timing, PTFI timing, and other control functions are determined by DIP switch selection.

\*QA 5004-216 Remote Display (Optional)



5004-M-78 Chassis terminal designations



Rear view showing connector pins

## Ordering Information

| Description                                                                                                                                                                                                                                         | Catalog Number |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| <b>5004-M-78 Boiler FSG Controller</b>                                                                                                                                                                                                              |                |
| FSG Controller w/ Integral Display. Universal UV, IR, UV Self-Check, and Flame Rod Input. DIP switch selectable purge, PTFI time, RS-485 Modbus Communications. Fits Q7800A1005, Q7800B1003, and CB780 wiring sub bases. QA5004-216 remote display. | 5004-M-78      |

## 5004-M-110 QUANTA-FLAME PRIMARY CONTROL

### System Overview

The Quanta-Flame 5004-M-110 controller is a state-of-the-art microcomputer based Burner Management System designed for a single burner boiler or process heat application. An LCD display provides real-time diagnostic and status messages for the operator.

Unlike other flame safeguard controllers that require a variety of modules to make a complete system (programmers, flame amplifiers, displays, etc.) the Preferred Quanta-Flame 5004-M-110 has just one processor with a built-in universal amplifier that accepts UV, IR and Flame Rod inputs.

Service technicians can carry this one processor on their trucks and be equipped to replace a large number of existing flame safeguard controller combinations.



*Quanta-Flame Primary Control*

The 5004-M-110 mounts directly into an existing 60-1466-2 or 60-1386-2 wiring sub-base. The 5004-M-110 interfaces to the annunciator QA 5004-85 when additional annunciation is required. Existing flame sensors and scanners can be reused. An auxiliary connector is used for interface with Modbus communication or to provide a remote reset function.

*Quanta-Flame Primary Control Dimensions*

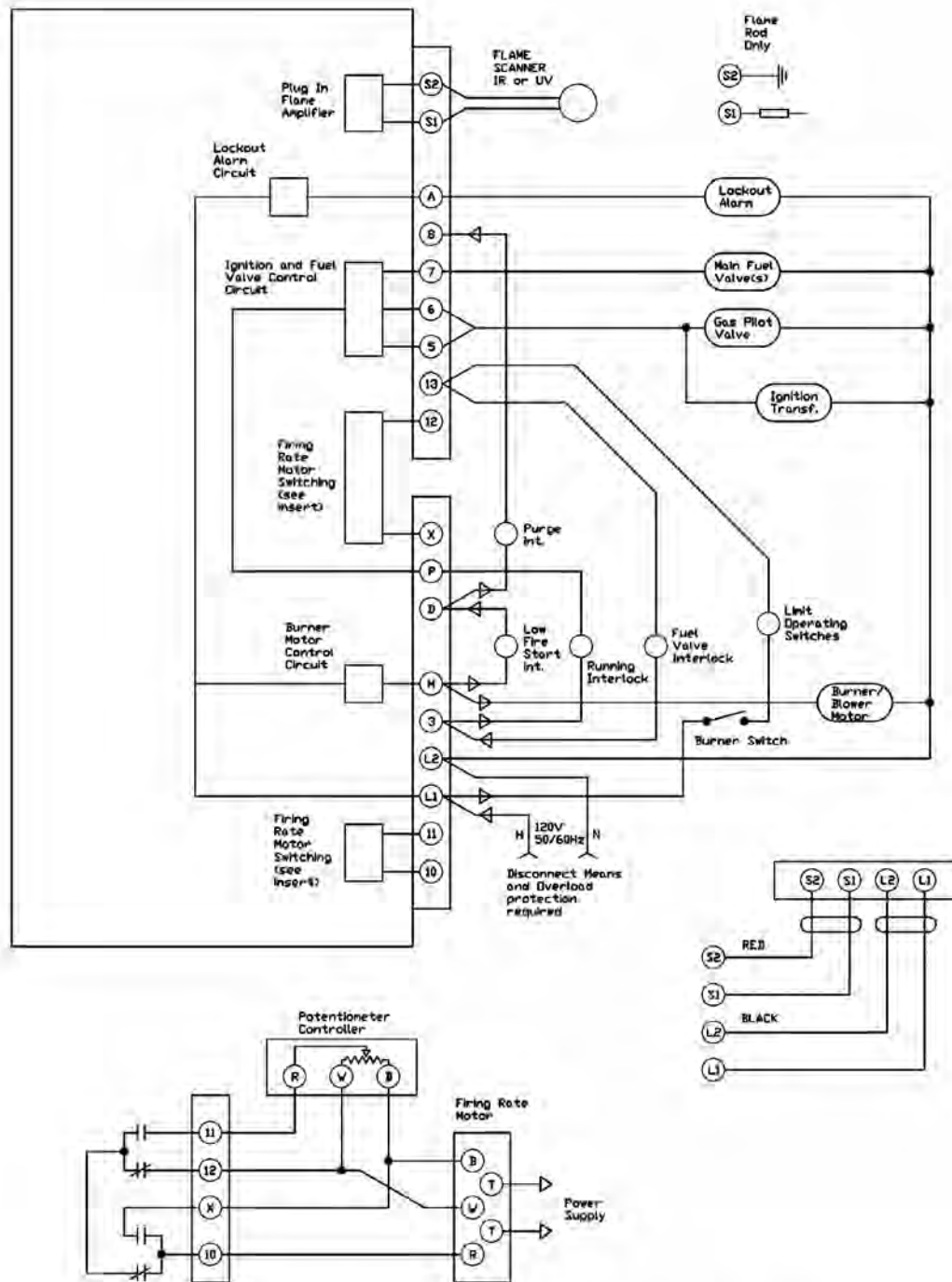
The 5004-M-110 replaces the following Fireye E110 combinations:  
E110 Flame monitor consisting of EB700 Chassis and EC600 Dust cover

#### E110 Compatibility:

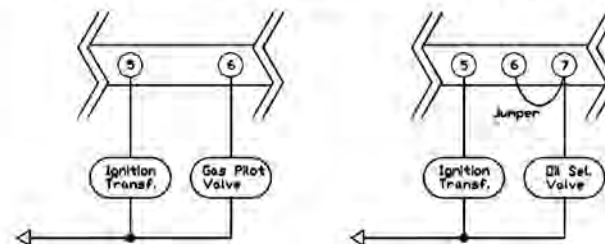
| Any of these Amplifiers  | Any of these Programmers |
|--------------------------|--------------------------|
| EUV1-Standard UV         | EP160                    |
| E1R1-Infrared            | EP161                    |
| E1R2-Infrared            | EP170                    |
| E1R3-Infrared            | EPD160                   |
| ERT1-Flame Rectification | EPD161                   |
|                          | EPD170                   |

# 5004-M-110 QUANTA-FLAME PRIMARY CONTROL

## System Overview



TYPICAL WIRING ARRANGEMENT FOR PILOT IGNITED BURNER



Quanta-Flame Primary Control Wiring Diagram

## 5004-795 FLAME SAFEGUARD CONTROLLER

### Product Overview

#### Description

The **Quanta-Flame 5004-795** is a state-of-the-art flame safeguard controller series designed for on-off single burner process heat applications. The controller sequences the burner through purge, ignition, Pilot Trial for Ignition, Main Trial for Ignition, and "run" modes. It monitors the burner flame and running interlocks to safely shut down the burner in the event of an unsafe operating condition.

- No re-wiring required when replacing an R4795 controller
- Operates with existing UV sensors and flame rods
- 5004-795A model automatically resets when power is restored after an interruption

The 5004-795 series controllers are a direct replacement for most Honeywell R4795 controls.

#### Controller Functions

The controller sequences the burner through purge, ignition, Pilot Trial for Ignition, Main Trial for Ignition, and "run" modes. It monitors the burner flame and running interlocks to safely shut down the burner in the event of an unsafe operating condition. LEDs are provided for status and diagnostics including: flame Proven, Limits Made, Combustion Air Present, Pilot Gas Valves Energized, Main Gas Valves Energized, Air Switch Fault, Flame Failure, Lockout, and Power.

#### Features Include

- Optional plug-in diagnostic display
- Microcomputer burner control
- DIP switch selectable purge time (30, 60, 150, 180, 300, 450) seconds
- Standard relay alarm contact
- Pilot test mode
- Selectable Trial for Ignition times (3, 5, 10, or 15) seconds
- Selectable Interrupted or Intermittent Pilot
- Selectable Recycle or Non-Recycle modes
- Every unit interfaces to ultraviolet or flame rod sensors
- Easy control panel mounting

#### Functional Summary

##### Recycle Mode

When selected, the control will recycle the burner through Purge and startup when the main burner has shutdown with a Flame Failure alarm. The recycling of the burner will only occur after the main burner has been in operation. There is no recycle on pilot flame failure.



Quanta-Flame 5004-795 Flame Safeguard Controller

#### Pilot Turndown Test Mode

Permits the pilot to ignite and remain burning regardless if Interrupted or Intermittent pilot has been selected. The main burner will not be ignited as long as the control is in this mode. This permits the service technician to adjust and inspect the pilot flame. To enter this mode hold the reset button down until the limit light begins to flash (10 seconds). To exit the pilot test mode press the reset button and the control will reset into the normal run mode.

#### Interrupted Pilot

The pilot will ignite and be turned off 10 seconds after the main burner valve is opened.

#### Intermittent (non-interrupted pilot)

The pilot will ignite and remain lit for the entire duration of the main burner run cycle.

#### Pilot Verification Feature

The ignitor will be de-energized 5 seconds before the main valve is energized to ensure the pilot flame is stable before lighting the main burner.

#### False Flame Indication

If the control senses a flame out of the proper sequence, the sequence will stop and wait for 30 seconds for the False Flame signal to disappear. During this time the Flame Fail light and the Alarm light will blink on and off. If the signal disappears the lights will cease blinking and the sequence will continue. If the False Flame signal is present for more than 30 seconds the lights will stay on continuously and the control will go into lockout.

#### Flame Signal Analog Meter Jacks

Two test probe inputs are located on the front of the control. By inserting the meter probes from a high impedance (100k ohm/volt) DC volt meter the control will indicate the relative flame signal level in the range of 0 to 5 VDC.



## 5004-795 FLAME SAFEGUARD CONTROLLER

### System Overview

#### Selectable Purge Time

The purge time is selectable by means of the selector switches located under the right hand cover of the control. The purge times selected by each switch (5 through 8) are added together for the total purge time. (For example, the maximum purge time is 7 + 10 + 30 + 60 seconds or 107 seconds).

#### Shorted Air Switch Check

The control verifies that the air switch is not shorted at each occurrence of control lockout. When the fan is de-energized during lockout the control will check to see if the air switch opens. If the air switch fails to open the "air fail" light will blink to indicate the air switch is still closed. This will alert the operator that the air switch is not functioning properly.

#### Air Failure

The control constantly monitors the airflow switch input. The input must be present before the purge time will begin. If the control loses the air switch input at some point in the burner cycle after the start of purge, the control will reset to the start of the purge cycle and wait for the air switch to close.

#### Control Reset

When the control enters a Lockout condition the red Alarm light will light and begin blinking. To reset the control press the "reset" button on the front of the control for three seconds. The control will not reset on power interruption. lockout conditions for the control are:

- Flame failure
- False flame present for more that 30 seconds
- Relay failure and internal fault



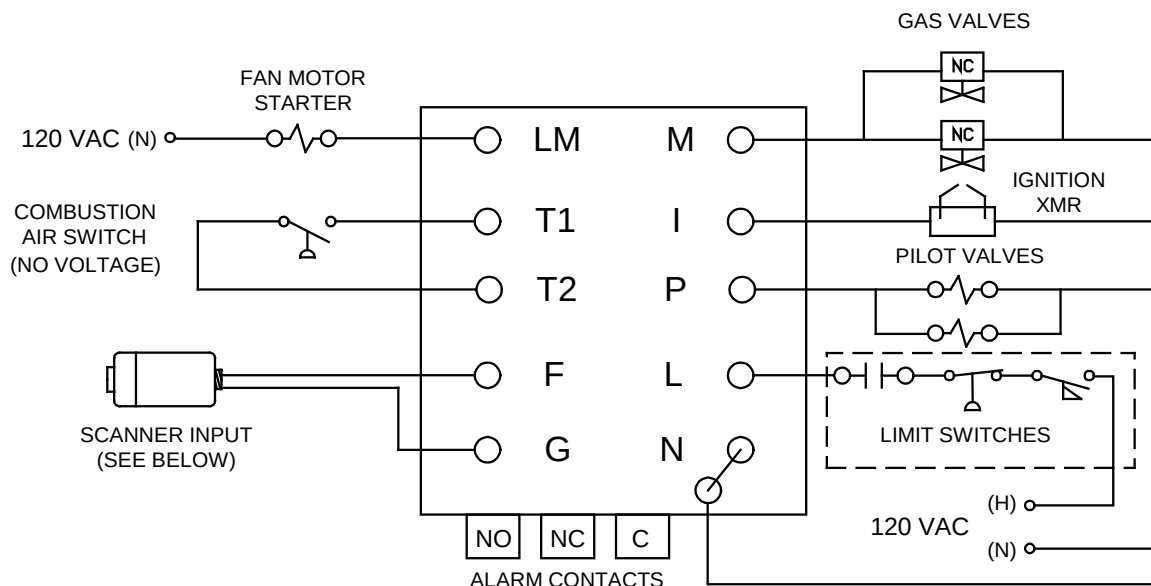
5004-216RN Flush-Mount Remote Display

#### Remote Display

The optional 5004-216RN display is a panel mounted display for the 5004 Series Quanta-Flame Controls. It mounts in a control panel through a 1/8 DIN mounting hole and is secured with the included mounting clips.

During operation the display will indicate each step in the control sequence. When the main burner is in the run mode the flame signal level will be indicated in a range of 0 to 5 VDC.

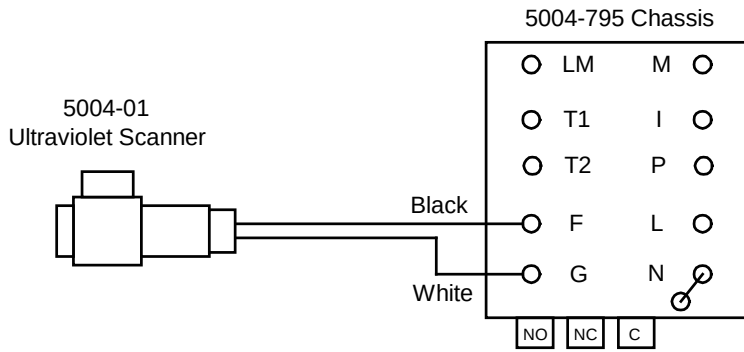
The display constantly refreshes itself with new information from the control. This refreshing is indicated by the slight periodic blink of the messages.



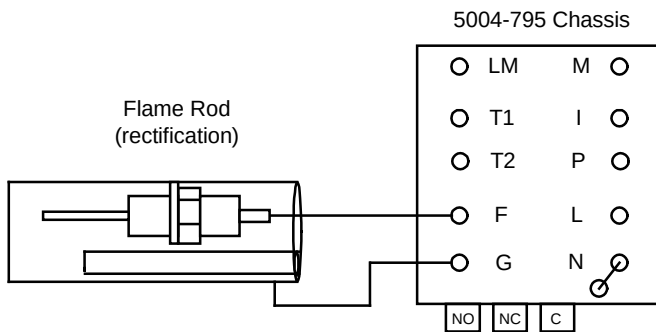
Typical 5004-795 Series Wiring Schematic.

# 5004-795 FLAME SAFEGUARD CONTROLLER

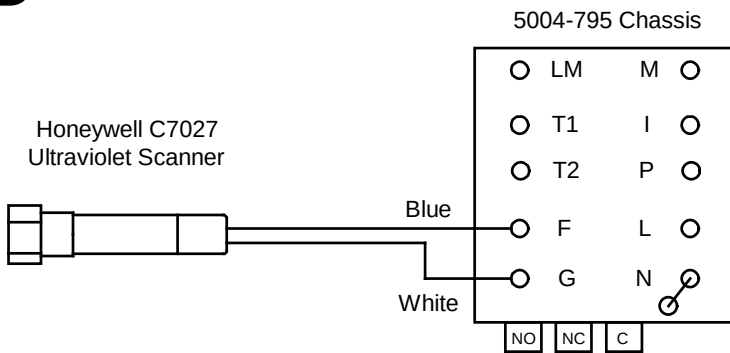
## System Overview



Scanner Wiring for 5004-01 Flame Scanners



Flame Rod Wiring for 5004-795 Flame Safeguard Controller



Scanner Wiring for Honeywell Flame Scanners

### Controller Inputs:

#### Power (Terminal L)

Input that receives all the permissives and the burner start signal switch or contact

#### Neutral (Terminal N)

Grounded neutral connection to control.

#### Air Switch (Terminals T1 & T2)

Input is connected to the combustion airflow switch. This must be a dry contact. No voltage can be applied to these terminals. Voltage applied to these terminals will damage control and void the warranty

#### Flame Sensor (Terminals F & G)

Sensor inputs:

Flame rod connects to Terminal F

UV sensor connects to F & G. (see wiring schematics)

### Outputs

#### Combustion Fan (Terminal LM)

Output to energize the burner combustion fan.

#### Pilot (Terminal P)

Output to energize the burner pilot valve.

#### Ignition (Terminal I)

Output to energize the ignition transformer.

#### Main (Terminal M)

Output to energize the burner main valve.

#### Alarm (NO, NC, C)

This is a dry contact output, which closes when an alarm condition occurs. (rated up to 230 VAC, 2 A max)

### Product Certifications:

#### UL Recognized:

File No. E233069

#### CSA Certified:

Number 204571-1435343

## 5004-795 FLAME SAFEGUARD CONTROLLER

### System Overview

#### Controller Specifications:

##### Mechanical

**Enclosure:** 5" H by 5" W by 1 3/4" D  
**Shipping Weight:** 2 lbs. for all models  
**Area Classification:** NEMA 1  
**Temperature Range:** 0°F to +140°F (-40°C to +60°C)

##### Electrical

**Voltage:** 120 VAC 50/60Hz

**Power Consumption:** 2 VA

##### Load Ratings

**(pilot & main):** 10 A (1/4 HP inductive)

**Fan Output** 15 A (1/3 HP inductive)

**Total Connected Load:** 15 A (1800 VA)

**Alarm Contact:** 230 VAC, 2 A maximum

#### Optional Panel-Mounted Display

The optional 5004-216RN display is a panel-mounted display for the 5004 Series Quanta-Flame Controls. It mounts in a control panel through a 1/8 DIN mounting hole and is secured with the included mounting clips.

During operation the display will indicate each step in the control sequence. When the main burner is in the "run" mode the flame signal level will be indicated in a range of 0 to 5 VDC.

#### Ordering Information

| Description                                                                                                                                                                           | Catalog Number  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>5004-795 "Purge" Controller (Replaces HW R4795 Controllers)</b>                                                                                                                    |                 |
| UV scanner or flame rod input. Purge and TFI time selectable                                                                                                                          | 5004-795-0-0-00 |
| UV scanner or flame rod input. Purge and TFI time selectable; Automatic Reset (w/new controller only)                                                                                 | 5004-795-0-A-00 |
| UV scanner or flame rod input. Purge and TFI time selectable; Historical Alarm Log (last 16 alarm events) Requires optional 5004-216 display                                          | 5004-795-0-0-LG |
| UV scanner or flame rod input. Purge and TFI time selectable; Automatic Reset (w/new controller only); Historical Alarm Log (last 16 alarm events) Requires optional 5004-216 display | 5004-795-0-A-LG |

#### Suggested Specification:

1. Microprocessor Flame Safeguard Controller  
Controller shall be U.L. recognized and CSA certified for single burner boiler applications. The controller shall be a plug-in replacement for Honeywell R4795 controllers. The controller shall be capable of accepting inputs from ultraviolet, self-checking ultraviolet, and flame rod detectors without changing controller hardware. Pilot Trial for Ignition (PTFI) timing, and other control functions shall be DIP switch selectable.

##### 2. Flame Safeguard Controller Hardware

Controller and included flame amplifier circuitry shall be microprocessor-based and include the following as a minimum:

- Removable LCD display for status information and troubleshooting information.
- Optional remote display
- Sequence status LEDs on the controller faceplate including:

The display constantly refreshes itself with new information from the control. This refreshing is indicated by the slight periodic blink of the messages.

During the "trial for ignition" period the display may show a blank line across the top row. This indicates the presence of an electrical noise field generated by the ignition circuit. This in no way affects the display or the control. The display will revert to the proper message when the electrical noise ends.

#### Display Specifications:

##### Mechanical

**Enclosure:** 1 3/4" H by 3 1/2" L by 3" D  
(1/8th DIN)

**Area Classification:** NEMA Type 4 Membrane Front

**Electrical Supply:** 120 VAC 50/60 Hz

**Power consumption:** 2 VA

**Output:** Relay reset contact (15 A),  
communication cable to 5004  
control

**Environmental:** Temperature: 0° F to 140° F  
(-20° C to +60° C).

## 5004-890 FLAME SAFEGUARD CONTROLLER

### Product Overview

The **Quanta-Flame 5004-890** is a state-of-the-art flame safeguard controller series designed for on-off single burner process heat applications. The controller sequences the burner through Ignition, Pilot Trial for Ignition, and Main Flame Trial for Ignition. The primary difference between these controllers and the 5004-795 series controllers is the 890 series controllers lack blower motor terminals. The 5004-890 series controllers monitor the burner flame and running interlocks to safely shut down the burner in the event of an unsafe operating condition.

The 5004-890 controllers are direct replacements for most Honeywell RA890 controls. They operate with the existing Q270 wiring bases, C7027A UV scanners or flame rods.

- No re-wiring required when replacing an RA890 controller.
- Operates with existing UV sensors and flame rods.
- 5004-890A model resets automatically when power is restored to the controller after an interruption.
- 5004-890S model supports a standing pilot. (Pilot remains on continuously.)

The 5004-890 replaces the following models of Honeywell controls:

- RA890F-1288
- RA890G-1260
- RA890F-1031
- RA890G-1047
- RA890F-1056
- RA890G-1062
- RA890F-1072
- RA890G-1112
- RA890G-1120
- RA890G-1179
- RA890G-1187
- RA890F-1262
- RA890F-1437
- RA890F-1510

### Controller Functions

The controller sequences the burner through purge, ignition, pilot, and main flame. It monitors the burner flame and running interlocks to safely shut down the burner in the event of an unsafe operating condition.

### Features include:

- Optional plug in diagnostic display
- Microcomputer burner control
- Standard relay alarm contact
- Pilot Test Mode
- Selectable Trial for Ignition times (3, 5, 10, or 15)
- Selectable Interrupted or Intermittent Pilot
- Selectable Recycle or Non-Recycle modes
- Every unit interfaces to ultraviolet or flame rod sensors



*Quanta-Flame 5004-890 Flame Safeguard Controller*



### Functional Summary

#### Recycle Mode

When selected, the control will recycle the burner through Purge and startup when the main burner has shutdown with a flame failure alarm. The recycling of the burner will only occur after the main burner has been in operation. There is no recycle on pilot flame failure.

#### Pilot Turndown Test Mode

Permits the pilot to ignite and remain burning regardless if interrupted or intermittent pilot has been selected. The main burner will not be ignited as long as the control is in this mode. This permits the service technician to adjust and inspect the pilot flame.

#### Interrupted Pilot

The pilot will ignite and be turned off 10 seconds after the main burner valve is opened.

#### Intermittent (non-interrupted) Pilot

The pilot will ignite and remain lit for the entire duration of the main burner run cycle.

#### Pilot Verification Feature

The ignitor will be de-energized 5 seconds before the main valve is energized to ensure the pilot flame is stable before lighting the main burner.

#### False Flame Indication

If the control senses a flame out of the proper sequence, the sequence will stop and wait for 30 seconds for the false flame signal to disappear. During this time, the flame fail light and the alarm light will blink on and off. If the signal disappears, the lights will cease blinking, and the sequence will continue. If the false flame signal is present for more than 30 seconds, the lights will stay on and stop blinking, and the control will go into lockout.



# 5004-890 FLAME SAFEGUARD CONTROLLER

## System Overview

### Flame Signal Analog Meter Jacks

Two test probe inputs are located on the front of the control. By inserting the meter probes from a high impedance (100k ohm/volt) DC volt meter the control will indicate the relative flame signal level in the range of 0 to 5 VDC.

### Control Reset

When the control enters a Lockout condition the red Alarm light will light and begin blinking. To reset the control, press the "reset" button on the front of the control. The control will not reset on power interruption. Lockout conditions for the control are:

- Flame failure
- False flame present for more than 30 seconds
- Relay failure and internal fault

### Product Certifications:

**UL Recognized:** File No. E233069

**CSA Certified:** Number 204571-1435343

### Controller Specifications:

#### Mechanical

**Enclosure:** 5" H by 5" W by 1 3/4" D

**Shipping Weight:** 2 lbs. for all models

**Area Classification:** NEMA 1

**Temperature Range:** 0° F to +140° F  
(-40° C to +60° C)

### Electrical

**Voltage:** 120 VAC 50/60Hz

**Power Consumption:** 2 VA

#### Load Ratings

**(pilot & main):** 10 A (1/4 HP inductive)

**Total Connected Load:** 15 A (1800 VA)

**Alarm Contact:** 230 VAC, 2 A maximum

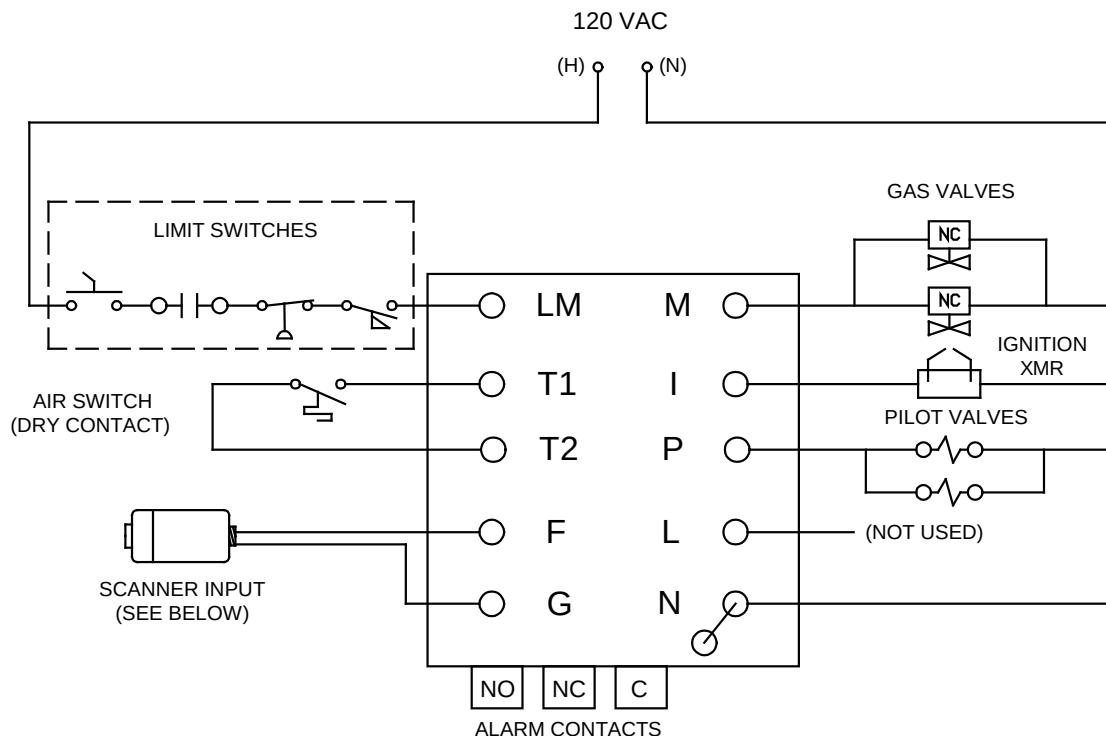
### Optional Panel-Mounted Display

The optional 5004-216RN display is a panel-mounted display for the 5004 Series Quanta-Flame Controls. It mounts in a control panel through a 1/8 DIN mounting hole and is secured with the included mounting clips.

During operation the display will indicate each step in the control sequence. When the main burner is in the run mode the flame signal level will be indicated in a range of 0 to 5 VDC.

The display constantly refreshes itself with new information from the control. This refreshing is indicated by the slight periodic blink of the messages.

During the "trial for ignition" period the display may show a blank line across the top row. This indicates the presence of an electrical noise field generated by the ignition circuit. This in no way affects the display or the control. The display will revert to the proper message when the electrical noise ends.



Typical 5004-890 Wiring Schematic.

# 5004-890 FLAME SAFEGUARD CONTROLLER

## System Overview



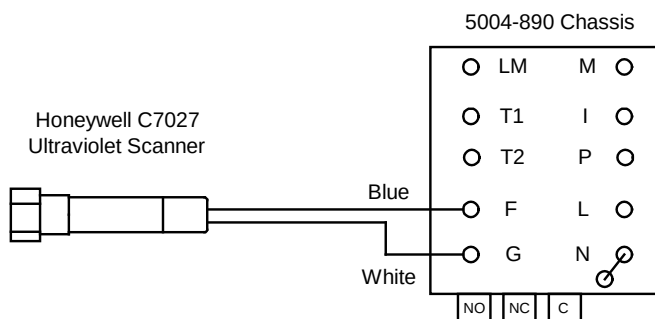
Optional 5004-216RN Flush-Mount Remote Display



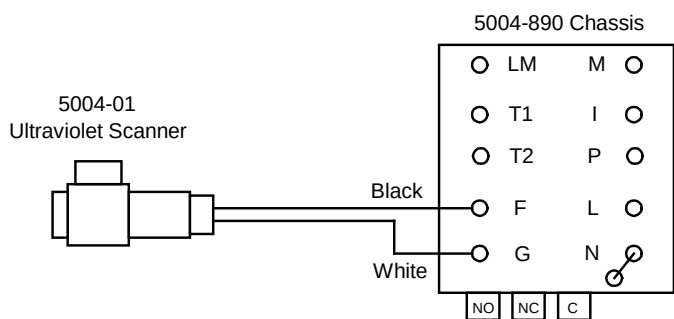
Rear View of 5004-216RN shows remote reset terminal block, 12-pin connection display cable connect, and power input terminal block



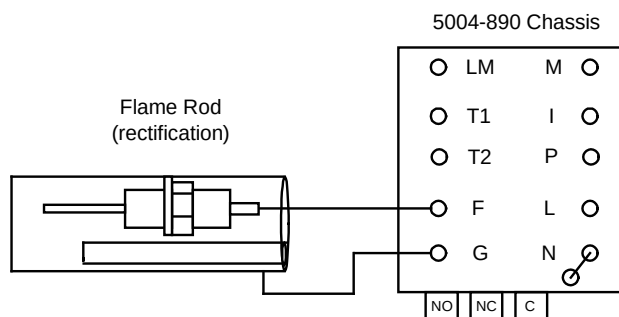
Optional Control Connector and Display Cable Attached to 5004-890 chassis



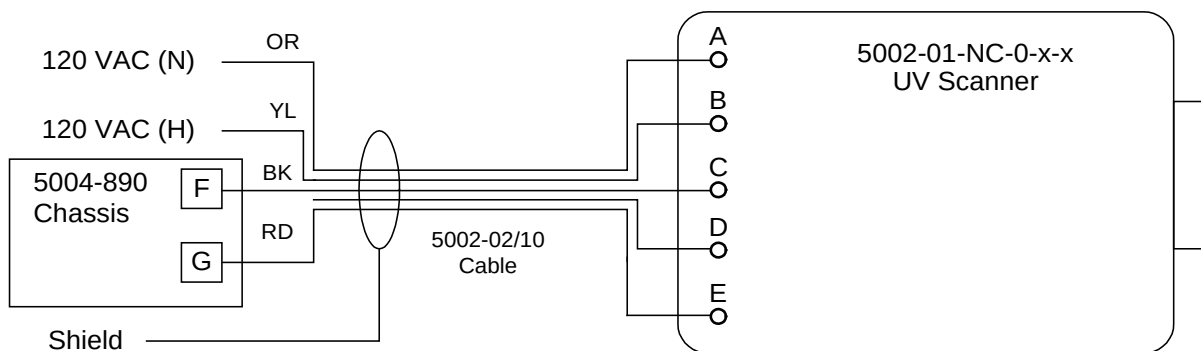
Scanner Wiring for Honeywell Flame Scanners



Scanner Wiring for 5004-01 Flame Scanners



Flame Rod Wiring for 5004-890 Flame Safeguard Controller



Scanner Wiring for 5002-01-NC UV scanner to 5004-890 Flame Safeguard Controller

## 5004-890 FLAME SAFEGUARD CONTROLLER

### Ordering Information

#### Controller Inputs:

##### Power (Terminal L)

Input that receives all the permissives and the burner start signal switch or contact

##### Neutral (Terminal N)

Grounded neutral connection to control.

##### Air Switch (Terminals T1 & T2)

Input is connected to the combustion airflow switch. This must be a dry contact. No voltage can be applied to these terminals. Voltage applied to these terminals will damage control and void the warranty

##### Flame Sensor (Terminals F & G)

Sensor inputs:

Flame rod connects to Terminal F

UV sensor connects to F & G. (see wiring schematics)

#### Controller Outputs:

##### Pilot (Terminal P)

Output to energize the burner pilot valve.

##### Ignition (Terminal I)

Output to energize the ignition transformer.

##### Main (Terminal M)

Output to energize the burner main valve.

##### Alarm (NO, NC, C)

This is a dry contact output, which closes when an alarm condition occurs. (rated up to 230 VAC, 2 A max)

#### Display Specifications (Model 5004-216RN):

##### Mechanical

##### Enclosure:

1¾" H by 3½" L by 3" D (1/8th DIN)

##### Area Classification:

NEMA Type 4 Membrane Front

##### Electrical Supply:

120 VAC 50/60 Hz

##### Power consumption:

2 VA

##### Output:

Relay reset contact (15 A), communication cable to 5004 control

##### Environmental:

Temperature: 0° F to 140° F  
(-20° C to +60° C).

### Ordering Information

| Description                                                                                                                                                                                                           | Catalog Number  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>5004-890 "No-Purge" Controller (Replaces HW RA-890F &amp; G Controllers)</b>                                                                                                                                       |                 |
| UV scanner or flame rod input. Purge and TFI time selectable                                                                                                                                                          | 5004-890-0-0-00 |
| UV scanner or flame rod input. Purge and TFI time selectable; Automatic Reset (w/new controller only)                                                                                                                 | 5004-890-0-A-00 |
| UV scanner or flame rod input. Purge and TFI time selectable; Standing Pilot (Only available with a flame rod sensor. Not available with UV detection. Not field selectable)                                          | 5004-890-S-0-00 |
| UV scanner or flame rod input. Purge and TFI time selectable; Automatic Reset (w/new controller only); Standing Pilot (Only available with a flame rod sensor. Not available with UV detection. Not field selectable) | 5004-890-S-A-00 |

## 5004-890 FLAME SAFEGUARD CONTROLLER

### Suggested Specification

#### Ordering Information (Flame Safeguard Controller Accessories)

| Description                                                                                   | Catalog Number  |
|-----------------------------------------------------------------------------------------------|-----------------|
| Wiring base for model 5004-890, 5004-795                                                      | 5004-270        |
| Plug in display for the 5004 series controls                                                  | 5004-216        |
| Remote Display package - Remote Display,Interface & 6 foot Cable                              | 5004-216-R      |
| Remote Display package - Remote Display with NEMA 4 front membrane, Interface, & 6 foot Cable | 5004-216-RN     |
| Tester & Demonstrator for 5004-890 & 5004-795                                                 | 5004-890-Tester |
| Remote Display for Data Acquisition Module                                                    | QD485           |

#### Suggested Specification:

##### 1. Microprocessor Flame Safeguard Controller

Controller shall be U.L. recognized and CSA certified for single burner boiler applications. The controller shall be a plug-in replacement for Honeywell RA890F and RA890G controllers. The controller shall be capable of accepting inputs from ultraviolet, self-checking ultraviolet, and flame rod detectors without changing controller hardware. Pilot Trial for Ignition (PTFI) timing, and other control functions shall be DIP switch selectable.

##### 2. Flame Safeguard Controller Hardware

Controller and included flame amplifier circuitry shall be microprocessor-based and include the following as a minimum:

- Removable LCD display for status information and troubleshooting information.
- Optional remote display
- Sequence status LEDs on the controller faceplate including: limits made(green), pilot (yellow), main (yellow), flame fail (red), alarm (red) power (red), flame (red),
- Test jacks for direct flame intensity measurement (0-5 VDC)

##### 3. Flame Safeguard Functions

The controller shall cycle the burner from standby, supervised

Pilot Trial for Ignition, Main Flame Trial for Ignition and main flame. De-energization of pre-ignition interlocks, running interlocks, or loss of flame signal shall result in the safe shutdown of the burner.

##### 4. Manufacturer

The flame safeguard controller shall be model 5004-890 manufactured by Preferred Utilities Mfg. of Danbury, CT.



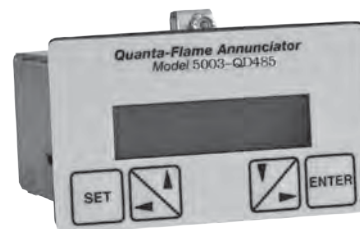
# QUANTA-MAX MULTIPLE BURNER FLAME INPUT MODULE

## System Overview

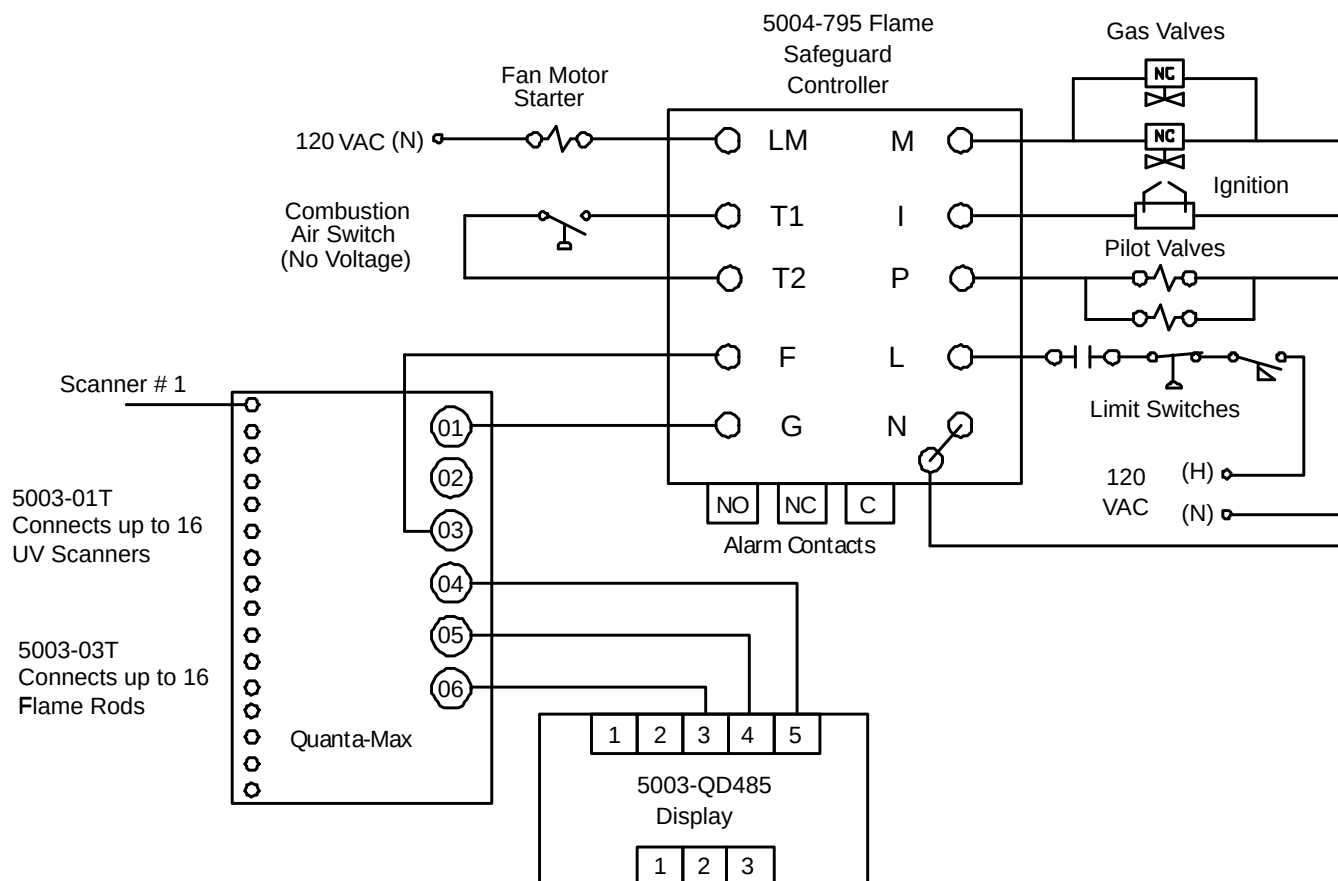
The **Quanta-Max Multiple Burner Input Module** is an economical way to monitor the flame inputs from up to 16 burners, outputting to one single burner flame safeguard system. This system is ideal for ovens, kilns, cabin heaters, and other furnaces that have multiple burners, but just one fuel header safety shutoff valve. This system is not appropriate for boilers because NFPA 85 requires individual burner safety shutoff valves for multiple burner boilers.

### Quanta-Max Features

- Multiple burner system monitors up to 16 burners when used with a 5004-795 controller
- Model 5003-01T accepts UV scanners
- Model 5003-03T accepts flame rod sensors
- Accepts Honeywell, Fireye, Eclipse, PCI, or Preferred flame scanners
- RS-485 Communication Interface
- Display each sensor flame level (with LCD display)
- Burner sequence and alarm display
- Isolated 5 Amp relay alarm contact.
- Optional History Logging of previous shutdowns
- Built-in 120 VAC 50/60 Hz supply
- Small panel space requirements
- Ideal for PLC-based flame safeguard systems



Quanta-Max and QD485 Display



Typical Quanta-Max Wiring Schematic.

Note the flame scanner inputs are universal, and the flame output signal works with most flame safeguard controllers.

# QUANTA-MAX MULTIPLE BURNER FLAME INPUT MODULE

## Suggested Specification

The Quanta-Max system provides individual scanner flame intensity, as well as first-out annunciation of which flame signal went below the adjustable threshold first. Number of flame sensors, flame detection thresholds, and other control functions are determined by DIP switch settings.

Historical trending is provided for the last 16 alarm occurrences. Alarms, first-outs, and other information is available remotely through the RS-232 interface.

### Quanta-Max Specifications

#### Mechanical:

**Enclosure:** 5 7/8" H x 4 3/8" W x 1 5/8" D

#### Electrical

#### Transmitter Unit

**Voltage:** 120 VAC 50/60 Hz (Standard),  
Power consumption: 2 VA  
220 VAC 50/60 Hz (Model Available)

#### Inputs

**5003-01T:** UV Sensor Input (2-wires)  
PCI, Eclipse, Honeywell, Fireye  
**5003-03T:** Flame Rod (1 wire each)- common ground  
**Relay:** Dry contact

#### Receiver Unit

**Voltage:** 120 VAC 50/60 Hz  
220 VAC 50/60 Hz (Model Available)

#### Outputs

**5003-01T:** UV output  
**5003-03T:** Flame Rod output  
Both models have supervised dry contact (5 A)

### Ordering Information

| Description                                                    | Catalog Number  |
|----------------------------------------------------------------|-----------------|
| Four (4) UV Scanner inputs                                     | 5003-01-OT-04-x |
| Four (4) UV Scanner inputs & Four (4) contact closure outputs  | 5003-01-RT-04-x |
| Eight (8) UV Scanner inputs                                    | 5003-01-OT-08-x |
| Eight (8) UV Scanner inputs Eight (8) contact closure outputs  | 5003-01-RT-08-x |
| Sixteen (16) UV Scanner inputs                                 | 5003-01-OT-16-x |
| Four (4) Flame Rod inputs                                      | 5003-03-OT-04-x |
| Four (4) Flame Rod inputs & Four (4) contact closure outputs   | 5003-03-RT-04-x |
| Eight (8) Flame Rod inputs                                     | 5003-03-OT-08-x |
| Eight (8) Flame Rod inputs & Eight (8) contact closure outputs | 5003-03-RT-08-x |
| Sixteen (16) Flame Rod inputs                                  | 5003-03-OT-16-x |

"x" Suffix: H - Honeywell C7027A-104  
P - PCI PC II  
G - GN Electronics/Preferred (any)  
F - Fireye UV-1A

### Suggested Specification:

#### 1. Multiple Burner Flame Input Module

System shall be capable of monitoring up to 16 flame scanner inputs and providing a single output signal to a separate flame safeguard controller. Input module shall accept flame scanner inputs from a variety of manufacturers and interface with varying flame safeguard controllers. Individual flame signal strength shall be indicated, and first-out annunciation shall be provided to determine which flame signal first fell below adjustable threshold levels.

#### 2. Operation

System shall accept UV or flame rods signals from all major scanner manufacturers. The number of flame signals connected, and their trip thresholds shall be DIP switch programmable. The

control shall interface with a separate 2 x 16 character LCD display, and provide a single "flame proven" signal to a separate flame safeguard controller. Flame proven logic shall be customizable per the application--programmed at the factory. Historical trending of the last 16 alarm conditions shall be provided.

#### 3. Manufacturer

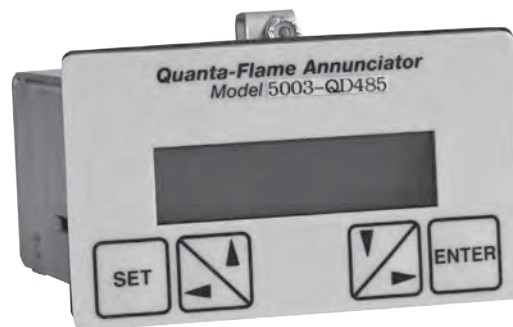
Flame input module shall be Preferred Utilities Mfg. of Danbury, CT, Quanta-Max system model number 5003-01T (UV sensors) or 5003-03T (flame rods). LCD display shall be Preferred Instruments QD485. Flame safeguard controller, if required, shall be 5004-890, 5004-795, or 5004-M series.

# QA-16 DATA ACQUISITION SYSTEM

## System Overview



QA-16 Annunciator Module



QD485 Remote Display

### Description

The **QA-16** is an inexpensive 16-point data acquisition system for use on single burner, and small multiple burner combustion systems. Two versions of the controller are made--the QA-16 has 8 discrete (120 VAC) inputs and 8 analog (0 to 12 VDC) inputs. The QA-16D version has 16 discrete inputs and no analog inputs. The QA-16 interfaces with the QD485 LCD display to provide programmable, customized status, diagnostic, and troubleshooting messages. Two QA-16 processors can be combined to double the amount of available I/O.

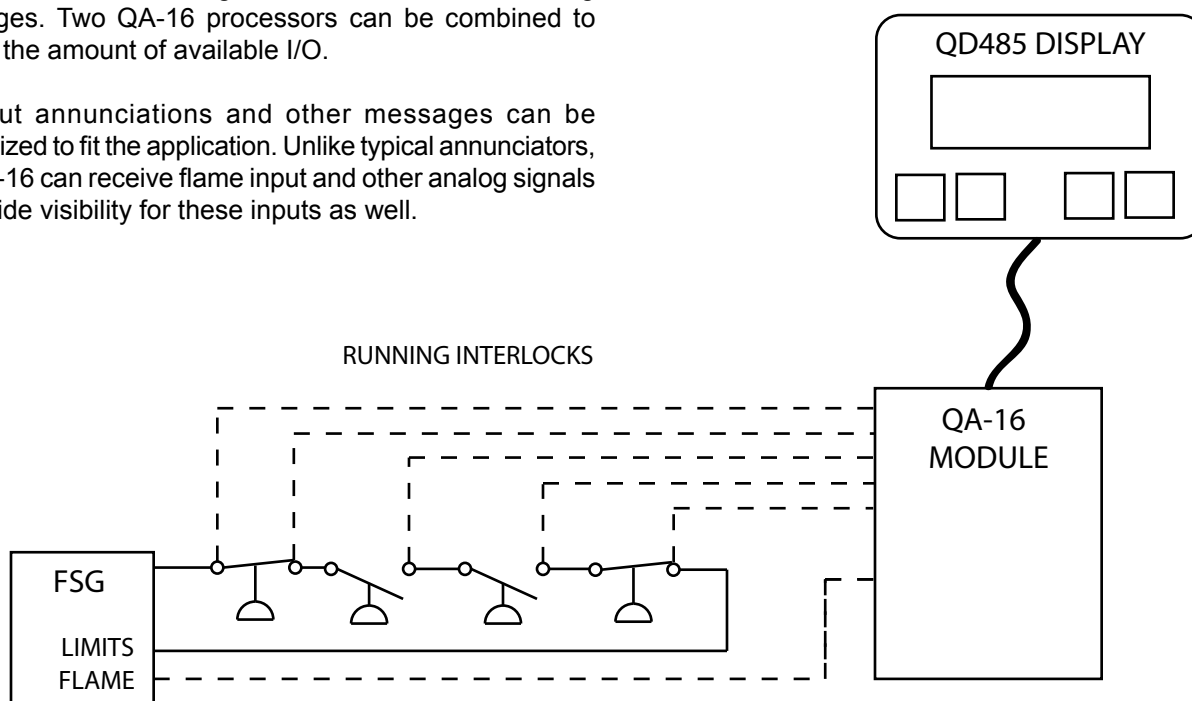
First-out annunciations and other messages can be customized to fit the application. Unlike typical annunciators, the QA-16 can receive flame input and other analog signals to provide visibility for these inputs as well.

### The QD485 Display Features

- 2x16 segment back-lit display with NEMA 4 membrane front and sealing gasket
- Optional History Logging of past Alarm occurrences
- Optional RS485 communication Interface
- Non-volatile memory (keeps settings for 10 years)
- Operator interface key pad on front of unit
- 1/8th DIN standard size for easy mounting in control panels
- Built-in 120 VAC 50/60 Hz supply

### The QA-16 Features

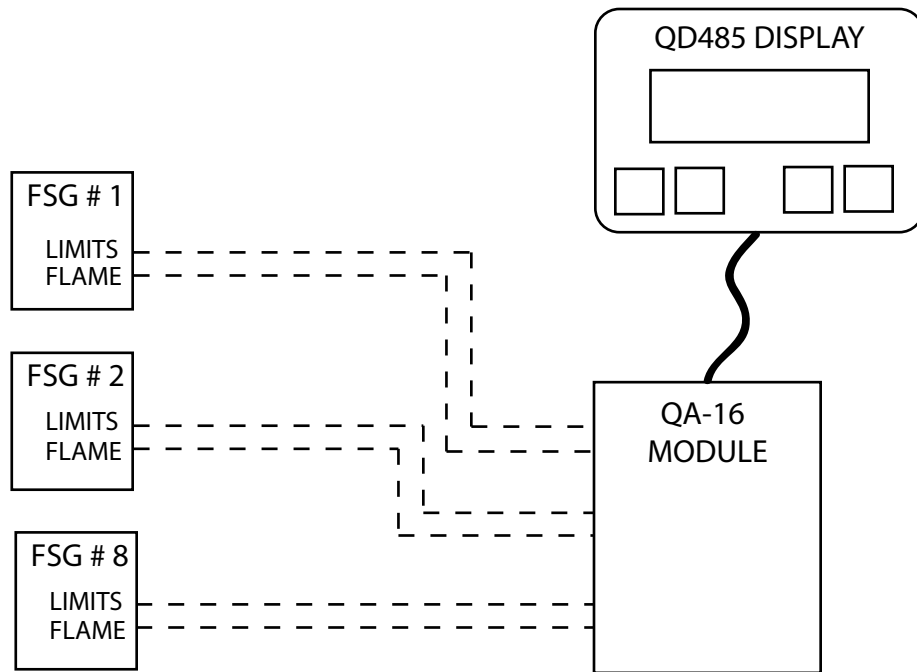
- Digital annunciation of up to 8 discrete inputs and 8 analog inputs (QA-16) or 16 discrete inputs only (QA-16D).



Typical QA-16 Configuration for a Single Burner Application

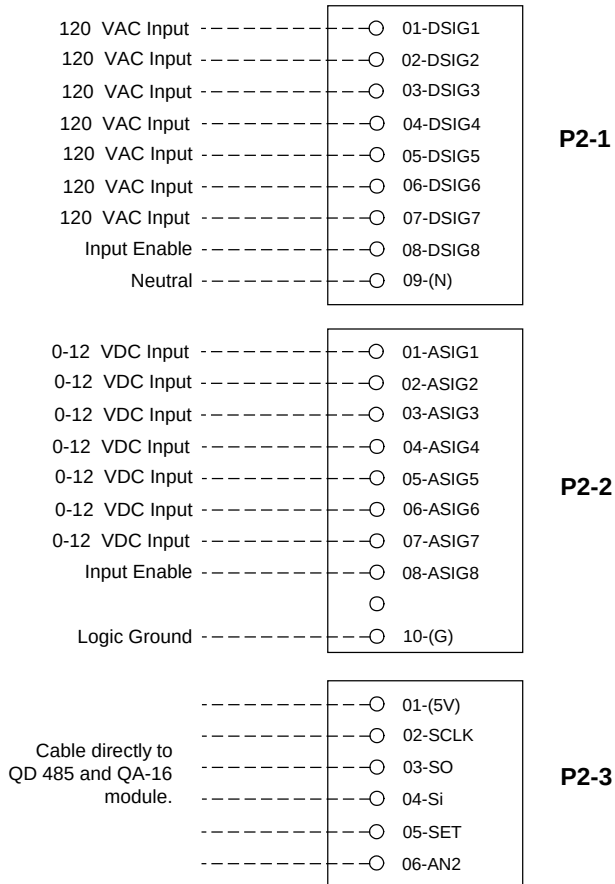
# QA-16 DATA ACQUISITION SYSTEM

## System Overview



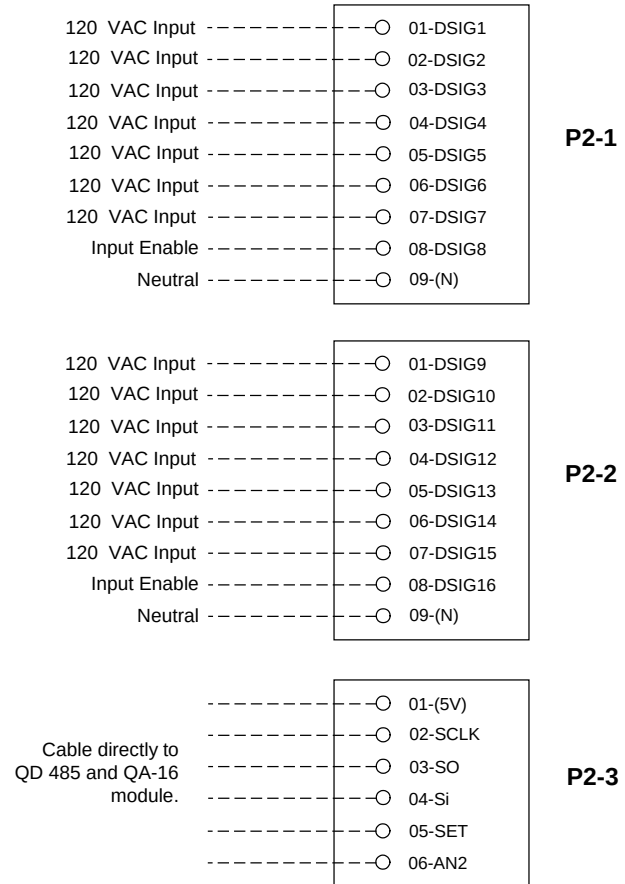
Multiple Burner Configuration of the QA-16. Note only the limit circuits and the flame inputs for each burner are monitored.

**Wiring Diagram  
(QA-16)**



QA-16 External Wiring Diagram

**Wiring Diagram  
(QA-16D)**



QA-16D Version has 16 Discrete Inputs and no Analog Inputs



## QA-16 DATA ACQUISITION SYSTEM

### Ordering Information

#### Ordering Information

| Description                                                                                             | Catalog Number |
|---------------------------------------------------------------------------------------------------------|----------------|
| Quanta-Max RS485 Operator Interface Display                                                             | 5003-QD485     |
| Display with history logging (Last 16 occurrences)                                                      | 5003-QD485-LG  |
| Receives RS485 from sender and converts to UV/FR individual sensor signals & one combined UV/FR signal. | 5003-01R       |
| Annunciator with Operator Interface Display (1/8 DIN panel mount) 16 point analog/digital inputs        | QD485QA16      |
| Annunciator with Operator Interface Display (1/8 DIN panel mount) 16 point digital inputs               | QD485QD16      |
| Annunciator Display Only                                                                                | 5501QD485      |
| 16 point digital input Annunciator Module                                                               | 5501QD16       |
| 16 point analog/digital input Annunciator Module                                                        | 5501QA16       |
| History logging (Last 10 alarm occurrences)                                                             | QD485-History  |
| Custom message for display                                                                              | QD485-Messages |

#### Suggested Specification (QA-16):

##### 1. Microprocessor Data Acquisition System

System shall be capable of monitoring up to 8 discrete (limit) inputs and up to 8 analog (flame signal) inputs. First-out annunciation and English language messages shall be indicated on a 2x16 LCD display suitable for flush-mounting in an enclosure front. The controller shall provide historical logging of past alarms and communicate via RS-232 connection. Display messages and trip logic shall be customized for each application. One relay output shall be supplied to provide a common alarm contact, trip indication, or other external function. For increase input/output capability, two data acquisition modules shall interface to a common display, providing a total of sixteen discrete inputs and sixteen analog inputs.

##### 2. Manufacturer

Data acquisition system shall consist of one or two Preferred Instruments QA-16 modules interfaced to a Preferred Instruments QD485 display module. System shall be programmed by Preferred Utilities Mfg. of Danbury, CT.

#### Suggested Specification (QA-16D):

##### 1. Microprocessor Data Acquisition System

System shall be capable of monitoring up to 16 discrete (limit) inputs. First-out annunciation and English language messages shall be indicated on a 2x16 LCD display suitable for flush-mounting in an enclosure front. The controller shall provide historical logging of past alarms and communicate via RS-232 connection. Display messages and trip logic shall be customizable for each application. One relay output shall be provided to provide a common alarm contact, trip indication, or other external function. For increase input/output capability, two data acquisition modules shall interface to a common display, providing a total of sixteen discrete inputs and sixteen analog inputs.

##### 2. Manufacturer

Data acquisition system shall consist of one or two Preferred Instruments QA-16D modules interfaced to a Preferred Instruments QD485 display module. System shall be programmed by Preferred Utilities Mfg. of Danbury, CT.

## PLANT WIDE CONTROLLER (PWC)

### Overview

- Programmable Function Controller (PFC)  
Large 704 "Block" memory, six (6) I/O board Rack (Chassis).
- LCD Operator and Setup Display  
160x240 pixel LCD display with Membrane, tactile feedback keyboard, cursor arrow and full numeric keypad.
- Hardwired Panel  
Status lights, switches and control dials provide simple manual control for easy troubleshooting and service.
- Alarm/ Event Summary  
200 point, alarms, system events and operator actions are listed in "first in first out" order with time/date stamp.
- Optically Isolated RS485 Modbus Data Highway  
SCADA (Supervisor Control and Data Acquisition) remote monitoring and/or control.
- 120 VAC Power Distribution  
Fuses, terminals and internal 24 VDC power supply.
- Wall or Pump Set Mounted Enclosure  
UL508A NEMA 4 Enclosure
- Universal Analog Input Board



*Plant Wide Controller*

### State-of-the-Art

#### Sequencing, Monitoring and Control

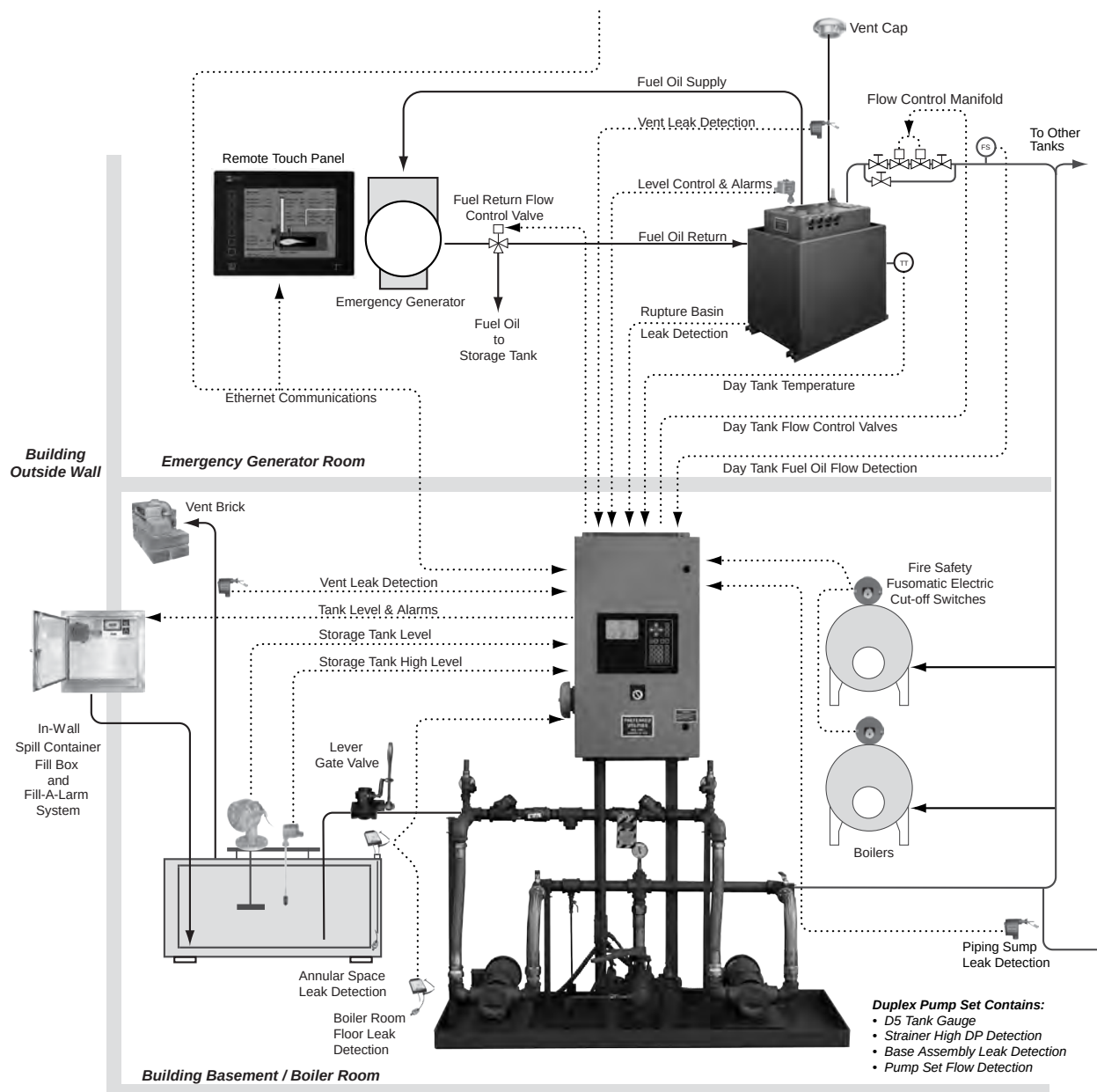
The **Plant Wide Controller (PWC)** is a state-of-the-art equipment sequencing, control and monitoring system. The PWC combines innovative ease of operation, communication and expansion capabilities with boiler plant control application expertise. Off-the-shelf, standard applications for boiler modulating lead/ lag, cooling towers and air compressors can be expanded to include additional monitoring or control additional pumps, variable speed drives and valves. Multiple communication protocols allow simultaneous communication to a personal computer or SCADA Systems using a control network. The PWC is a complete plant monitoring, control and communication interface.

### Easy to Use

- Easy Installation – The PWC integrates a powerful Programmable Function Controller (PFC), I/O boards, hardwired and LCD HMI, power distribution, 24 VDC power supplies, external communications, isolation relays into a single wall mountable controller. No external control devices are required.
- Easy to Operate – Large LCD Display, intuitive operation, setup, alarm/ event summary allow quick process assessment and maintenance monitoring.
- Easy to Configure – PWC configuration tools maintain the look and feel of the PCC-III and offer advanced features. The PWC uses an intuitive "blockware" configuration language with multiple block outputs and special purpose "super" blocks that greatly simplify complex logic such as outdoor air reset and boiler sequencing.

# PLANT WIDE CONTROLLER (PWC)

## Applications



### Tank Monitoring Applications

- **Tank Level Gauges** - The PWC interfaces with wire float, ultrasonic, pressure-based, and other types of tank gauges. Multiple tanks can be monitored through one PWC.
- **Tank Level Switches** - Digital inputs are provided to monitor tank high and low level contacts, pump off, pump on, and overfill contacts.
- **Leak Detection** - Digital inputs are available for multiple leak detection inputs including interstitial or annular space leak detection, as well as engine room leak detection.
- **Unmanned Facilities** - Provides for off-site monitoring and control using internal modem or RS485 interface. Serves as a single plant monitoring point for Building Automation Systems and personal computers.

### Pump Control and Monitoring Systems

- **Transfer Pump Control** - Multiple headered transfer pumps can be start/ stopped, or put on a timed rotation schedule to even wear among pumps.
- **Pump Proving** - Inputs from multiple pump flow switches can be configured to prove pumps are running normally.
- **Return Pump Control** - When gravity return systems are not practical, the PWC can activate return pumps to prevent overfilling of day tanks.

## PLANT WIDE CONTROLLER (PWC)

### Configuration

```
FUEL SYSTEM SETUP
STATUS:          PUMP SELECT  AUTO
P#1 P#2    DAY TK  MANUAL SELECT  1
OFF  OFF    LVL OK
MT GALS:      227.9
MT LEVEL:     19.5
LAST DLVRV:   0.0
11.5  3.5 RUN TIME: STATUS:  ALARM
PRESS TO CLEAR ALARMS >>>  RESET
12:46 08/06 Main Tank Leak      ALARM
```

Fuel System Setup

```
SYSTEM STATUS
Build- 06.71 Nov 06 2009, 11:38:30
Time - 14:26:37 Fri Aug 6, 2010

MEMORY TYPE      TOTAL      REMAINING
Constants        22560      18440
Intercycle       22560      21524
Menus&Screens    32767      27049
EGUs             12300      10394
Charts           16384      16240
Historical       1024       1024
Retentive:
Quantity         634       605
Writes          1600000     1600013
```

System Status

```
TANK CALIBRATION
MAIN TAN  1
VOLT 0%:  1.704
VOLT 100%: 2.254

ZERO VALUE ADJUSTMENT
ACTUAL IN: 19.5
ZERO ADJ:  0.0
ADJ'D IN:  19.5
```

Tank Calibration

```
TUNING PARAMETERS
MAIN TANK: #1

HI ALARM:  373.0
LOW ALARM:  41.4
HI LVL TEST: TEST
LAST DELIVERY SETTINGS
START DB:   20.7
FIN TIME:   0.17
```

Tuning Parameters

### “Blockware”

The PWC uses an intuitive “blockware” configuration language. Functions (AIN, PID, LOALM, F(x)... ) are simply copied into a configuration, and then the control signals are “wired” from block to block. Preferred’s innovative PWC\_Draw™ for MS Windows® uses a graphical, “drag and drop” interface. It allows the user to print or plot blockware drawings, and then download them to a PWC via a standard RS232 port. Additionally, blockware and displays may be edited from the spreadsheet style PWC\_Edit™.

## PLANT WIDE CONTROLLER (PWC)

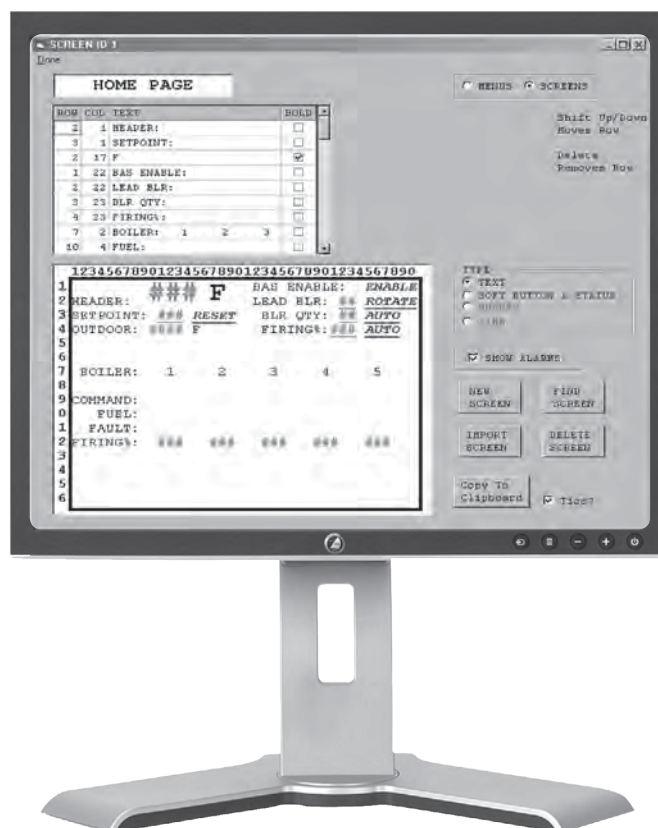
### Configuration

#### LCD Display Commissioning

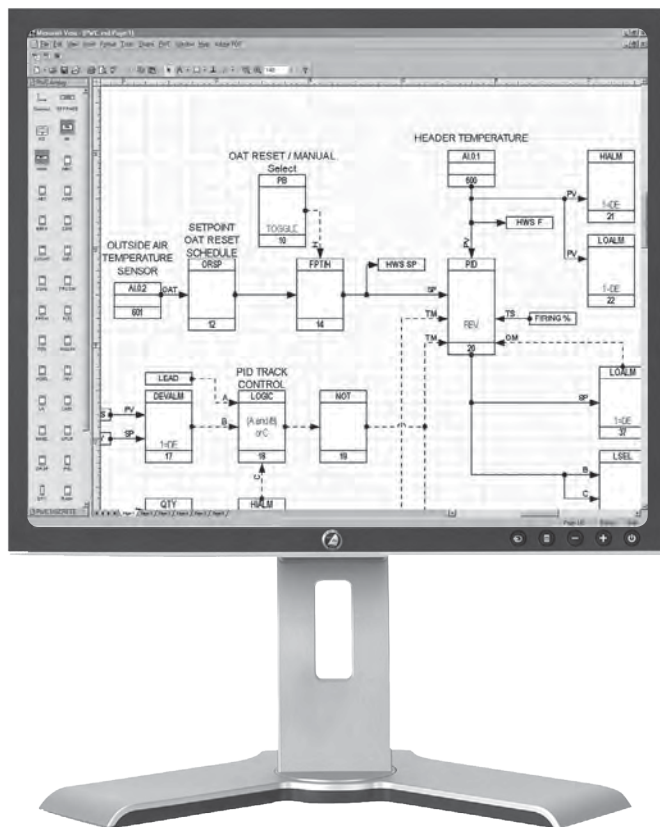
Plant wide controller configurations are designed to allow commissioning to be accomplished from the controller mounted displays. Project specific tuning displays may be created to present and group key “blockware” parameters for field tuning. Additionally, any block parameter may be edited from the front panel display using the “parameter edit” mode. Laptop computers are only required when it is necessary to change wiring between blocks or add additional blocks.

#### PWC\_Edit™

The “point and click” simplicity of the PWC\_Edit software makes “blockware” configuration simple and intuitive. The program uses a straightforward spreadsheet format with a convenient fill-in-the-blanks approach. Each block has an unlimited length “comments” field for clear documentation. The “blockware” data and comments can be printed to any MS Windows® compatible printer. PWC\_Edit offers fill-in-the-blanks style display generation. Display text can be presented as either regular or bold. Dynamic-text, softbuttons, status, numeric values, time values and alarms may be added to any display. The “chart edit” display allows configuration of trace and chart selections using a menu style system. The generated configurations are then easily downloaded using a standard RS232 DB9F cable.



PWC\_Edit Overview Display Screen Setup



PWC\_Draw Screen

#### PWC\_Draw™

The powerful object-oriented CAD interface in PWC\_Draw makes the program the ideal choice for rapid “blockware” programming in a visual environment. The program is built on a Visio® platform with extensive visual basic automation. Standard functions are included in menus of pre-drawn figures for each PWC Blockware function type. Functions are simply dragged onto the drawing page and connected with “smart connector” lines to interconnect the blocks. Block inputs are automatically generated by placing the block connections. Double clicking on any block allows the user to edit data within the block. Drawings can be saved as AutoCAD® drawings and can be printed on any MS Windows® compatible printer or plotter. “Blockware” data can also be printed in the PWC\_Edit tabular format.



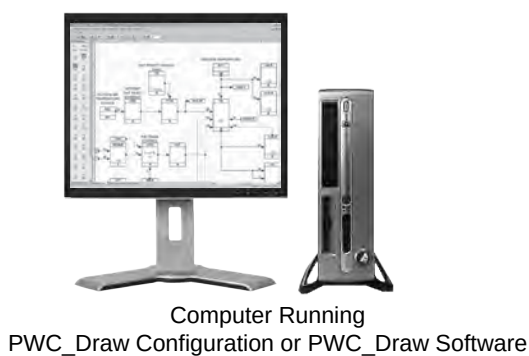
# PLANT WIDE CONTROLLER (PWC)

## Communication

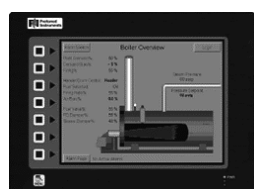
### Control Network

The PWC includes an RS485 Modbus port to communication with Building Automation System (BAS), Building Management System (BMS) or Supervisory Control and Data Acquisition (SCADA) systems.

Bacnet and Modbus over Ethernet.



SINGLE ETHERNET  
CONNECTION TO  
PLANT



ETHERNET



PREFERRED  
COMMSTATION  
190781-RS-485

RS485

Bacnet  
to Building Automation System

OIT  
BRIDGE



SCADA/Flex Server  
or  
Building Automation System (BAS)

Control Network  
(RS485 Modbus)



PCC-III  
Controllers



JC-xxD  
Instruments

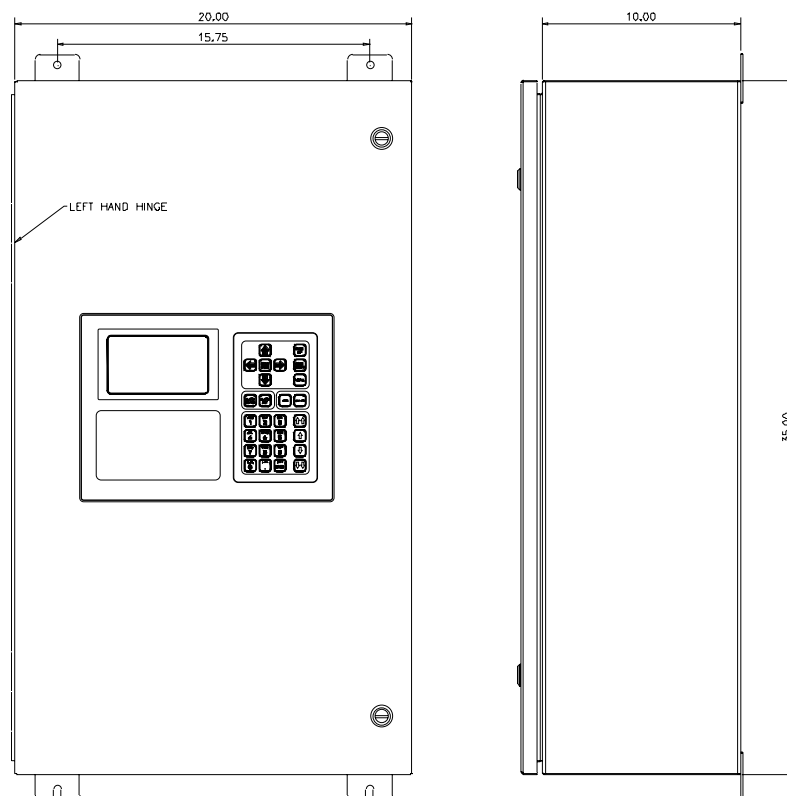
RS485



PWC CPU Board

# PLANT WIDE CONTROLLER (PWC)

## Specifications



### Mechanical

Case Size: 35" H x 20" W x 10 D  
 Enclosure Type: Wall mounted  
 Case: 7 Slot, (CPU + 6 I/O Slots)  
 Weight: 55 lbs.

### Environmental

Operating Temp: 32° to 122° F (0° to 50° C)  
 Storage Temp: -20° to 150° F (-28° to 65° C)  
 Humidity Limits: 15 to 95% (noncondensing)  
 Enclosure: NEMA 4

### Performance

Accuracy: 0.025% Analog I/O  
 Resolution: 16 bit input/12 bit output  
 Microprocessor: 32 bit, 128k EEPROM  
 Execution Cycle: Five per second  
 Time/Date Clock: (battery backed)

### Operator Control Panel

LCD Graphic Display: 2.9" H x 5.1" W  
 Keyboard: Membrane, tactile feedback

### Standard Lead/Lag:

Menu style  
 "Fill-In-The-Blanks" setup.

### Control Language:

Function block style,  
 60 functions, 600 Blocks

### Security:

2 password levels

### Custom Blockware

Configuration Software: PWC\_Edit™ spread sheet based  
 or PWC\_Draw™ graphical, editor.  
 (Windows PC Required)

### Communication

#### Control Network:

Protocol: Modbus (ASCII or RTU mode)  
 Speed: 1200 to 38,400 baud  
 Type: RS485, optically isolated

#### Programming Port

Speed: 38,400 baud  
 Type: RS232, DB9F connector

### Electrical

Input Power: 120 VAC (+/- 15%), 12A total,  
 0.7A internal  
 Built in surge suppressors

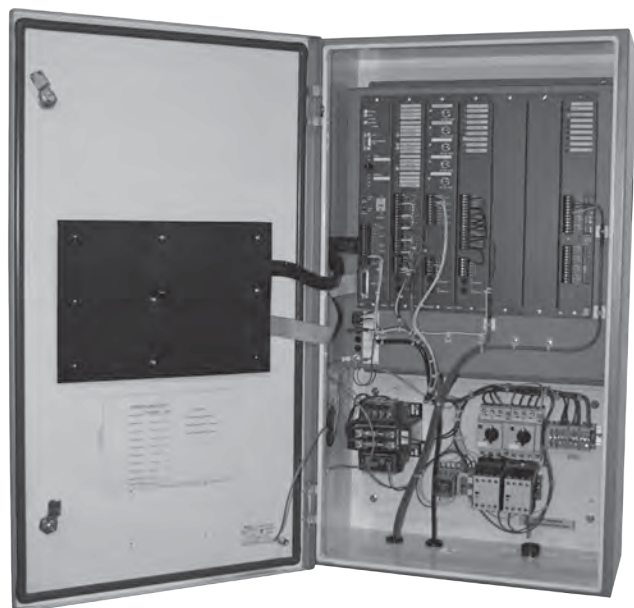
#### Internal Power Supply:

24 VDC @ 300 mADC for  
 external use

### Configuration

# PLANT WIDE CONTROLLER (PWC)

## Specifications



PWC shown with door open, pump motor starters and circuit breakers with step down transformer installed on a removable subplate.

Expandable - Plug-in I/O expansion modules are easy to install. "Blockware" configuration language allows control strategies to be easily adapted to on-site conditions.



"Hand-Off-Auto" Relay Output Board. Toggle switch directly activates output in "Hand" and "Off."

## Input/Output Specifications

### CPU Board:

|                |                                                  |
|----------------|--------------------------------------------------|
| Analog Inputs: | Quantity: 2                                      |
|                | Type: 4-20 mADC or<br>-20°F to +300°F Thermistor |
| Relay Output:  | Quantity: 1                                      |
|                | Type: SPDT, 8A, ½ HP, 120VAC                     |

### Hand-Off-Auto Relay Output (HOA-ROUT) Board:

|                  |                                                           |
|------------------|-----------------------------------------------------------|
| Relay Output:    | Quantity: 5                                               |
|                  | Type: SPST, 8A, ½ HP, 120VAC                              |
| Toggle Switches: | Quantity: 5                                               |
|                  | Type: Hand-Off-Auto (hardwired)<br>SPDT, 8A, ½ HP, 120VAC |
| LED Indicators:  | Quantity: 10                                              |
|                  | Type: "Call for Operation" and<br>"Output Status"         |

### Auto/Manual Analog Output (A/M-AOUT) Board:

|                  |                                                   |
|------------------|---------------------------------------------------|
| Analog Output:   | Quantity: 5                                       |
|                  | Type: 4-20 mADC or 0-135 ohm<br>(any combination) |
| Toggle Switches: | Quantity: 5                                       |
|                  | Type: Auto-Manual                                 |
| Control Dial:    | Quantity: 5                                       |
|                  | Type: 0-100%<br>(Manual Potentiometer)            |
| Bargraphs:       | Quantity: 5                                       |
|                  | Type: 0-100%, 10 segment                          |

### Discrete Input (DIN) Board:

|                 |                                   |
|-----------------|-----------------------------------|
| Digital Inputs: | Quantity: 15                      |
|                 | Type: 120 VAC, optically isolated |
| LED Indicators: | Quantity: 15                      |
|                 | Type: Status Indication           |

### Analog Input (AIN) Board:

|                 |                                                                                                   |
|-----------------|---------------------------------------------------------------------------------------------------|
| Analog Input:   | Quantity: 8                                                                                       |
|                 | Type: Universal,<br>Switch Selectable as:                                                         |
|                 | - 4-20 mADC, 2 wire                                                                               |
|                 | - Thermistor, -20°F to 300°F,<br>Thermocouple Type J,<br>0-1200° F, 0-5 VDC, or<br>Potentiometers |
|                 | - Pulse, 0.01 – 4000 Hz,<br>0-15 VDC                                                              |
| LED Indicators: | Quantity: 8                                                                                       |
|                 | Type: Status Indication                                                                           |

### Relay Output (ROUT) Board:

|                 |                                                   |
|-----------------|---------------------------------------------------|
| Relay Output:   | Quantity: 8                                       |
|                 | Type: (2) SPDT, (6) SPST-NO,<br>8A, ½ HP, 120 VAC |
| LED Indicators: | Quantity: 8                                       |
|                 | Type: Status Indication                           |

PLANT WIDE CONTROLLER (PWC)

Ordering Information

Catalog Number: PWCN4 -C a b c d e f - [#I]-[# P]

| Optional Input/Output Boards (slots a - f):                                                  |            |                 |                              |
|----------------------------------------------------------------------------------------------|------------|-----------------|------------------------------|
| x                                                                                            | None       |                 |                              |
| A                                                                                            | AIN        | 8 ch.           | Universal, Switch Selectable |
| D                                                                                            | DIN        | 15 ch.          | 120 VAC, Optically Isolated  |
| H                                                                                            | HOA-ROUT   | 5 ch.           | Relay, 8A, 120VAC            |
| R                                                                                            | ROUT       | 8 ch.           | Relay, 8A, 120VAC            |
| O                                                                                            | A/M-AOUT   | 5 ch.           | 4-20 mADC or 0-135 ohm       |
| Specify A/M-AOUT output channel cards:<br>(one required per active channel, any combination) |            |                 |                              |
| 1 ch                                                                                         | 4-20 mADC  | (#I = quantity) |                              |
| 1 ch                                                                                         | 135ohm pot | (#P = quantity) |                              |

## PLANT WIDE CONTROLLER (PWC)

### Suggested Specifications

#### 1. General

Supply a microprocessor-based control system with field expandable plug-in Input/ Output modules. Control logic shall be either Ladder Logic or Function Block based. Any/all loop controllers, programmable logic controllers, and/or historical trend recorders within the Control System shall be interconnected via serial links to minimize wiring of internal control signals from device to device. The control system logic and calibration data shall be stored in a non-volatile memory that does not require battery backup. A field replaceable battery back-up shall be included to maintain the system time/date clock. The control system shall operate on 120 VAC and include a surge suppressor. The control system shall include a 24 VDC power supply with 300 mADC available for external use that is UL508A rated for 120° F.

#### 2. Enclosure

A pump set or wall mounted, factory assembled, NEMA 4, continuous seam welded, steel enclosure shall be provided. The enclosure shall incorporate ¼ turn latches for securing the enclosure closed and ease of opening. The enclosure shall be proved with a formed steel hinge and stainless steel hinge pins. The enclosure is to incorporate a 10" x 17 ¾ removable sub-plate for the monitoring of control hardware items. The enclosure is to be prime coated and painted, with the exterior finish of gray textured enamel and the interior being white baked enamel.

#### 3. Operating Displays

The control System shall have a flat panel LCD Display for operator control, alarm listing, control tuning and troubleshooting functions. Provide tactile feedback, numeric keypad for data entry. Provide dedicated pushbuttons for "alarm silence" and to view a plant overview displays. The display shall be 5" x 2.9", 8 line x 40 character or larger. The control system shall include a password protected menu system for controller tuning functions.

#### 4. Alarm And Event Management

Alarms, events and operator actions shall be logged with time/ date stamp and English language description. The control system shall include a 200 point memory minimum. Provide an "alarm display" page for viewing the most recent 8 alarms/ events with scrolling capability to view the complete 200 point alarm/ event memory. New alarms shall trigger the common alarm output relay. Events shall be recorded, but shall not trigger an alarm. A dedicated "alarm silence" button shall silence the alarm output.

#### 5. Control Panel Mounted Indicators

Provide individual long life LED status indicators for all controlled equipment. All indicators shall be labeled with a permanent marking.

#### 6. Input/Output Signal Types

The control system shall include the following input/ output signal types: Analog inputs shall be universal type and must be field selectable between 4-20 mADC, Thermistor, Thermocouple, Potentiometer and pulser. Analog outputs shall be 4-20 mADC and 0-135 ohm. Discrete inputs shall be 120 VAC, optically isolated type. Relay outputs shall be SPDT and SPST, 8A, ½ HP, 120VAC.

#### 7. Reliability

Field wiring shorts or ground loops within one pump, valve or fan shall not affect automatic or manual operation of other devices. Provide electrically isolated relay contact and isolated 4-20 mADC/0-135 ohm modulating control outputs. Each transmitter and sensor shall have individual power supply short circuit protection. "Hard manual" backup stations shall be provided to ensure continued central operator control in the event of CPU memory corruption or failure. Include hardwired "hand-off-auto" control switches inserted directly into every boiler, pump, damper, fan, etc., and start/ stop circuit. Each 4-20 mADC or 0-135 ohm modulating control output must include a hardwired manual backup station with auto/ manual switch, output control knob or pushbuttons, and output level indicator (bargraph, analog meter or digital display). The manual station hardware must function when the CPU is not functioning.

#### 8. Control Network

In addition to the remote monitoring features, the control system must include a RS485 Modbus communication interface to a supervisory Control And Data Acquisition (SCADA) System, Building Automation System (BAS), or Building Management System (BMS).

#### 9. Quality Assurance

The control enclosure shall be manufactured and labeled in accordance with UL508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components is not sufficient. The assembled control enclosure, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). Lack of an NRTL certified UL508A wiring methods inspection and labeling will be grounds for control enclosure rejection.



## PCC-III MULTIPLE LOOP CONTROLLER

### Overview



### Reliable, Flexible Control and Monitoring

The PCC-III Multiple Loop Controller is a boiler or multiple loop process controller. The large I/O quantity, integral Oxygen sensor, highly visible front panel, intuitive "Blockware", redundant memories, 4-20 mA DC input and outputs, 120 VAC discrete contact inputs, isolated relay outputs, 24 VDC transmitter power supply, the ability to control electric positioners directly and built-in industry standard communications allows the PCC-III to be integrated into complex systems with a minimum number of external components. The PCC-III is a complete control solution for individual boilers or multiple control loops.

- Multiple loop controller  
Large 160 block memory and 18 I/O points as a standard with three (3) additional I/O card slots for available expansion up to 31 I/O.
- Highly Visible LED Displays
  - 10 Process Variables displayed with English language description
  - 10 Point ("first-out") annunciator with English language messages
  - Large 5.1", 51 segment bargraphs
- Intuitive "Blockware" configuration language  
Completely configurable from controller front panel. No external keypads or terminals are required for any reason
- Dual redundant memory modules  
Protects configuration data, tuning parameters and operating status information
- Optically Isolated RS485 Modbus data highway  
Ensures safe and reliable communications
- 120 VAC Discrete Input, Relay and Triac Output  
Boiler system compatibility and 24 VDC internal power supply
- Flush Mounted NEMA 13 Front Panel



*PCC-III Multiple Loop Controller*

### User Friendly

- Easy Installation – The PCC-III integrates a flexible, highly visible HMI, up to 31 I/O points (including isolated discrete and analog inputs, relay outputs and triac and 4-20 mA DC outputs), 24VDC power supplies and network communications into a single panel mounted NEMA 13 controller.
- Easy to operate - The PCC-III comes with large numeric and English language displays, pushbuttons and intuitive bargraphs which provide clear process information. A flexible display allows the operator to view up to 10 different process variables, each with up to a 16 character English language description message. The "first-in-first-out" annunciator allows the operator to view the order of alarms and acknowledge each separately. Configurable "lights and buttons" allow incorporation of auxiliary functions into the controller without the addition of external hardware.
- Easy to configure - The PCC-III uses an intuitive "Blockware" configuration language. Functions (AIN, PID, LOALM, F(x), etc) are simply copied into a configuration, and then the control signals are "wired" from block to block. Preferred's innovative PC3\_Draw™ for MS Windows® uses a graphical, "drag and drop" interface. Blockware can also be edited directly from the PCC-III front panel or the spreadsheet style PC3\_Edit™. The PCC-III includes automated setup tools to help reduce commissioning time and improve control system tuning.

## PCC-III MULTIPLE LOOP CONTROLLER

### Overview

#### Safe Boiler Operation

The Preferred PCC-III controller, joined with proper fuel and combustion air flow regulating elements, assures accurate and repeatable combustion control. Fuel and air flows are matched in order to maintain proper fuel to air ratio at all times. Too little air causes unburned fuel losses and too much air causes excessive stack losses. Improper fuel air ratio can be DANGEROUS. Any combustion project requires the assessment of existing piping, burner and boiler conditions, process measurements, analyzers, linkages, actuators, control valves, control dampers and operational requirements. Preferred's focus on combustion applications, with thousands of boiler control system installations, brings the required experience to the evaluation, development and commissioning of each project. With its redundant non-volatile memories and "service manual" mode, the PCC-III Controller is capable of "self-recovery" in the event of a severe 120 VAC electrical power disturbance or some other occurrence that alters data in its memory. Moreover, an integral optically isolated RS485 Data Highway helps prevent a single controller failure from disrupting an entire network.

#### Lower Installed Cost

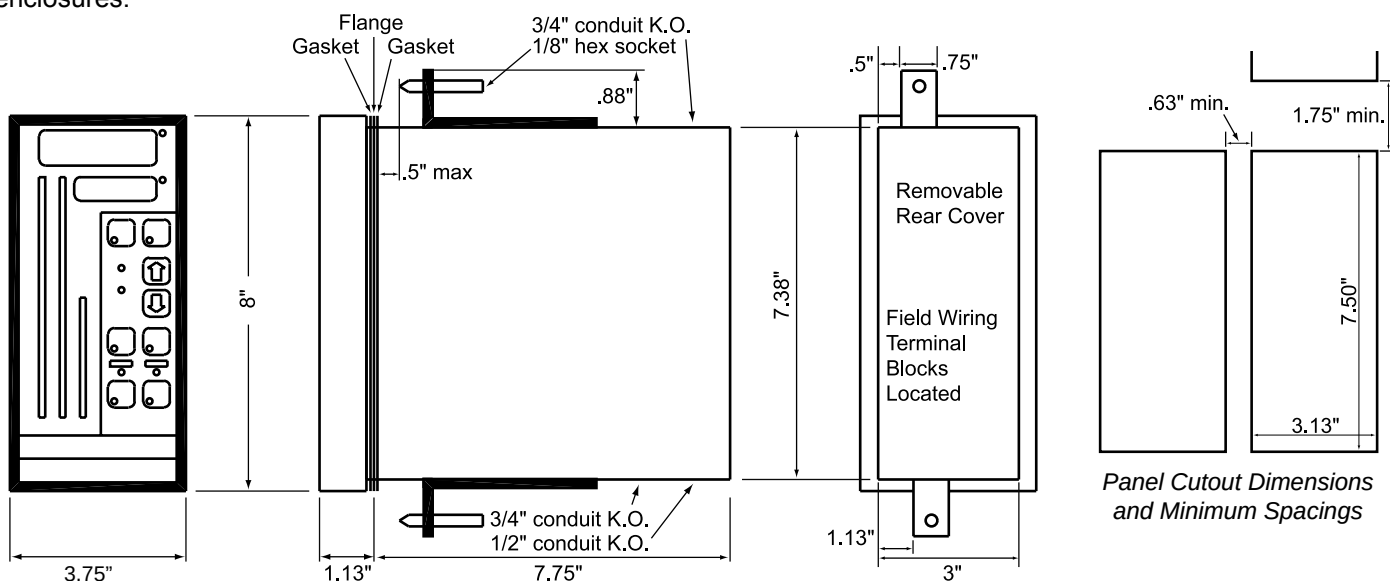
When considering any controller, it is important to consider the total "installed" cost. The PCC-III offers the lowest installed cost in the industry. Other controllers routinely require external hardware such as interfacing relays, communication isolators, 24V power supplies, laptops or configurators and possibly extra controllers to manage a specific application. The PCC-III overcomes many of these issues by incorporating these features into the basic controller. The PCC-III "Z" option card, as an example, eliminates the need for an external flue gas excess oxygen transmitter, while standard 120 VAC inputs and 8 Amp relay outputs eliminate the need for interposing relays. While most other controllers are well over 15" long, the compact PCC-III fits easily into less expensive 8" deep cabinets or enclosures.

#### Multiple Loops

Due to its ability to handle several control loops, application of a single PCC-III may allow a reduction in the total number of controllers necessary for an installation. The large 160 function block configuration memory allows any function to be assigned to each block, providing unequalled flexibility and enough power to handle just about any boiler control strategy.

#### Expandable I/O

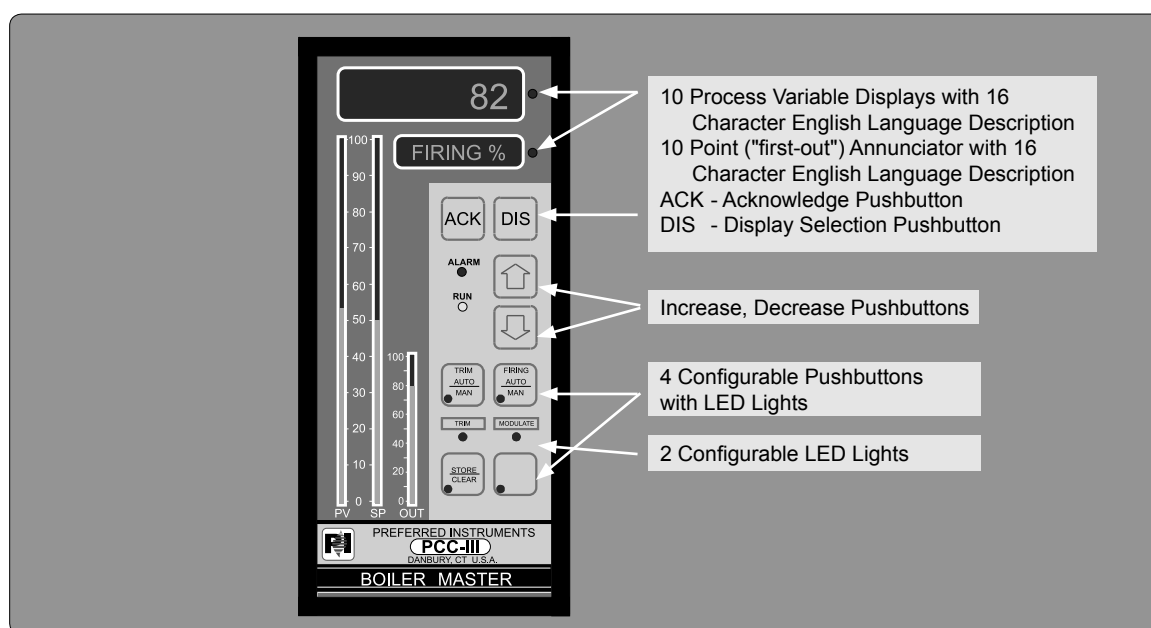
The wide variety of PCC-III option boards allow one to expand the I/O capabilities of a given controller to fit any application. Refer to the specifications page for expansion card possibilities. Up to 15 analog inputs can be used to support complex control strategies or satisfy data acquisition needs. The PCC-III can be equipped with up to 6 relay outputs. These outputs are rated for up to 8A inductive loads and can be used on most applications without external "helper" relays. Additionally, the PCC-III offers Triac outputs to drive reversible AC electric actuators, solenoids, horns and other devices. The "G" Triac Output option card includes a "position feedback" potentiometer or 4-20 mADC inputs for closed loop servo positioning.



Panel Cutout Dimensions and Minimum Spacings

## PCC-III MULTIPLE LOOP CONTROLLER

### Applications



### PCC-III Multiple Loop Controller Example Applications:

#### Boiler Monitoring

- Flue Gas Oxygen Monitoring with ASME "By Losses" Efficiency Calculation for One (1) or Two (2) Boilers
- Data Acquisition with up to 15 Analog Inputs or 13 Digital Inputs

#### Header Temperature or Pressure Control

- Two (2) or Three (3) Boiler Modulating Lead/Lag Control
- Plant Master Modulating Control

#### Single Point Positioning Combustion Control

- Firing Rate Control
- Firing Rate Control with Oxygen Trim Control using Link Trim Actuator (LTA) or Fuel Trim Output
- Firing Rate Control with Draft or Drum Level Control

#### Parallel Positioning Combustion Control

- Firing Rate Control
- Firing Rate Control with Oxygen Trim Control
- Firing Rate Control with Oxygen Trim Control and Variable Speed Drive (VSD) Combustion Air Fan Control

#### Fully Metered Combustion Control

- Firing Rate Control
- Firing Rate Control with Oxygen Trim Control
- Firing Rate Control with Oxygen Trim Control and Variable Speed Drive (VSD) Combustion Air Fan Control

Refer to Engineering Data Section for features and Benefits of Single Point Positioning, Parallel Positioning and Fully Metered Combustion Control System.

# PCC-III MULTIPLE LOOP CONTROLLER

## Configuration

### Combustion Control Features

Combustion is a demanding process control application. The following are some of the PCC-III features developed to meet those demands.

### Multiple Function Generator F(x) blocks

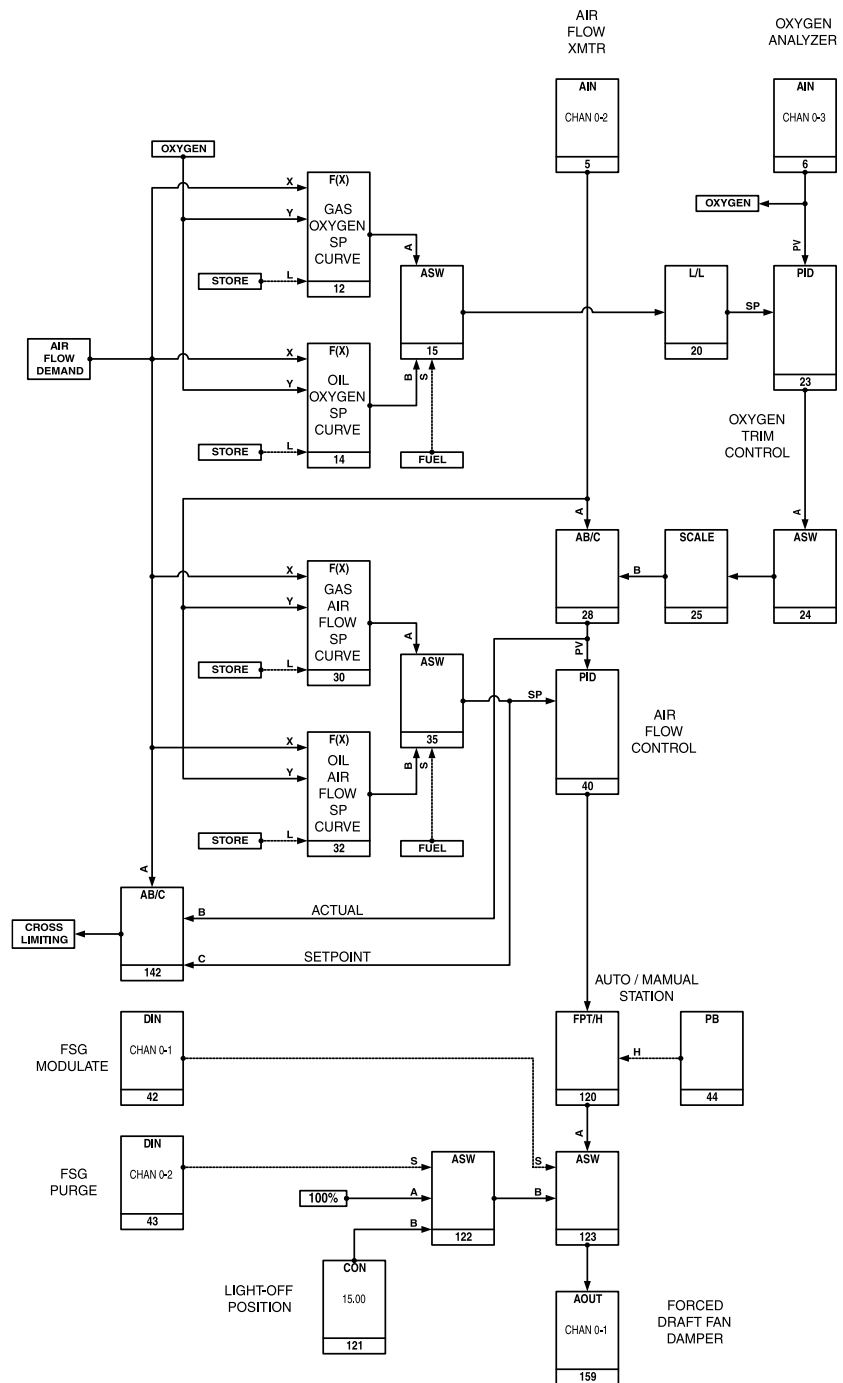
The F(x) block is used to “characterize” or “curve fit” an analog signal by allowing each value of the input to be assigned an independent output value. The PCC-III's F(x) block allows 11 breakpoints to define the input vs. output profile. The blocks are used to set up feedforward and remote setpoint signals as well as linearize relationships. For example, in combustion air flow control applications, F(x) blocks are used to “characterize” the Air Flow Demand signal to create Air Flow Controller and Oxygen Trim Controller setpoints. The example shown to the right uses separate F(x) blocks to “characterize” different setpoints for gas and oil firing. The PCC-III has the capacity to use as many F(x) functions as are required by the application.

### “Learn Mode”

The PCC-III “Learn Mode” feature allows multiple F(x) block input vs. output profiles to be entered simultaneously. This capacity is best described with an example (refer to the example blockware diagram at right). During commissioning, the control technician adjusts air and fuel flows manually to establish optimal firing conditions for a particular load point. With the conditions set, the technician simply presses the “store” button for the PCC-III to store (learn) the current firing rate, oxygen value and burner air flow rate into the appropriate F(x) blocks simultaneously. This causes considerable time in commissioning, as well as an optimally “characterized” process.

### Boiler Efficiency Function Block

The boiler efficiency function allows real time calculation of the boiler's efficiency with results displayed on the controller's front panel, recorder and/ or data acquisition system. Boiler efficiency is calculated using the ASME “by losses” method. This function requires inputs of flue gas temperature, combustion (ambient) air temperature, percent oxygen in the flue gas, and percent firing rate to evaluate the efficiency. Not only does this function help establish “on-line” fired equipment efficiency, but it also helps detect changes in efficiency, alerting operating personnel of potential maintenance concerns before they become a problem. The results of efficiency calculations can also be used in advanced control applications.



*Simplified Blockware Diagram Example showing the combustion air flow control and Oxygen trim portion of a full metering combustion control application*



## PCC-III MULTIPLE LOOP CONTROLLER Configuration

Programming configurations is a challenging task for most programmable controllers. The PCC-III multiple loop controller is the exception to this rule with three different ways to create configurations. Configurations can always be made directly from the faceplate of the controller, using the built-in edit buttons, but the task is made even easier with Preferred's PC3\_Edit™ and PC3\_Draw™ software. Both programs allow the user to design Blockware configurations and upload/download them to the PCC-III controller through the PC3-Link™ cable connecting the serial port of your computer to a standard RS232 connection on the PCC-III controller. PC3\_Edit™ provides a straightforward spreadsheet style interface while PC3\_Draw™ uses a powerful object-oriented visual interface. Both programs are built for MS Windows®.

### PC3\_Edit™

The "point and click" simplicity of the PC3\_Edit™ software makes "Blockware" configuration simple and intuitive. The program uses a straightforward spreadsheet format with a convenient fill-in-the-blanks approach. Each Block has an unlimited length "comments" field for clear documentation. The "Blockware" data and comments can be printed to any MS Windows® compatible printer. The generated configurations are then easily downloaded to the controller through the PC3-Link™ cable.

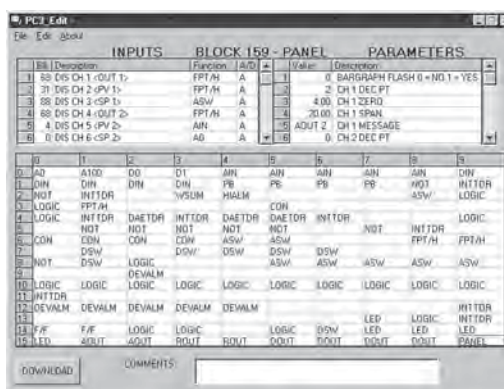
### PC3\_Draw™

The powerful object-oriented CAD interface in PC3\_Draw™ makes the program the ideal choice for rapid "Blockware" programming in a visual environment. The program is built on a Visio® platform with extensive Visual Basic automation. Standard functions are included in menus of pre-drawn figures for each PCC-III Blockware function type. Functions are simply dragged onto the drawing page and connected with "smart connector" lines to interconnect the blocks. Block inputs are automatically generated by placing the block connections. Double clicking on any block allows the user to edit data within the block. Drawings can be printed on any MS Windows® compatible printer or plotter. "Blockware" data can also be printed in the PC3\_Edit™ tabular format.

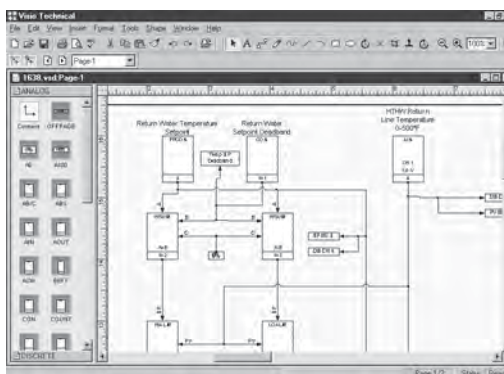
Whatever the configuration needs, Preferred Instruments has an easy solution for you. Whether it's the straightforward approach of PC3\_Edit™ or the more robust graphical abilities of PC3\_Draw™, configurations will never be the chore they used to be.



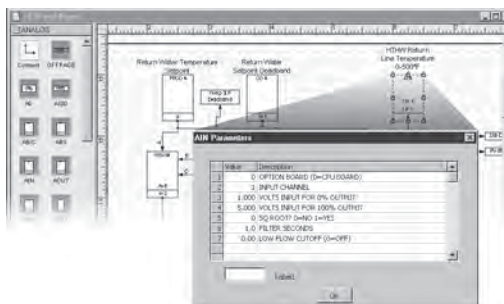
The PCC-III can be configured directly from the front panel or with Preferred's PC3\_Edit™ or PC3\_Draw™ Software.



PC3\_Edit™ Allows easy uploading, editing, and downloading of "Blockware" configurations.



PC3\_Draw™ uses a visual, "drag and drop" approach to "Blockware" design.





# PCC-III MULTIPLE LOOP CONTROLLER

## Specifications

### Mechanical

|                   |                                  |
|-------------------|----------------------------------|
| Case Size:        | 7.38" H X 3.00" W X 7.75" D      |
| Enclosure Type:   | Flush panel mounted              |
| Front Panel Size: | 8.00" H X 3.75" W                |
| Panel Cutout:     | 7.50" H X 3.13" W (+/- .062)     |
| Weight:           | 6 lbs. (excluding option boards) |

### Environmental

|                  |                                |
|------------------|--------------------------------|
| Operating Temp:  | 32° to 122° F (0° to 50° C)    |
| Storage Temp:    | -20° to 150° F (-28° to 65° C) |
| Humidity Limits: | 15 to 95% (noncondensing)      |
| Front Panel:     | NEMA 13/IP65                   |

### Performance

|                  |                                         |
|------------------|-----------------------------------------|
| Accuracy:        | 0.025% Analog Inputs and Outputs, 70° F |
| Resolution:      | 16 bit input/16 bit output              |
| Microprocessor:  | 32 bit, 256k RAM                        |
| Execution Cycle: | Ten per second                          |
| Non-Volatile     |                                         |
| Memory Life:     | 10.8 - 30 years, Blockware dependent    |

### Operator Control Panel

|                    |                            |
|--------------------|----------------------------|
| Displays:          |                            |
| Alphanumeric:      | 8 character LED (0.2")     |
| Numeric:           | 4.5 digit LED (0.43")      |
| Bargraphs:         |                            |
| PV & SP:           | 51 segment LED (5.1")      |
| Output:            | 21 segment LED (2.1")      |
| Pushbuttons:       | Membrane, tactile feedback |
| Faceplate:         | Mylar, splashproof         |
| Alarm Annunciator: | 10 point, first out        |
| Status Indicators: | 6 LED, configurable        |
| User Defined       |                            |
| Pushbuttons:       | 4 configurable             |

### Configuration

|                    |                                                                                          |
|--------------------|------------------------------------------------------------------------------------------|
| Language:          | Function block style,<br>60 functions, 160 Blocks                                        |
| Security:          | 4 password levels<br>Redundant memories                                                  |
| User Interface:    |                                                                                          |
| Faceplate:         | Fully front face configurable<br>4 dedicated EDIT keys located<br>under hinged cover     |
| Laptop (optional): | PC3_Edit™ spread sheet based<br>editor or PC3_Draw™ graphical,<br>object-oriented editor |

### Communication

|                |                                                   |
|----------------|---------------------------------------------------|
| Network:       |                                                   |
| Protocol:      | Modbus (ASCII or RTU mode)                        |
| Speed:         | 1200 to 38,400 baud                               |
| Type:          | RS485, optically isolated                         |
| Configuration: |                                                   |
| Speed:         | 1200 to 38,400 baud                               |
| Type:          | RS232 with telephone modular<br>handset connector |

### Electrical

|                          |                                                                                           |
|--------------------------|-------------------------------------------------------------------------------------------|
| Input Power:             | 120 VAC (+/- 15%)<br>Built in surge suppressors                                           |
| Internal Power Supplies: | 24 VDC @ 215 mADC<br>(for 2 wire transmitters)<br>5 VDC @ 50 mADC<br>(for potentiometers) |

### Input/Output (Standard - no option cards)

|                   |           |                                                          |
|-------------------|-----------|----------------------------------------------------------|
| Analog Inputs:    | Quantity: | 5                                                        |
|                   | Type:     | 4 - 20 mADC, 0 - 5 VDC                                   |
| Analog Outputs:   | Quantity: | 2                                                        |
|                   | Type:     | 4-20 mADC, 750 ohm load                                  |
| Discrete Inputs:  | Quantity: | 5                                                        |
|                   | Type:     | 120 VAC opto-isolated                                    |
| Discrete Outputs: | Quantity: | 6                                                        |
|                   | Type:     | (2) SPDT relay, 8A, 120V<br>(4) 24 VDC, (sinking), 100mA |

### Input/Output Option Cards

#### Option Board A:

|                |           |                        |
|----------------|-----------|------------------------|
| Analog Inputs: | Quantity: | 5                      |
|                | Type:     | 4 - 20 mADC, 0 - 5 VDC |

#### Option Board F:

|                 |           |                        |
|-----------------|-----------|------------------------|
| Analog Inputs:  | Quantity: | 3                      |
|                 | Type:     | 4 - 20 mADC, 0 - 5 VDC |
| Analog Outputs: | Quantity: | 2                      |
|                 | Type:     | 4 - 20 mADC            |

#### Option Board G:

|                |           |                               |
|----------------|-----------|-------------------------------|
| Triac Output:  | Quantity: | 2 pair                        |
|                | Type:     | 2 A 24 - 120 VAC              |
| Analog Inputs: | Quantity: | 2                             |
|                | Type:     | Pot / 0 - 5 VDC / 4 - 20 mADC |

#### Option Board J:

|                 |           |                              |
|-----------------|-----------|------------------------------|
| Digital Inputs: | Quantity: | 4                            |
|                 | Type:     | 120 VAC, Optically-Isolated  |
| Relay Outputs:  | Quantity: | 2                            |
|                 | Type:     | Relay contact, 8 A inductive |

#### Option Board S:

|               |           |                  |
|---------------|-----------|------------------|
| Triac Output: | Quantity: | 1 pair           |
|               | Type:     | 2 A 24 - 120 VAC |

#### Option Board Z:

|               |           |                             |
|---------------|-----------|-----------------------------|
| Analog Input: | Quantity: | 3                           |
|               | Type:     | 120 VAC, Optically-Isolated |
| Triac Output: | Quantity: | 1 pair                      |
|               | Type:     | 2 A - 120 VAC               |

## PCC-III MULTIPLE LOOP CONTROLLER

### Standard Configuration

A number of common controller configurations can be ordered pre-programmed into the PCC-III to perform a variety of different control functions including:

- Plant Master
- Single Point Positioning (Jackshaft) Boiler Master
- Parallel Positioning Boiler Master
- Fully Metered Boiler Master
- Feedwater Control
- Condensate Level Control
- Stand-Alone Oxygen Analyzer

Note: although the controllers are provided pre-programmed, there will still be additional field programming required to enter site-specific data into the controllers including: transmitter ranges, customized text descriptions, tuning parameters, etc.

#### Plant Master Configuration Options:

| Title                                     | Description                                                                                                                                                           | Catalog Number | PCC-III Model Number |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|
| Plant Master (current outputs)            | Includes steam header pressure control. This controller may be combined with any boiler Submaster controller to form a complete system.                               | PC3-00003C     | PCC-III-0000         |
| Plant Master with 3 Steam Boiler Lead/Lag | Includes steam header pressure control and lead/lag sequencing for three boilers. External lead boiler selector switch and Boiler Submaster Controllers are required. | PC3-10013C     | PCC-III-J000         |

#### Single Point Positioning Boiler Master Configuration Options:

| Title                                              | Description                                                                                                                                                                                                                                                                                                                   | Catalog Number | PCC-III Model Number |
|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|
| Steam Boiler Submaster Jackshaft (current outputs) | Includes boiler steam pressure control for a boiler equipped with a jackshaft. This is a complete system.                                                                                                                                                                                                                     | PC3-10103C     | PCC-III-0000         |
| Steam Boiler Submaster Jackshaft (triac outputs)   | Includes boiler steam pressure control for a boiler equipped with a jackshaft. This is a complete system.                                                                                                                                                                                                                     | PC3-10013C     | PCC-III-G000         |
| Hot Water Boiler Submaster Jackshaft               | Includes hot water generator temperature control for a hot water generator equipped with a jacks haft. This is a complete system.                                                                                                                                                                                             | PC3-10153C     | PCC-III-Z000         |
| Oxygen Trim w/Efficiency Jackshaft (Z-board)       | Includes oxygen trim logic for a jackshaft-equipped boiler. Fuel trim equipped pressure regulator and I/P converter are required. Configuration is set up for use with Preferred's ZP Oxygen Analyzer. This controller may be used as a stand alone system or combined with PC3-10103 or PC3-10153 to form a complete system. | PC3-10313C     | PCC-III-Z000         |
| Oxygen Trim w/Efficiency Jackshaft (Z-board)       | Includes oxygen trim logic for a jackshaft-equipped boiler. Differential link trim actuator is required. Configuration is set up for use with Preferred's ZP Oxygen Analyzer. This controller may be used as a stand-alone system or combined with PC3-10103 or PC3-10153 to form a complete system.                          | PC3-10363TA    | PCC-III-ZG00         |
| Boiler Submaster/ Draft, Jackshaft                 | Includes boiler steam pressure control and draft damper control for a jackshaft-equipped boiler. This is a complete system.                                                                                                                                                                                                   | PC3-12043C     | PCC-III-0G00         |

## PCC-III MULTIPLE LOOP CONTROLLER

### Standard Configuration

#### Parallel Positioning Boiler Master Configuration Options:

| Title                                                                            | Description                                                                                                                                                                            | Catalog Number | PCC-III Model Number |
|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|
| Boiler Submaster/<br>Fuel/Air Ratio, Parallel<br>Positioning (no Oxygen<br>Trim) | Includes boiler steam pressure control with fuel valve, air-fuel ratio logic and air damper control configuration for parallel positioning field equipment. This is a complete system. | PC3-12053C     | PCC-III-0000         |

#### Fully Metered Boiler Master Configuration Options:

| Title                                               | Description                                                                                                                                                                                                                                             | Catalog Number | PCC-III Model Number |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|
| Steam Boiler Submaster/<br>Fuel Flow, Full Metering | Includes boiler steam pressure control and one (1) fuel valve control configured for fully metered field equipment. This configuration is used with PC3-12073C.                                                                                         | PC3-12033C     | PCC-III-0000         |
| Air Flow/ Oxygen Trim,<br>Full Metering             | Includes air-fuel ratio logic, air damper control and oxygen trim logic configuration for fully metered field equipment. Configuration is set up for use with Preferred's ZP Oxygen Analyzer. This configuration is used with PC3-12033C or PC3-12493C. | PC3-12073C     | PCC-III-Z000         |

#### Auxilliary Configuration Options:

| Title                           | Description                                                                                                     | Catalog Number | PCC-III Model Number |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------|----------------------|
| One Element Drum Level          | Feedwater valve control using drum level measurement.                                                           | PC3-10213C     | PCC-III-0000         |
| Two Element Drum Level          | Feedwater valve control using steam flow and drum level measurements.                                           | PC3-10203C     | PCC-III-0000         |
| Three Element Drum Level        | Feedwater valve control using steam flow, drum level and feedwater flow measurements.                           | PC3-10223C     | PCC-III-0000         |
| Condensate Tank Level           | Condensate valve control with condensate level measurement.                                                     | PC3-10263C     | PCC-III-0000         |
| Deaerator Tank Level            | Condensate flow valve control with Deaerator level measurement.                                                 | PC3-10273C     | PCC-III-0000         |
| Oxygen Analyzer w/<br>Efficienc | Stand alone oxygen analyzer configuration. Configuration is set up for use with Preferred's ZP Oxygen Analyzer. | PC3-11033C     | PCC-III-Z000         |
| Standard PID Controller         | Standard PID logic with high and low alarm.                                                                     | PC3-STDPID     | PCC-III-0000         |

## PCC-III MULTIPLE LOOP CONTROLLER

### Ordering Information

1. Specify the PCC-III catalog number as shown below.
2. Consult factory for pre-configured combustion control strategies that may be included for an additional cost.
3. Optionally specify PC3\_Edit™ or PC3\_Draw™ programming packages.
4. Optionally specify the "DCS-III" Controller for monitoring applications. The "DCS-III" is a PCC-III Controller without faceplate and case. It is supplied with a bracket for mounting on an enclosure sub panel.

Catalog Number: PCC III a b c 0

| Option Card Slot #1: |                                                               |        |                              |                   |
|----------------------|---------------------------------------------------------------|--------|------------------------------|-------------------|
| 0                    | none                                                          |        |                              |                   |
| A                    | AIN                                                           | 5 ch.  | 4-20 mADC / 0-5 VDC          |                   |
| F                    | AIN                                                           | 3 ch.  | 4-20 mADC / 0-5 VDC          |                   |
|                      | AOUT                                                          | 2 ch.  | 4-20 mADC                    | Combination Board |
| G                    | TOUT                                                          | 2 pair | Triac Outputs, 2A 24-120 VAC |                   |
|                      | AIN                                                           | 2 ch.  | Pot / 0-5 VDC / 4-20 mADC    | Combination Board |
| J                    | DIN                                                           | 4 ch.  | 120 VAC, Optically Isolated  |                   |
|                      | DIN                                                           | 2 ch.  | Relay Contact, 8A Inductive  | Combination Board |
| Z                    | ZP Oxygen Analyzer Amplifier and Stack Temperature Controller |        |                              |                   |
| Option Card Slot #2  |                                                               |        |                              |                   |
|                      | Select card type from the "Slot 1" list above                 |        |                              |                   |
| Option Card Slot #3  |                                                               |        |                              |                   |
| 0                    | none                                                          |        |                              |                   |
| S                    | TOUT                                                          | 1 pair | Triac Outputs, 2A 24-120 VAC |                   |

Optional Input/Output Board Expansion Examples:

| PCC-III Model # | 4-20 mADC<br>0-5 VDC<br>AIN | 4-20 mADC<br>AOUT | 120 VAC<br>DIN | 8A (relay)<br>ROUT | 2A<br>(triac pairs)<br>TOUT | 200 mADC<br>(sinking)<br>DOUT | Total I/O |
|-----------------|-----------------------------|-------------------|----------------|--------------------|-----------------------------|-------------------------------|-----------|
| PCC-III-0000    | 5                           | 2                 | 5              | 2                  | 0                           | 4                             | 18        |
| PCC-III-AA00    | 15                          | 2                 | 5              | 2                  | 0                           | 4                             | 28        |
| PCC-III-FF00    | 11                          | 6                 | 5              | 2                  | 0                           | 4                             | 28        |
| PCC-III-JJ00    | 5                           | 2                 | 13             | 6                  | 0                           | 4                             | 30        |
| PCC-III-GGS0    | 9                           | 2                 | 5              | 2                  | 5                           | 4                             | 27        |
| PCC-III-FGS0    | 10                          | 4                 | 5              | 2                  | 3                           | 4                             | 28        |
| PCC-III-AJ00    | 10                          | 2                 | 9              | 4                  | 0                           | 4                             | 29        |

Note: The examples given in no way reflect the number of option card possibilities. The PCC-III has a total of three (3) option card slots, of which one is designated for use by the "S" card only. The remaining two slots can house any of the remaining option cards in any desired combination.

specifications subject to change without notice

## PCC-III MULTIPLE LOOP CONTROLLER

### Suggested Specifications

#### 1. General

Supply a microprocessor-based multiple loop controller suitable for flush mounting on the face of a control panel. The controller shall provide for balanceless-bumpless transfer. In normal operation, this unit receives analog inputs, calculates the output and positions the associated final control element. The operator can manually override this function by selecting the manual mode of operation and adjusting the final control element. Primary operating voltage shall be 120 volts, 60 Hz, single phase. Plug-in field wiring shall allow removal of the controller circuit boards without disconnecting any panel or field wiring from the terminal strips. The controller shall include all necessary 24 VDC power to supply input and output circuits.

#### 2. Enclosure

Controllers shall be flush mounted on the control cabinet and shall have NEMA 13 rated (oil/water spray) front panel displays, keyboard, cabinet to case and case to front panel gasketing. Controllers shall be able to operate indefinitely in 120° F locations with no cooling fans. Controller tuning and configuration menus shall be concealed behind a panel front located door.

#### 3. Operator Interface

Digital displays and keypad shall be provided on the controller front panel. The controller shall be capable of displaying up to 10 process variables with English language descriptions. Additionally, controllers shall have a ten point English language "first - out" annunciator. Controllers shall have two 50 segment red LED bargraphs to locally display the process variable and setpoint and one 20 segment red LED bargraph to display the output. All operator pushbuttons shall be of the membrane type and shall have tactile feedback. Status indications shall be long life LEDs.

#### 4. Configuration

Control strategy shall not use "blockware" type language. The controller shall be supplied with an onboard library of 61 analog and discrete functions and have a minimum 160 block memory. Any quantity or combination of function blocks (AIN, PID, LOALM, F(x), etc.) shall be easily copied into a control strategy and "wired" from block to block. The controller shall be capable of calculating real time boiler efficiency based on the ASME "by losses" method. The calculation must use real time inputs of boiler firing rate, flue gas oxygen, flue gas temperature and fuel selected. Two sets of adjustable fuel chemistry data parameters shall be included, and firing rate scaled radiation losses shall be used for maximum accuracy. Calculations that rely on fixed constants or manually entered values for these conditions are not acceptable. Fuel/Air ratio curve and oxygen trim setpoint curve adjustment shall be automated for rapid, error-free burner setup. Only a single operator action shall be required to store commissioning data into multiple characterizer curves for a particular load point. "examine" and "block force" modes shall be provided to allow rapid system troubleshooting. Each controller shall be completely field configurable from the front panel keypad without the use of external

computers or hand-held terminals. Configuration changes, tuning, and oxygen trim setpoint curve adjustment shall be accomplished via a keypad on the controller front panel. Each controller shall have several levels of access security to prevent unauthorized configuration. Provide laptop computer, software, and cables if all forms of controller configuration cannot be performed from the controller faceplate.

#### 5. Input/ Output Signal Types

The Controller shall use 120 VAC for discrete inputs and outputs for system compatibility. Analog inputs shall be 1 - 5V or 4-20 mADC. Analog input and output signals shall be isolated from earth ground for ground loop prevention. The controller shall include optional TRIAC, 24-120 VAC solid state switch output boards to directly interface with electric actuators. Controller I/O quantities shall be expandable with plug-in I/O option cards.

#### 6. Reliability

Control signals that are shared by multiple boilers (e.g. Plant master demand, and RS485 communications links) shall have signal isolators in each boiler section. This is to prevent an equipment or wiring failure in one boiler from shutting down any other boiler. Each transmitter and sensor input channel shall have individual power supply short circuit protection. Configuration and calibration data shall be stored in a non-volatile EEPROM plug-in memory module. In addition, a redundant plug-in backup memory module shall be furnished that will automatically download into the primary memory if primary memory data is corrupted. As an alternate to redundant plug-in memory modules, provide all necessary portable computers, software and hardware to allow configuration downloading and archival.

#### 7. Communication

Each controller shall be equipped with an isolated RS485 communications data highway that communicates in Modbus protocol. Isolation is required to prevent damage to all controllers on the same RS485 cable should a 120 VAC short occur anywhere in the system. The RS485 protocol shall allow: Auto/ Manual mode change, setpoint change, variation of the manual output, sensing and silencing of alarms, change of any configuration parameter (including PID tuning constants), change of timers, etc. Controllers shall not depend on a serial communications link to send sensor data required from controller to controller unless the link is fully redundant. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA system is not included in this project.

#### 8. Quality Assurance

The controllers shall be manufactured and labeled in accordance with UL508A (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). Lack of an NRTL certified UL508A wiring methods inspection and labeling will be grounds for controller rejection.



# DRAFT CONTROL ACTUATOR

Model JC-22-PL2-1006

## Introduction

The Preferred Instruments **JC-22-PL2-1006** is a linear actuator with an integral microprocessor-based draft controller and a solid state draft range pressure sensor.

The **JC-22-PL2-1006** is housed in a durable metal enclosure with a removable cover.

The **JC-22-PL2-1006** is a direct replacement for the *Hays Cleveland CDR* model # 9502-1012-B-8.

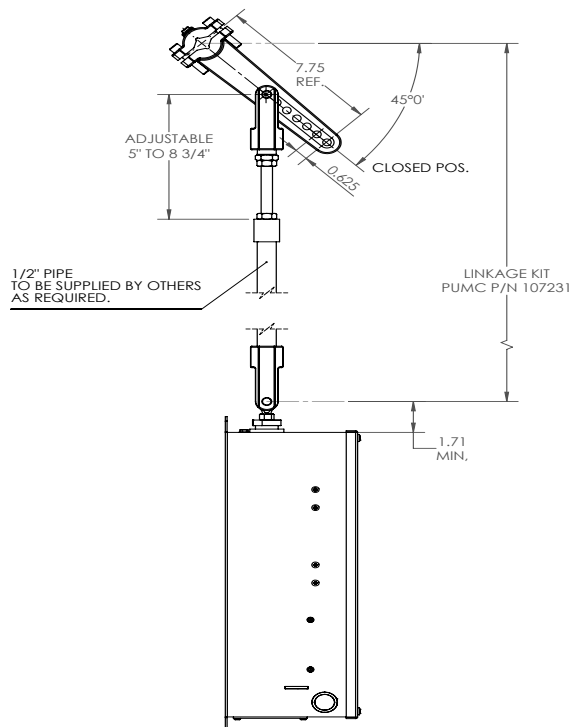
The **JC-22-PL2-1006** provides automatic modulation for any negative or positive draft application.

## Specifications

Weight & Dimension: 21 lbs. 17.5" L x 7.5" W x 5.9" H  
 Power Requirements: 120 VAC, 50/60Hz, 360 VA  
 Motor: 72 RPM synchronous motor  
 Sample Connection: 1/4" NPT female fitting  
 Ambient Temp Range: 0 to 140F (-18 to 60C)

## Application

Travel: 6 inch linear, 60 sec. stroke  
 Thrust: 150 lbs  
 User Auxiliary Switch: Damper Fully Open, 16A, 250VAC  
 Set Point: Adjustable, 0 to +2.0" w.c. or 0 to -2.0" w.c. (field selectable)  
 Dampening: Adjustable, 1.5 to 15 seconds for 90% response to a step change  
 Dead Band: Adjustable, 0.01 to 0.08" w.c.  
 Proportional Band: Adjustable, 0.03 to 0.2" w.c. (deviation from set point required to run at full speed)



## Operation

Offers a 6-inch range of travel with a 60-second nominal stroke time. The **JC-22-PL2-1006**'s thrust range is rated at 150 lbs with a cool-running 72 RPM synchronous motor.

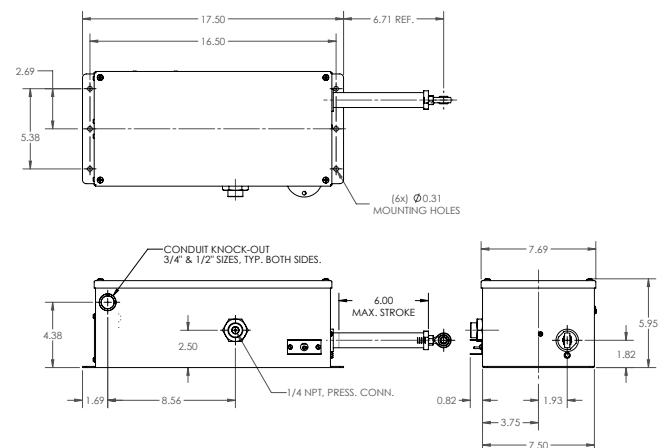
The actuator is self locking in the "last" position if there is a power loss.

Preferred's **JC-22-PL2-1006** interfaces with your burner management system:

The **JC-22-PL2-1006** is a sequencing draft controller.

Includes burner management interfacing relays for automated open damper during purge, and closed damper after shutdown.

Includes an automatic/ open selector switch. This allows the user to blow soot without interrupting the burner firing and allows the burner to fire in the "open" damper mode under emergency conditions.



# DRAFT RANGE HIGH DIFFERENTIAL PRESSURE CUTOFF

Model JC-22-HDPCO-8

## Introduction

The JC-22-HDPCO-8 is a draft range differential pressure switch with red warning light and time delayed cutout relay contacts. The normally energized cutout relay contacts open when the differential pressure is higher than the setpoint for more than 8 seconds. The setpoint is field adjustable over the 0.05" to 9.0"wc range.

The **JC-22-HDPCO-8** is a direct replacement for the *Hays Cleveland* model # AFS-952-55-B.

## Application

The most common application of the JC-22-HDPCO-8 is as a high pressure cutoff switch for combustion draft control systems.

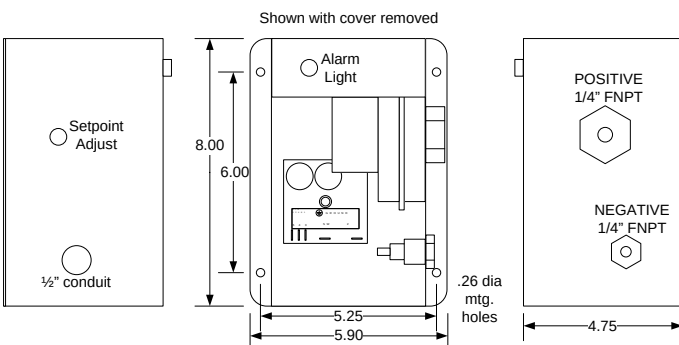
**High Positive Pressure Cutoff:** Cutoff when positive pressure exceeds setpoint for more than 8 seconds.

**High Negative Pressure Cutoff:** Cutoff when negative pressure exceeds setpoint for more than 8 seconds.

**High differential Pressure Cutoff:** Cutoff when differential pressure exceeds setpoint for more than 8 seconds.

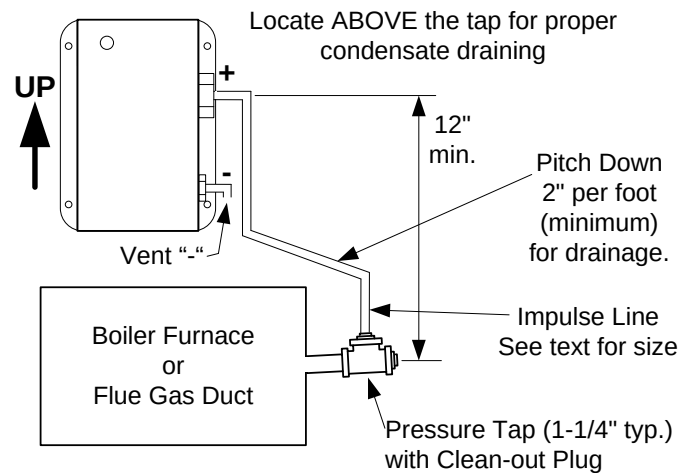
## Specifications:

|                  |                             |
|------------------|-----------------------------|
| Range:           | 0.05"wc to 9.0"wc           |
| Deadband:        | Progressive                 |
|                  | 0-1" SP: +/- 0.03" max      |
|                  | 9" SP: +/- 0.9" max         |
| Max Pressure:    | 20" wc, port to ambient     |
| Life:            | 100,000 cycles min.         |
| Operation Temp.: | -20°F to 150°F              |
| Power:           | 120 Vac, 50/60, 5 VA        |
| Output:          | SPDT, 10A/120 Vac           |
| Enclosure:       | NEMA 1                      |
| Orientation:     | Diaphragm in vertical plane |
| Ports:           | 1/4" FNPT                   |
| Weight:          | 5 lbs.                      |



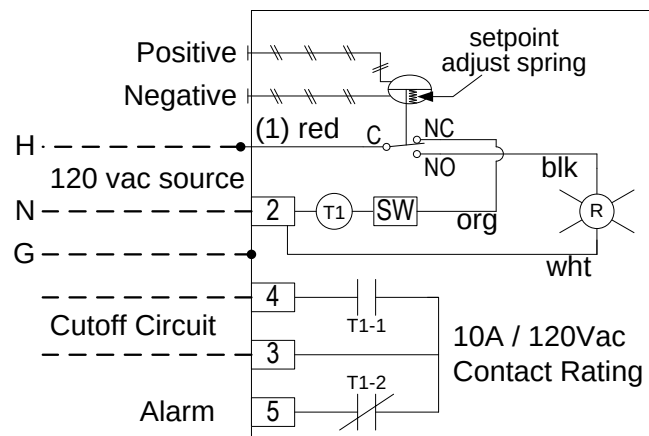
*Note: JC-22-LDCO-8 version is available for low positive pressure or low negative pressure applications.*

## Typical Installation:



Typical Boiler Draft Cutout Application

## Wiring:



JC-22-HDPCO-8 schematic

## DRAFT CONTROLLER

### Model JC-22D

Uncontrolled stack draft can cause burner instability, unreliable ignition, and affect fuel-air ratio control repeatability. Burner manufacturers typically recommend draft controls be installed in applications where:

- Stack height exceeds 75 feet
- Multiple furnaces are connected to a single stack

#### JC-22D "Floating" Draft Control Mode

- Direct Field Replacement for existing JC-20F11AR2 and similar units
- Compatible with existing electric draft actuator, does not require feedback pots
- Uses proportional control to direct the damper open or closed until the draft returns to setpoint.

#### JC-22D "Precise" Draft Control Mode

- Precise PID control
- "GAP" PID Draft Control uses a dual gain strategy (ie.: lower gain near setpoint, higher gain farther away from setpoint) to allow precise draft control without hunting due to draft pulsations.
- Firing rate feedforward allows the controller to instantly respond to changes in firing rate demand without waiting for the outlet pressure to deviate from the acceptable range. This is especially important in Induced Flue Gas Recirculation (IFGR) applications.
- Adjustable start position directs the outlet damper to 100% for purge and then closes the damper to a predetermined position for light-off. Boilers with very tall stacks, oversized ID fans, or wide turndown Low NOx burners may not be able to light-off with the outlet damper wide open.

#### Automatic Draft Sequence

- Damper positioned for purge, light-off, post-purge and burner shutdown. To prevent pressurizing the boiler during startup, the draft damper opens immediately, and the burner fan start is delayed 0 - 30 seconds (adjustable). The damper is closed when the boiler is off-line to minimize energy waste.

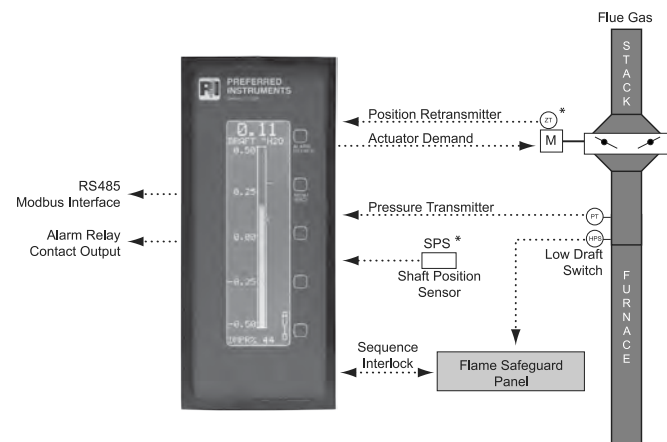
#### Low Draft Alarm Message and Contact

#### Automatic Draft Control Increases Boiler Efficiency

- Reducing the air infiltration into the furnace reduces heat lost up the stack. Uncontrolled boiler draft results in a more negative boiler pressure and therefore more cold air being drawn into the boiler
- Maintaining a stable and optimum draft despite changes in ambient air temperature, wind velocities, firing rates, and flue pass sooting conditions allows the burner control systems to operate with less excess air. At a given F.D. fan inlet damper position, the air flow through the burner will change as boiler draft changes.



JC-22D Draft Controller



Draft Control General Arrangement

\*Not required for "floating" point draft control applications

#### Description

The JC-22D Draft Monitor and Controller is a microprocessor-based draft controller, indicating instrument, and alarm monitor. The JC-22D directly accepts a 4-20 mADC draft transmitter signal, 120 VAC flame safeguard interface, and outputs a solid state switching (triac) or 4-20 mADC outlet damper actuator control signal. Draft is continuously displayed using a highly visible backlit LCD display. An intuitive bargraph display and alarm message provide clear boiler draft status. All adjustments can be made directly from the faceplate of the instrument by scrolling

# DRAFT CONTROLLER

## Model JC-22D

through user friendly, English language menus. The outlet damper may be controlled in "auto" or "manual" mode and will automatically sequence through the purge, light-off, post-purge and burner shutdown modes in response to flame safeguard system inputs. The JC-22D automatically positions the outlet damper according to burner operation based on either the field selectable "floating" or "precise draft" control modes.

### Specifications

#### Panel

Power Supply: 120 VAC, +/- 15%, 50/60Hz, 15 VA  
Case Size: 8" H x 3.5" W x 7.5" D  
Enclosure Type: NEMA 4 faceplate  
Ambient Temp.: +32° to 122° F  
Displays: High Contrast LCD Display

Bargraph Range: -1.00 to +1.00" W.C.  
Alarm Setpoints: One (1) adjustable contact with adjustable time delay

#### Inputs

Draft Input: 4-20 mADC digital filtered  
Firing Rate Input: 300 ohm (minimum) or 4-20 mADC  
Discrete Input: Five, Optically isolated  
120 VDC, 10 mA load  
Actuator Feedback: 300 ohm min feedback pot (required for GAP PID Control Mode)

#### Outputs

Relay Outputs: Three SPDT Relays  
10 A Resistive, 8 FLA, ½ HP, 120 VAC  
Actuator Outputs: One Triac pair, 2 FLA/24-120 VAC or 4-20 mADC  
Network: 1200 - 38400 Baud; RS485 Modbus, ASCII or RTU

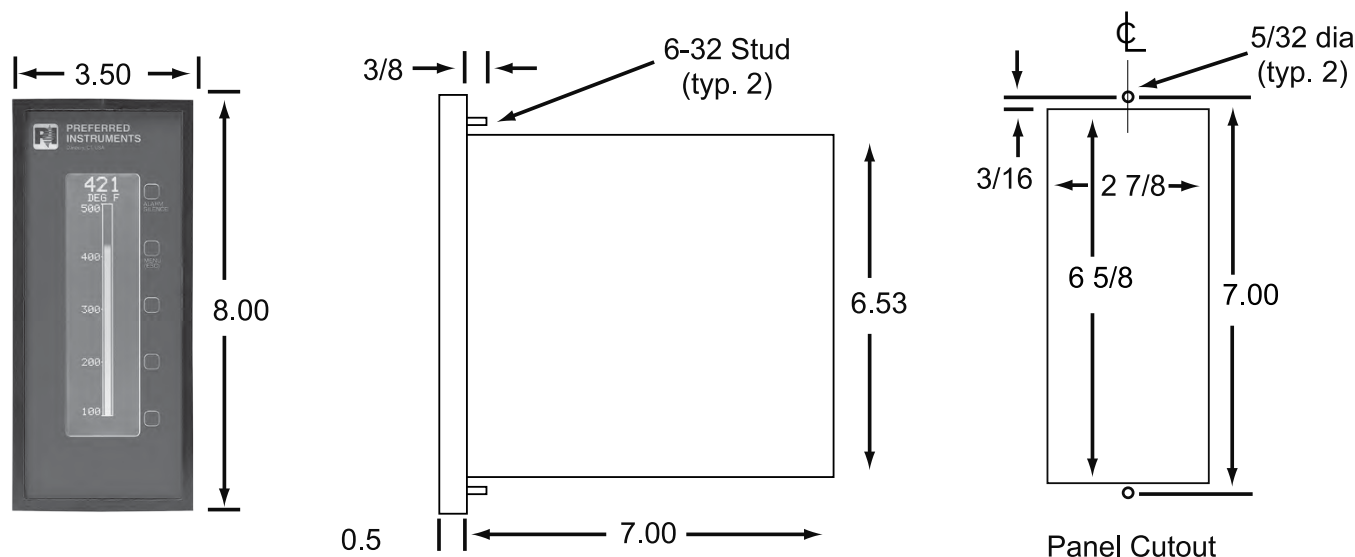
### Ordering Information

#### To order a "Floating" Draft Control System, specify the following:

- 1) Specify Model JC-22D Draft Controller with Model JC-XMTR Draft Range Transmitter Assembly
- 2) Specify DM-2 Electric Rotary Actuator or PL-2 Electric Linear Actuator
- 3) Alternately, Specify Model JC-22D Draft Controller and Model E-Link Draft Damper Assembly

#### To order a "Precise" Draft Control System, specify the following:

- 1) Specify Model JC-22D Draft Controller with Model JC-XMTR Draft Range Transmitter Assembly
- 2) Specify SM Electric Rotary Actuator Triac or R-AL-2-3-P1-4-S2-0 Electric Linear Actuator (4-20 mA)
- 3) Alternately, Specify Model JC-22D Draft Controller and Model E-Link Draft Damper Assembly
- 4) Specify Model SPS Shaft Position Sensor (when required)



JC-22D Mounting and Clearance Dimensions

# DRAFT CONTROLLER

Model JC-22D

## Suggested Specifications

### 1. Application

Provide a self contained automatic sequence draft controller for each furnace. The controller shall be microprocessor-based and suitable for flush, panel mounting. Provide a field mountable 4-20 mADC pressure draft transmitter for measuring boiler outlet draft. Provide a high flue gas pressure (low draft) switch with 5 second delay for use in the Flame Safeguard Limit Circuit.

### 2. Draft Controller

The Controller shall continuously indicate furnace draft, draft setpoint and alarm setpoint on a highly visible backlit LCD display. The control shall provide both automatic and manual damper control. Provide an integral or separate 4", 0.5% resolution (minimum) bargraph display in engineering units with visual alarm indication. Provide a "high boiler pressure" alarm, "alarm silence" pushbutton and one 10 A alarm relay output. The housing shall be panel mountable, fully gasketed with NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. The controller shall include setup menus for easy operation, tuning and troubleshooting from the Controller faceplate. No external configuration tools shall be required.

### 3. Automatic Draft Sequence

The controller shall include an automatic draft sequence as follows: during burner "off" periods the draft control damper shall remain closed to hold residual heat within the boiler. On a call for burner operation the outlet damper shall be driven open for pre-purge. To prevent pressurizing the boiler, the burner fan shall start after a field adjustable time delay after starting to open the draft damper. The damper shall remain open for burner light-off. When the fuel valve opens, the draft control damper shall be released from the open position and modulate as required by the draft setpoint. During normal burner shut-down the damper shall be driven open during the post-purge period and then closed when the fan stops. Abnormal burner shut-down (safety lock-out of flame safeguard control) shall cause the damper to drive open where it shall remain until the flame safeguard system is reset. The controller shall interconnect with the flame safeguard system directly using 120 VAC signals.

### 4. Draft Damper Modulation

When the precise draft control mode is required, the controller shall provide boiler outlet damper modulating control based on characterizable firing rate feed-forward signal to assure stable draft during load changes and "GAP" PID Draft Control for improved stability. Provide a Model SPS firing rate feedback potentiometer as manufactured by Preferred Instruments, Danbury, CT, or firing rate output from the firing rate controller. The controller shall be capable of establishing an adjustable position for burner light-off. Each fuel shall have an independent light-off position. The controller shall not close the light-off contact output unless the damper is above the proper position and the pressure is below the starting draft setpoint. Alternately, the controller shall be field selectable to provide "floating" draft control. When "floating" draft control is selected, the controller shall provide proportional control of the boiler outlet damper to maintain boiler draft at setpoint using a 24 VAC, Triac positioning output.

### 5. Draft Range Transmitter and High Pressure Switch

Provide a draft range transmitter and high pressure (low draft) switch with time delay relay. Both shall be supplied with field mountable, dust-tight, splash-proof enclosures. A single draft connection shall be piped to -1" W.C. to +1" W.C. 4-20 mADC transmitter and an independent low draft switch. The low draft switch setpoint shall be field adjustable from +0.15" W.C. to +4.0" W.C. The low draft switch shall be mounted and wired to a pilot light so as to illuminate when the low draft switch activates and to a 5 second time delay relay so as to provide an isolated "low draft cut-out", 10 A contact for use in the Flame Safeguard limit circuit. The time delay feature helps avoid nuisance burner shutdowns due to momentary draft fluctuations.

### 6. Draft Damper Actuator (when required)

Provide an electric Draft Damper Actuator for each furnace. The actuator shall have adequate power to automatically position the damper and shall be suitable for control by the draft controller. The actuator shall be totally enclosed in a dust-tight housing; have integral, snap-action, travel limit and open proving switches, be capable of being stopped, started, or instantly reversed without loss of power or overloading. A double ended output shaft shall have an integral brake for precise positioning without backlash and rotate 90° in 30 seconds. When the precise draft control mode is selected, the actuator shall include an electrically isolated feedback potentiometer.

### 7. Draft Damper Assembly - Model E-Link (when required)

Provide a factory assembled stack damper assembly for each furnace. The draft damper shall be a dual opposed blade design, have 24" inside diameter [select from 12", 16", 20" or 24" diameter to match boiler outlet, consult factory for larger sizes], constructed of 10 gauge rolled steel. Non-opposed blade damper designs are not acceptable. Factory mount the draft damper actuator, draft range transmitter and time delayed, high pressure (low draft) cut-out assemblies (described in the above paragraphs) on the damper assembly. The damper actuator and damper assembly shall be stroked at the factory to ensure proper alignment. "Shipped loose" components will not be accepted.

### 8. Communication

The Instrument shall include a RS485 Modbus network interface to communicate to a future Data Acquisition System (DAS) or Building Automation System (BAS).

### 9. Quality Assurance

The Instrument shall be manufactured and labeled in accordance with UL508 (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The draft control system shall be a Preferred Instruments, Danbury, CT, Model JC-22D Draft Controller with Model JC-22XMTR Draft Range Transmitter Assembly or JC-22D Draft Controller and E-Link Draft Damper Assembly and Model SPS Shaft Position Sensor (when required).



## DRAFT RANGE TRANSMITTER ASSEMBLY

Model JC-22XMTR (with Time Delayed High Pressure Cut-Out)

The JC-22XMTR draft transmitter is specially designed for furnace stack draft applications.

- -1" W.C. to +1" W.C. Draft Transmitter Range
- +0.15" W.C. to +4.0" W.C. High Pressure Cut-Out Setpoint (field adjustable)
- 5 Second High Pressure Cut-Out Time Delay Relay
- Combination Draft Range Transmitter, Independent High Pressure Cut-Out with 5 second time delay relay in one box and a single draft connection saves installation cost

Typical low range transmitters do not include these features and will not work reliably in draft control applications.

The Model JC-22XMTR Draft Transmitter Assembly is a field mountable furnace draft range transmitter and independent high pressure cut-out switch with 5 second time delay relay. The transmitter provides a 4-20 mADC signal for draft control and the time delay relay provides an isolated "high pressure cut-out" contact for use in the Flame Safeguard limit circuit. The time delay feature helps avoid nuisance burner shutdowns caused by momentary draft fluctuations. Transmitter is calibrated as +1" W.C. = 4 mA to provide fail-safe operation (damper opens).

### Suggested Specifications

Provide a -1" W.C. to +1" W.C., 4-20 mADC furnace draft range transmitter and an independent high pressure cut-out with 5 second time delay. Instruments shall be provided with a dust-tight, splash-proof enclosure. The high pressure setpoint shall be field adjustable from +0.15" W.C. to +4.0" W.C.. The high pressure switch shall be mounted and wired to a pilot light so as to illuminate when the switch activates and to a 5 second time delay relay so as to provide an isolated, 10 ampere contact for use in the Flame Safeguard limit circuit. The Draft Range Transmitter with time delayed high pressure cut-out shall be a Preferred Instruments, Danbury, CT Model JC-22XMTR.



*Draft Range Transmitter Assembly Model JC-22XMTR  
(with door shown closed)*



*Draft Range Transmitter Assembly with Model JC-22XMTR  
(shown with door open)*

### Specifications

|                                          |                                                |
|------------------------------------------|------------------------------------------------|
| <b>Enclosure:</b>                        | NEMA 4,12,13 field mounted                     |
| <b>Transmitter</b>                       |                                                |
| Range:                                   | +1" W.C. to -1" W.C.                           |
| Output:                                  | 4-20 mADC (2-wire)                             |
| Accuracy:                                | +/- 0.75% FS                                   |
| Power Supply:                            | 24 VDC                                         |
| <b>High Pressure (Low Draft) Cut-Out</b> |                                                |
| Range:                                   | +0.05" W.C. to +1.0" W.C.,<br>field adjustable |
| Dead band:                               | 0.05" W.C. (average)                           |
| Contact:                                 | 20 A/120 VAC                                   |

### Ordering Information

Specify Model JC-22XMTR-HPCO  
Model JC-22XMTR-LDCO

## SHAFT POSITION SENSOR

Model SPS

- 0 - 100% Boiler Firing Rate Signal
- Sensor used by Oxygen Trim, Furnace Draft or other control that require a boiler load index
- 45 to 160 degree stroke input allows installation flexibility

The Shaft Position Sensor (SPS) is a general-purpose feedback pot for applications that require firing rate feedback as a basis for establishing setpoints for other control loops such as oxygen trim or FGR flow.

### Specification

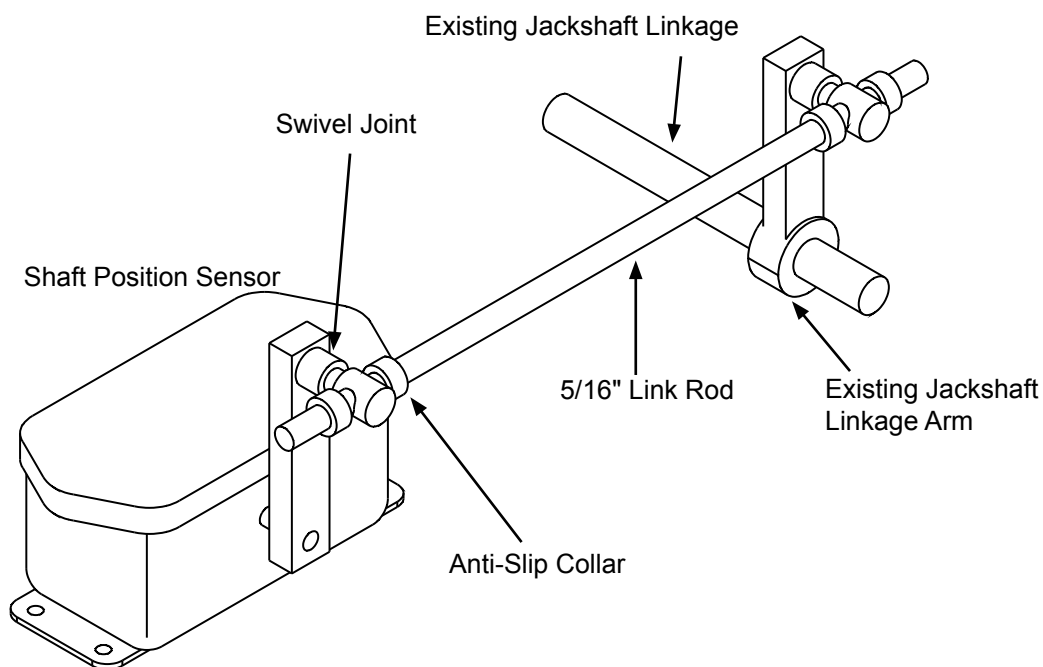
Stroke: 45 to 160 degree  
Output: 1K ohm Potentiometer  
Enclosure: NEMA 12  
Linkage Rod: 5/16" 6" x 3' linkage  
Swivel Joint  
Connection: 1/4" - 20 threaded

### Ordering Information

Model SPS



Shaft Position Sensor Model SPS



Typical Linkage Assembly

## DRAFT DAMPER ASSEMBLY

### Model E-Link

- Complete Draft Damper Assembly saves installation time and cost by factory mounting actuator, draft transmitter and low draft switch
- The Model E-Link Draft Damper Assembly and JC-22D Draft Controller form a complete draft control package

The Model E-Link Draft Damper Assembly pre-mounts a Model SM-15 servo actuator and JC-22XMTR Draft Range Transmitter Assembly. Only a stack draft connection is required. The Model E-Link Draft Damper Assembly is part of a full scope control package that assures safe and efficient control with undivided system responsibility.

### Suggested Specifications

Provide a factory assembled furnace outlet draft damper assembly for each boiler. Factory mount the draft damper actuator, draft transmitter and time delayed high pressure cut out. The draft damper shall be a dual opposed blade design, have 24" inside diameter (select from 12", 16", 20" or 24" diameter to match boiler or furnace outlet, consult factory for larger sizes), constructed of 10 gauge rolled steel. Non-opposed blade damper designs are not acceptable. The draft range transmitter and time delayed, high pressure (low draft) cut-out assembly shall be totally enclosed in a single dust-tight, splash-proof enclosure. A single draft connection shall be internally piped to a -1" W.C. to +1" W.C. 4-20 mADC transmitter and an independent low draft switch. The low draft switch setpoint shall be field adjustable from +0.15" W.C. to +4.0" W.C. The low draft switch shall be mounted and wired to a pilot light so as to illuminate when the low draft switch activates and to a 5 second time delay relay so as to provide an isolated "low draft cut-out," 10 A contact for use in the Flame Safeguard limit circuit. The time delay feature helps avoid nuisance burner shutdowns due to momentary draft fluctuations. The actuator shall have adequate power to automatically position the damper and shall be suitable for control by the draft controller. The actuator shall be totally enclosed in a dust-tight housing, have integral, snap-action, travel limit and open proving switches, electrically isolated feedback potentiometer. A output shaft shall have an integral brake for precise positioning without backlash, rotate 90° in 30 seconds and be capable of being stopped, started, or instantly reversed without loss of power or overloading. The damper actuator and damper assembly shall be stroked at the factory to ensure proper alignment. "Shipped loose" components will not be accepted. The draft damper assembly shall be a Preferred Instruments, Danbury CT, Model E-link Draft Damper Assembly.



Model E-Link  
Draft Damper Assembly

### Standard Equipment

Draft Damper Assembly preassembled with Model SM Electric Actuator and Model JC-22XMTR Draft Transmitter with delayed high pressure switch.

### Specifications

|                          |                                                              |
|--------------------------|--------------------------------------------------------------|
| <b>Damper Frame:</b>     | 10 gauge Carbon Steel Rolled Channel with mounting holes     |
| <b>Damper Blades:</b>    | (2) Opposed Blades, 10 gauge Carbon Steel                    |
| <b>Inside Diameters:</b> | 12", 16", 20", and 24" consult Factory for nonstandard sizes |
| <b>Height:</b>           | 8"                                                           |
| <b>Bolt Holes:</b>       | 16 for 24", 12 for 12", 16" and 20"                          |
| <b>Finish:</b>           | High temperature primer                                      |
| <b>Actuator:</b>         | SM Rotary Actuator, close coupled to Damper Shaft            |

### Ordering Information

1. Specify E-Link Draft Damper Assembly
2. Specify Damper Size (12", 16", 20" or 24"), consult factory for larger or non-listed sizes
3. Specify Model JC-22D Draft Controller
4. Specify Model SPS Shaft Position Sensor (not required for "Floating" Draft Control System)

## PROCESS BARGRAPH INDICATOR AND ALARM MONITOR

Model JC-10D

### High Visibility Bargraph and Numeric Display

- 4 Digit Numeric Display
- 200 Segment Bargraph
- Bargraph Alarm Setpoint Markings
- High Intensity, Long Life LED Backlighting

### Field Adjustable using English-Language Menus

- Inputs: 4-20 mADC, Thermistor, J or K Thermocouple
- 4-20 mADC Input and 4-20 mADC Output Scaling
- Bargraph Scaling
- Alarm Modes, Setpoints, Deadbands, and Time Delays

### Dual SPDT Relays

- Configurable: HI-HI, HI, LO, LO-LO, Manual Reset
- 10 A resistive, 8 FLA, ½ HP, 120 VAC

### NEMA 4 Front Panel

### Flexible Communications for Data Logging

- 4-20 mADC Re-transmission
- RS485 Modbus Interface

### **Description**

The JC-10D **Process Indicator** is a microprocessor-based Indicator/ Alarm that can be field configured for a wide variety of applications. The instrument provides a highly visible backlit LCD display with easy to understand bargraph, scaled numeric display, and front panel alarm messages. bargraph scaling, alarm setpoints, and time delays are all field selectable. Adjustments are made directly from the faceplate of the instrument by scrolling through a user friendly, English language menu. The unit is constructed of a rugged polymer housing with a gasketed NEMA 4 faceplate.

### **Typical Applications:**

Boiler Draft  
Boiler Drum Level  
Tank Levels  
Flow Rates  
Pressures  
Temperatures

### **Note:**

Any process condition that outputs a signal compatible with the JC-10D can be directed to this assembly.



JC-10D Process Indicator and Alarm Monitor  
(shown in Alarm Mode with reset pushbutton)

# PROCESS BARGRAPH INDICATOR AND ALARM MONITOR

Model JC-10D

## Versatile

Field selectable input types: 2 or 4 wire 4-20 mADC, 10k Thermistor, J or K Thermocouple, Potentiometer, 0-2.5 VDC, or Pulser. Thermistors and thermocouples are linearized and cold junction compensated. The numeric display can be scaled to any desired range from the front panel. The bargraph range and scaling can be set independently from the input scaling. The 4-20 mADC retransmission output can be scaled independently as well.

## Alarm Sequences

The two (2) alarms can be configured as HI-HI, HI, LO, or LO-LO alarms with individually adjustable deadbands and time delays. Alarm adjustment is done in scaled engineering units, not percentages. The two (2) relay outputs can be assigned as to an alarm or as a common alarm output with alarm silencing logic. Each relay can be configured as auto-reset or manual-reset.

## Suggested Specifications

Provide a remote reading, microprocessor-based process indicator and alarm system to monitor [specify required monitoring point such as boiler draft, drum level, tank level, flow or pressure...]. The instrument shall provide a continuous numeric and 4", 0.5% resolution (minimum) bargraph display. The instrument shall contain: dual adjustment alarm setpoints with 10 A relay outputs, unique messages and manual reset pushbutton. The Instrument shall be field selectable as 2 or 4 wire 4-20 mADC, 10k Thermistor, J or K Thermocouple, Potentiometer, 0-2.5 VDC, or Pulser. The Instrument shall provide cold junction, and upscale thermocouple break protection for thermocouples, 4-20 mADC and RS485 Modbus remote output signals. The housing shall be panel mountable, fully gasketed with a NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. No external configurator or laptop shall be required. The Instrument shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). Indicator and Alarm System shall be Preferred Instruments, Danbury, CT, Model JC-10D.

## Specifications

### Panel

Power Supply: 120VAC, +/- 15%, 50/60Hz, 15 VA  
Case Size: 8" H x 3.5" W x 7.5" D  
Enclosure Type: NEMA 4 faceplate  
Ambient Temp.: +32° to 122° F  
Displays: High Contrast LCD Display  
4" high, 0.5% Resolution Bargraph  
Alarm Setpoints: Two (2) adjustable with adjustable time delays HI-HI, H, L, LO-LO modes  
Manual Reset & Alarm Silence modes

### Inputs

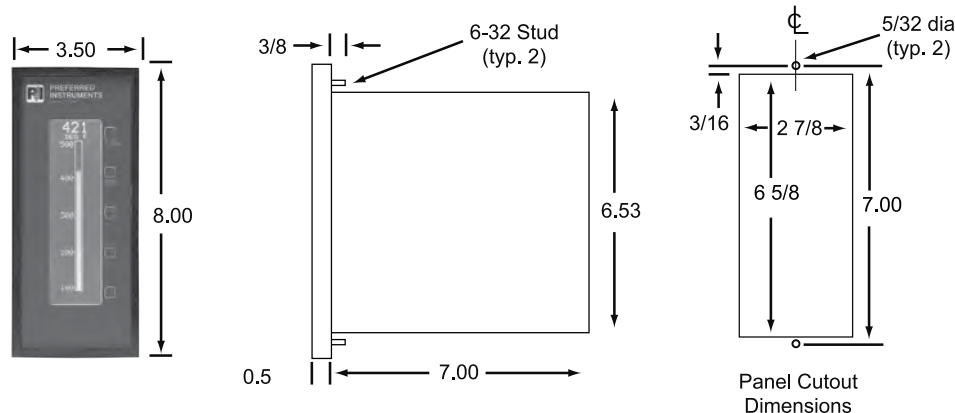
Input Types: Field selectable  
4-20 mADC, 100 ohm load  
Thermistor, -20° to +300° F  
Type J Thermocouple, 0°-1000° F  
Type K Thermocouple, 0°-2000° F  
Potentiometer, 100 ohm to 10 Kohm  
0-5 VDC  
Accuracy: 0.005% Resolution  
0.07 % Accuracy  
Sensor Power: 24 VDC @ 100 mA  
15 VDC @ 50 mA  
2.5 VDC @ 12 mA

### Outputs

Relay: Two SPDT Relays 10 A resistive, 8 FLA, ½ HP, 120 VAC  
Retransmit: 4-20 mADC, 650 ohm load maximum  
Network: 1200 - 38400 Baud; RS485 Modbus, ASCII or RTU

## Ordering Information

- JC-10D Instrument





# FLUE GAS TEMPERATURE MONITOR & CUTOUT

Model JC-15D

## Low Boiler Efficiency Alarm Message and Contact

- Elevated stack temperature will indicate reduced boiler efficiency
- Every 40° F increase in flue gas temperature results in an approximate 1% decrease in boiler efficiency

## Burner Shutdown Contact and Message

- Dangerously high temperatures place the boiler at risk of serious overheating damage
- Provides additional protection against mud-filled low water cutout float switch failures
- "Three out of every four accidents are caused by overheating, and 80% of the overheating losses resulted from continued firing with low water levels; despite the fact that boilers, ... are equipped with up-to-date controls."

(from M.P. Bragg and S.R. Laskey, "Low Water Accidents," The Hartford Steam Boiler Inspection and Insurance Co.)

## High Visibility Bargraph and Numeric Display

- 4 Digit Numeric Display
- 200 Segment Bargraph
- Bargraph Alarm Setpoint Markings
- High Intensity, Long Life LED Backlighting

## Field Adjustable using English-Language Menus

- Inputs: Type J or K Thermocouple
- 4-20 mADC Output Scaling
- Fahrenheit or Centigrade
- Bargraph Scaling
- Alarm Modes, Setpoints, Deadbands, and Time Delays

## NEMA 4 Front Panel

## Flexible Communications for Data Logging

- 4-20 mADC Temperature Re-transmission
- RS485 Modbus Interface

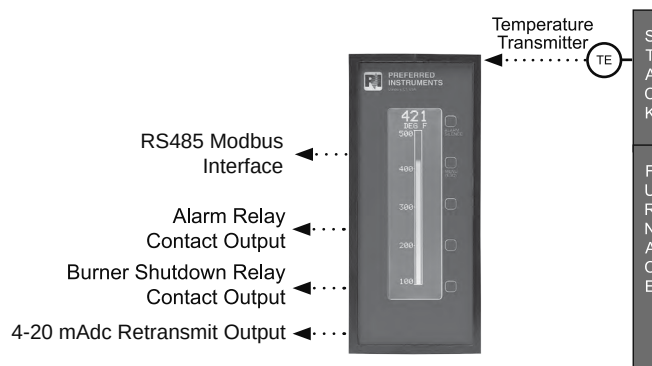
## Description

The JC-15D **Flue Gas Temperature Monitor** is a microprocessor-based indicating instrument for use with a heavy duty thermocouple assembly. Flue gas temperature is continuously displayed using a highly visible backlit LCD display. An intuitive bargraph display and alarm messages provide clear stack temperature status. Bargraph scaling, alarm setpoints, and time delays are all field selectable. All adjustments can be made directly from the faceplate of the instruments by scrolling through user friendly, English language menus.

The Type J thermocouple assembly is constructed of a seal welded inconel sheath for corrosion protection, and can be directly installed in the boiler's flue gas outlet. The unit includes a ½" male NPT process connection, cast iron head with thermal block, and ½" female NPT electrical connection.



JC-15D Faceplate and Display



Typical Arrangement



Thermocouple Assembly Model 104087D (20")

104087E (12")

## FLUE GAS TEMPERATURE MONITOR & CUTOUT

Model JC-15D

### Alarm Sequence

Bargraph and numeric displays continuously indicate the flue gas temperature. If the flue gas temperature exceeds the warning setpoint for more than 30 seconds (adjustable), the bargraph blinks, the “warning” message appears, and the alarm relay energizes. If the flue gas temperature continues to increase and exceeds the shutdown setpoint for more than 30 seconds (adjustable), the bargraph blinks, the “shutdown” message appears, the shutdown relay de-energizes and latches into “manual reset” mode. The burner shuts down if the JC-15D shutdown relay is wired into the burner interlocks. The shutdown relay remains de-energized and the “shutdown” message remains on the display until the operator presses the “reset” pushbutton.

The alarm relay can be used to activate an external bell or horn. The alarm relay de-energizes when the “warning” and “shutdown” alarms are both inactive. Alternately, pressing the JC-15D “alarm silence” pushbutton, or energizing the 120 VAC alarm silence input, or a Modbus command can de-energize the alarm relay in order to silence an audible alarm.

### Suggested Specifications

Provide a remote reading microprocessor-based flue gas temperature alarm and indicating instrument and a flue gas temperature sensor assembly for each boiler. The instrument shall provide a flue gas temperature display in engineering units, “inefficient” operation warning indication, “overheat” operating condition indication and alarm contacts. The Instrument shall continuously indicate flue gas temperature on a highly visible backlit LCD display. Provide an integral or separate 4 inch, 0.5% resolution (minimum) bargraph display in engineering units with visual alarm setpoint indication. Provide an “alarm silence” and “manual reset” pushbutton and two 10 ampere relays. The housing shall be panel mountable, fully gasketed with NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. No external configuration tools shall be required. The Instrument shall provide: cold junction compensation and upscale thermocouple break protection. The instrument shall include alarm messages as follows: When flue gas temperature exceeds the “warning” setpoint for more than 30 seconds (adjustable), the bargraph shall blink, and the “warning” message shall appear and an “alarm” relay energizes and if wired to an alarm circuit an alarm is activated. If the flue gas temperature continues to increase and exceeds the “shutdown” setpoint for more than 30 seconds (adjustable), the bargraph blinks, the “shutdown” message appears, the “shutdown” relay de-energizes and latches into the “manual reset” mode. If the “shutdown” relay is wired into the burner interlocks, the burner shuts down. The “shutdown” relay remains de-energized and the “shutdown” message remain on the display until the operator presses the integral “reset” pushbutton.

Provide a Flue Gas Temperature Sensor assembly for each boiler. The sensor assembly shall include: iron/constantan ISA Type J thermocouple, inconel sheath, ½" male NPT process connection, cast iron head and a 20" insertion length. Extension lead wire shall be one continuous length of 20 gauges ISA Type JX with PVC insulation. The assembly shall be installed in the boiler outlet before any damper or fan in accordance with manufacturers suggested installation instructions. The instrument shall include a RS485 Modbus network interface and a 4-20 mADC retransmit output to communicate to a future Data Acquisition System (DAS) or Building Automation System (BAS). The Instrument shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The Flue Gas Temperature Monitoring, Control and Alarm System shall be Preferred Instruments, Danbury, CT, Model JC-15D, with 104087D Thermocouple Assembly.

# FLUE GAS TEMPERATURE MONITOR & CUTOUT

Model JC-15D

## Specifications

### Panel

Power Supply: 120 VAC, +/- 15%, 50/60 Hz, 15 VA  
 Case Size: 8" H x 3.5" W x 7.5" D  
 Enclosure Type: NEMA 4 faceplate  
 Ambient Temp.: +32° to 122° F  
 Displays: High Contrast LCD Display  
 4" high, 0.5% Resolution Bargraph  
 Bargraph Range: 0°-2000° F field adjustable  
 Alarm Setpoints: Two (2) adjustable with adjustable time delays

### Ordering Information

1. JC-15D Instrument
2. 104087E Type J Thermocouple Assembly 12"
3. 104087D Type J Thermocouple Assembly 20"
4. 92088-J-B20PP Shielded type J thermocouple wire (specify wire length in multiples of 25 feet)
5. Optional Accessories:  
 SDA-B6 Alarm Bell. 85 db, weather-proof  
 SDA-VB Remote Audible/Visual Alarm

### Inputs

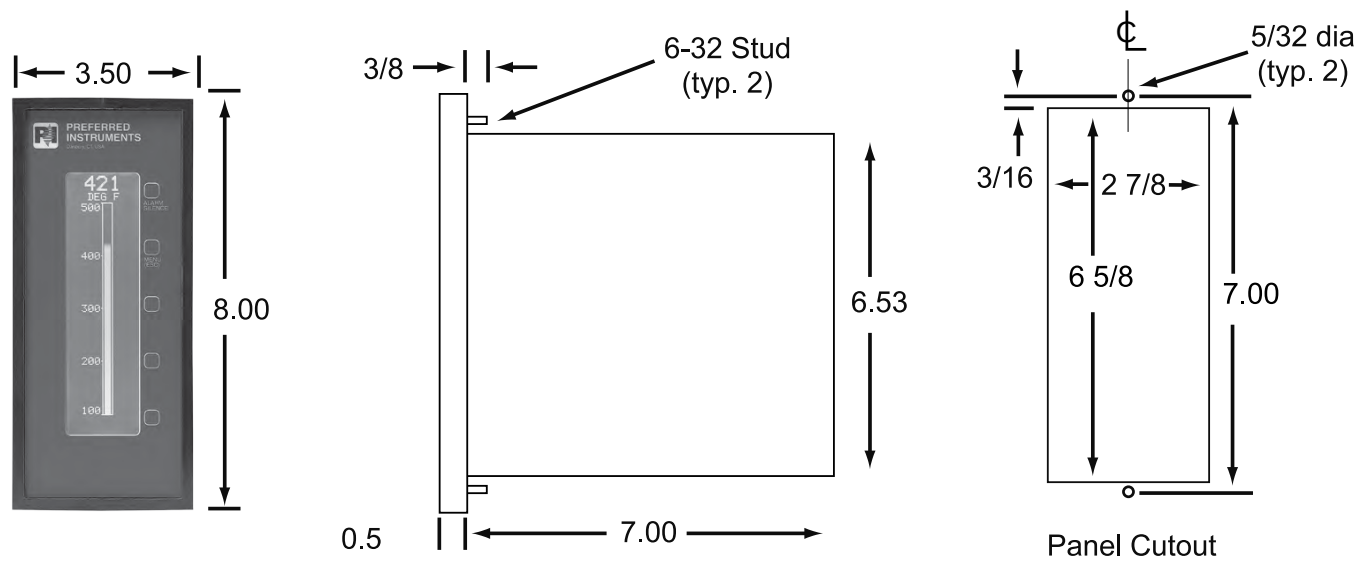
Input Types: Type J or Type K Thermocouple, field selectable  
 Accuracy: 0.005% Resolution  
 0.07% Accuracy  
 Break Protection: Upscale

### Outputs

Relay: Two SPDT Relays 10 A resistive, 8 FLA, ½ HP, 120 VAC  
 Retransmit: 4-20 mADC, 650 ohm load maximum  
 Network: 1200 - 38400 Baud; RS485 Modbus, ASCII or RTU

### Thermocouple

Assembly: Type J ungrounded  
 Probe Material: Inconel  
 Insertion Length: 20"  
 Connection: ½" MNPT



JC-15D Mounting and Clearance Dimensions

## SMOKE OPACITY MONITOR

Model JC-30D

The Preferred Instruments JC-30D Smoke Opacity Monitoring System assures an accurate measurement of the smoke emissions from boilers, incinerators, kilns, and similar sources of intermittent, visible emissions. Typical applications include commercial buildings, schools, hospitals, apartment complexes, and industrial plants. The information provided encourages increased emphasis on clean, efficient combustion and effective air pollution control.

The newly redesigned light source uses a low voltage, pre-focused, LED lamp with a projection angle of 5° to reduce scattered light inaccuracies. The light detector is a solid state, photopically filtered photoelectric cell. The unit's built-in optical "bulls eye" and variable blink rate LED assist in alignment verification. Lenses are specially designed for easy cleaning without dismantling the installed assembly.

### Long Life LED Light Source

### Early Warning Message and Relay Contact

- Deteriorating combustion conditions can be detected early before developing into major problems.

### Burner Safety Shutdown Message and Relay Contact

- Dangerously high opacity is an indication of an unsafe, likely fuel-rich flame condition.

### Single pass design, no moving parts

### High Visibility Bargraph and Numeric Display

### Three Alarm Sequences (field selectable):

- Standard
- NYC BAR
- Wood / Coal Overfire Air Fan

### NEMA 4 Front Panel

### Flexible Communications for Data Logging:

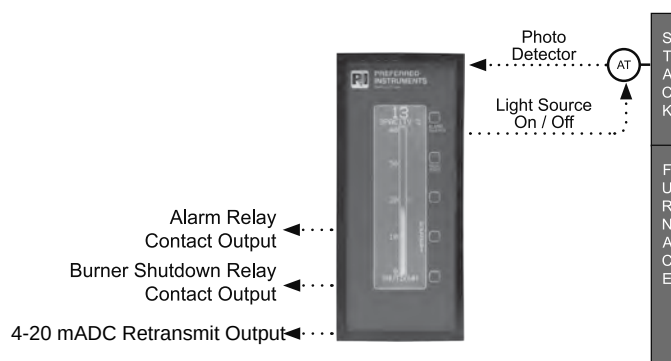
- 4-20 mADC Opacity Re-transmission
- RS485 Modbus Interface

### Automatic Calibration

The JC-30D includes a 120 VAC input that monitors the burner fan starter coil and initiates an Automatic Calibration cycle whenever the burner fan stops running (ensuring a clear stack condition). This prevents nuisance burner trips due to dust buildup. "WARNING: CLEAN LENSES NOW" is displayed when the dust level is high. At the completion of the Calibration Cycle, the JC-30D turns off the light source until the fan restarts, extending the life of the bulb. A Calibration Cycle can also be manually initiated from the JC-30D Menu (after a lens cleaning, re-alignment, etc).



JC-30D shown in "SHUTDOWN" condition  
(alarm message & reset pushbutton visible)



Typical JC-30D Arrangement

## SMOKE OPACITY MONITOR

Model JC-30D

### Description

The JC-30D Smoke Opacity Monitor is a microprocessor-based indicating instrument with a smoke duct mounted optical sensing assembly. The system provides a continuous opacity readout, alarm indication and shutdown capability. The smoke opacity percent is continuously displayed using a highly visible backlit LCD display. An intuitive bargraph display and alarm message provides rapid recognition of combustion conditions. All adjustments can be made directly from the faceplate of the instrument by scrolling through user-friendly, English language menus.

The light source uses a low voltage, pre-focused, LED lamp with a projection angle of less than 5° to reduce scattered light inaccuracies. The light sensor includes a solid state, photopically filtered photoelectric cell. The unit's built-in optical "bull's eye" and variable blink rate LED assist in verifying alignment. Lenses are specially designed for easy cleaning without dismantling the installed assembly. Cap seals and/or cooling blowers may be required for high temperature applications, and refractory lined breechings. Please contact factory for details.

### Operation

The indicating instrument continuously displays the percent smoke opacity and provides the following alarm and control sequences. Typically, the JC-30D alarm relay activates an external alarm bell or horn, and the shutdown relay is used to shut down the burner.

#### "Standard" Operating Sequence

**Smoke Opacity exceeds setpoint:** Bargraph blinks and "ALARM" message appears.

**After 20 seconds "smoke-puff" delay:** Alarm relay (K1) contact activates, the remote alarm bell or horn is activated. Pressing the "alarm silence" button deactivates (K1) relay and the external bell or horn.

#### Smoke Opacity continues for 120 seconds (adjustable):

The shutdown relay (K2) activates in manual reset mode, "shutdown" message appears, and the (K1) relay re-activates. When the smoke opacity condition clears, the JC-30D "reset" pushbutton must be pressed to reset the shutdown relay in order for the burner to restart.

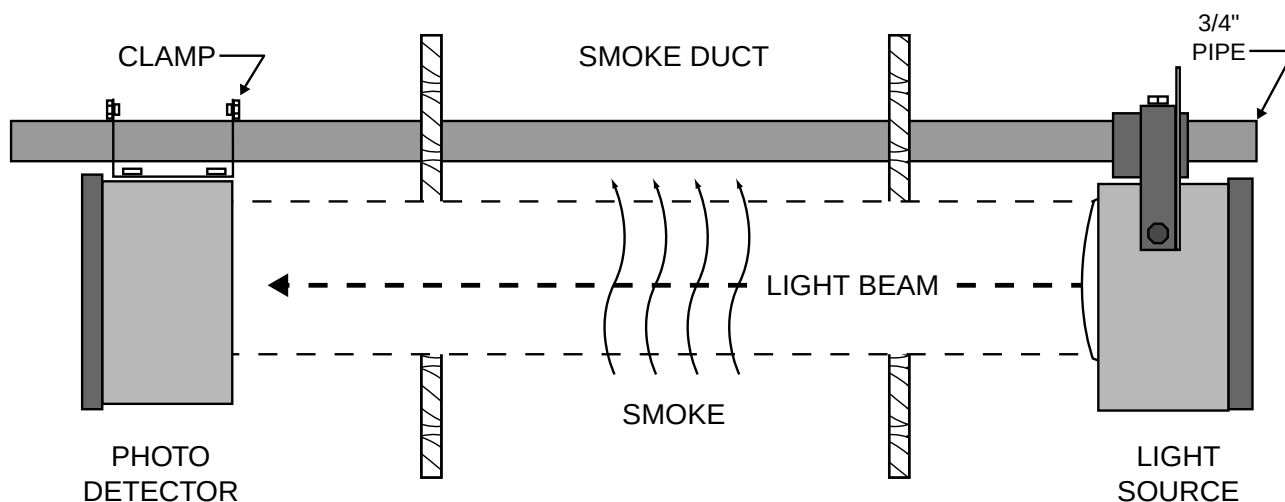
**Smoke Opacity returns to normal:** "Alarm" message disappears.

#### "NYC BAR" Sequence

This sequence is similar to the Standard Operating Sequence (above), but conforms to the New York City D.E.P. Bureau of Air Resources requirements. The (K1) relay activates instantly and the (K2) relay delay is fixed at 120 seconds (not adjustable). The 190712 Light Sensor Alarm Test filter complies with NYC BAR requirements.

#### "WOOD / COAL" Overfire Air Fan Sequence

This sequence is used with stoker fired boilers. See the Standard Operating Sequence (above) for (K1) relay and "alarm silence" button operation. The (K2) relay is used to reduce opacity by activating an overfire air fan or damper. When opacity has been above setpoint for 15 seconds (adjustable) the overfire air relay (K2) activates and a "fan on" message appears. When the smoke clears and drops below setpoint, the (K2) relay remains activated for an additional 180 seconds (adjustable) to help prevent a re-occurrence of excessive smoke.





# SMOKE OPACITY MONITOR

Model JC-30D

## Specifications

### Panel

Power Supply: 120 VAC 50/60Hz, 15 VA  
 Case Size: 8" H x 3.5" W x 7.5" D  
 Enclosure Type: NEMA 4 faceplate, Flush Mounting  
 Ambient Temp.: +32° to +122° F ambient  
 Digital: High Contrast LCD Display  
 4" high, 0.5% Resolution Bargraph  
 Status Messages: ALARM, SHUTDOWN,  
 WARNING: CLEAN LENSES NOW  
 EXCESS LIGHT  
 Alarm Setpoints: Adjustable 5-50%

### Light Source and Light Sensor

Calibration: Automatic, Off-Line  
 Spectral Response: Photopic  
 Peak and mean within 500-600nm  
 Angle of Projection: <5°  
 Operational Error: <5%  
 Span Drift: <2%  
 Zero Drift: <2%  
 Calibration Error: <1% (Linearity)  
 Response Time: <10 seconds for 95% change in  
 opacity  
 Sighting Distance: 1 to 8 foot smoke duct.  
 3 to 10 foot optical path length  
 Wiring Distance: 500 ft. max (16 ga. wire)  
 250 ft. max (20 ga. wire)  
 Sensor Housing: ¾" pipe mount

### Outputs

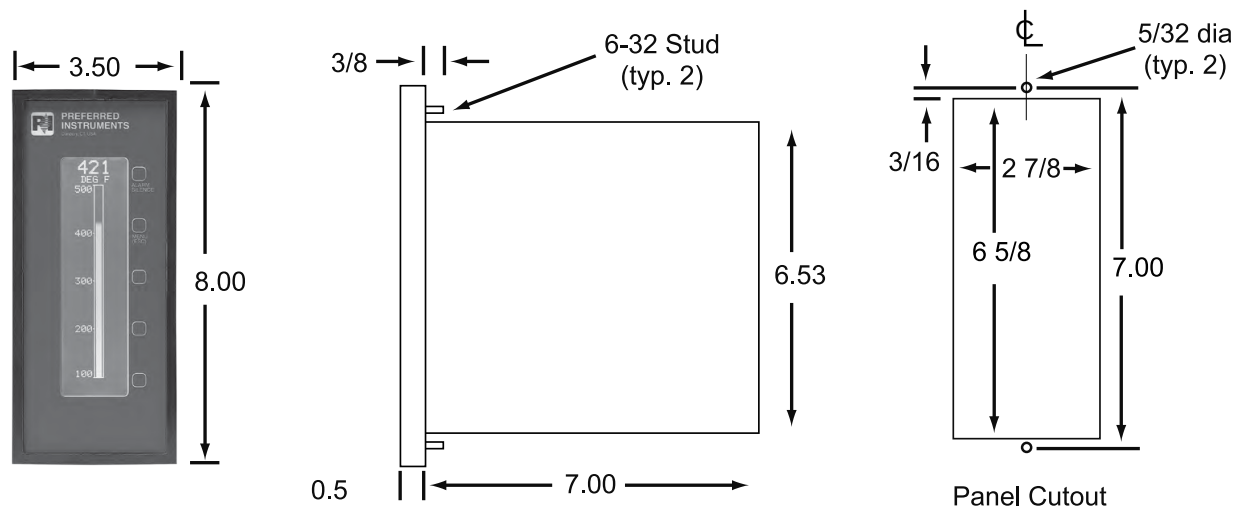
Relay Outputs: Two SPDT Relays  
 10 A resistive, 8 FLA, ½ HP,  
 120 VAC  
 Retransmission  
 Output: 4-20 mADC, 650 ohm load max  
 Network Output: 1200-38400 baud, RS485 Modbus,  
 ASCII or RTU

## Ordering Information

1. JC-30D Monitor, 190711L LED Light Source,  
 190712 Light Sensor, and two Light Sensor Shields  
 190713 are required for complete system.

## Optional Accessories

1. Pressure cap set with purge and non-purge fittings  
 (107226P)
2. Pressure cap set with integral blower (2 blowers)  
 (190275A)
3. Remote audible / visual alarm (SDA-VB)
4. Alarm bell, 6" dia., 85 db (SDA-B6)
5. Recorder-31 day, 2 ¼" strip chart (R88-E5)



# SMOKE OPACITY MONITOR

Model JC-30D

## 1. Application

Provide a smoke opacity monitor for each furnace. The smoke monitor shall consist of an LED light source, solid-state optical detector, and microprocessor-based alarm and indicating instrument. The instrument shall provide a smoke opacity percent display in engineering units, early deteriorating combustion conditions warning indication, burner safety shutdown indication and relay contacts. The instrument shall continuously indicate smoke density on a highly visible backlit LCD display. Provide an integral or separate 4", 0.5% resolution (minimum) bargraph display in engineering units with visual alarm setpoint indication. Provide an "alarm silence" and "manual reset" pushbutton and two 10 amp. relays. The housing shall be panel mountable, fully gasketed with NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. No external configurator or laptop shall be required. The "standard" operating sequence shall be as follows: when smoke density exceeds setpoint, the bargraph shall flash, and an "alarm" message shall appear. After a 20 second "smoke-puff" delay the "alarm" relay contact closes the circuit for the remote alarm device. Pressing the "alarm silence" pushbutton resets the alarm relay to silence the alarm device. If the smoke density reduces below the setpoint within 120 seconds (adjustable), the bargraph stops flashing and the "alarm" message disappears. If the smoke density exceeds the setpoint for 120 seconds or more, the "shutdown" message shall appear, the "alarm" relay re-closes and manually reset "shutdown" relay contact open to shut down the violating burner. Pressing the "alarm silence" pushbutton resets the alarm relay to silence the alarm device. When the smoke density then falls to below the setpoint, the "shutdown" message will remain on and

the "shutdown" relay will remain in the manual reset mode. With smoke opacity cleared, pressing the "reset" pushbutton will reset the system, the "shutdown" message will disappear, and the "shutdown" relay will reset to permit normal burner operation. In order to avoid nuisance burner trips caused by dust building up on the light source and sensor, the instrument must include an automatic, unattended re-calibration cycle whenever the burner fan stops running (ensuring a clear stack condition). The optical sensing unit lenses shall be designed to accommodate regular cleaning without dismantling the installed assembly. Light source and detector will sight 100% of the effluent path length. Light source will use a pre-focused LED lamp with a maximum 5 degree projection angle. Photo detector shall include a photopically filtered, solid state photo cell and alignment verification bulls eye.

## 2. Communication

The Instrument shall include a RS485 Modbus network interface and a 4-20 mA DC re-transmit output to communicate to a future Data Acquisition System (DAS) or Building Automation System (BAS).

## 3. Quality Assurance

The Instrument shall be manufactured and labeled in accordance with UL508A requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The draft control system shall be a Preferred Instruments, Danbury, CT, Model JC-30D.

## IN-SITU OXYGEN SENSOR

Model ZP (for use with PCC-III-ZXX0 Controller)

- Reliable, long-life flue gas Oxygen measurement
- Separate field-mounted transmitter not required
- Simple automated calibration
- Integral Oxygen trim and boiler efficiency control logic
- Instrument air is not required

Preferred Instruments engineers and manufactures boiler control systems for commercial, industrial, and institutional facilities. Preferred's boiler control systems include combustion, feedwater (drum level), draft & flue gas recirculation control functions. Preferred's integrated control systems provide a full scope control package that assures safe and efficient control with undivided system integration responsibility.



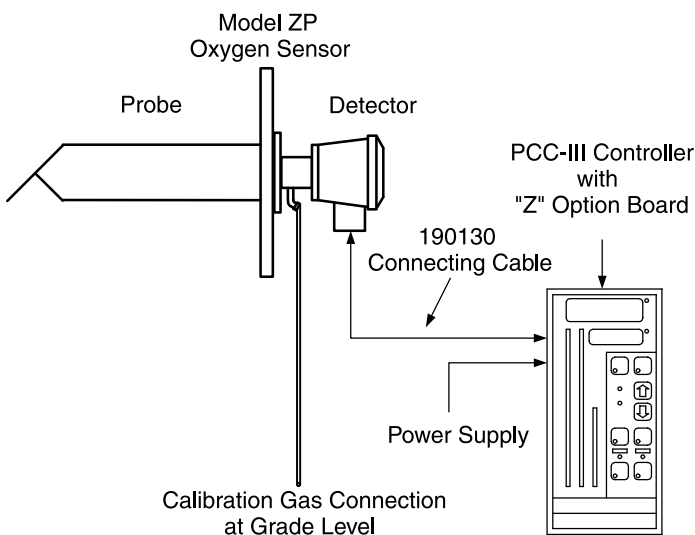
Model ZP Oxygen Sensor

### Detector

The detector consists of a zirconia oxide cell, a ceramic heater with thermocouple, terminals for connecting to the controller unit, a flange for connection to the probe, opening to accept reference (ambient) air and a connection for calibration gas. The detector works on a principle that when heated to 800° C (1472° F), the cell generates an electrical signal directly related to the oxygen concentration of the flue gas. Flue gases are passed through a filter to prevent dust and dirt from contaminating the cell. Calibration gas can be injected into the space behind the ceramic filter to allow on-line calibration without removal from the stack.

### Probe

The probe is a stainless steel assembly that mounts on a 3" 125 lb flange (flat face) located on the flue gas duct or stack. The probe protrudes into the flue gas stream and directs boiler flue gases from the middle third of the flue gas stream to the detector. The assembly's design provides for the removal of the detector for service or replacement without the need for removal of the entire probe.



Model ZP Oxygen Analyzer Arrangement

### System Specification

|                       |                                                                         |
|-----------------------|-------------------------------------------------------------------------|
| Gas Measured:         | Oxygen in flue gases                                                    |
| Sensing Method:       | In-situ field-replacable zirconia detector, and reliable ceramic heater |
| Flue Gas Temperature: | 0 to 1150° F                                                            |
| Measuring Range:      | 0 to 10% standard,<br>0 to 21% field configurable                       |
| Accuracy:             | +/- 1% of reading or 0.1% O2<br>(calibration gas dependent)             |
| Response Time:        | Initial 0.1 sec. / 90% 7 sec.                                           |
| Power Supply:         | 120 VAC, 60 Hz.                                                         |
| Power Consumption:    | 82 VA total (ZP and PCC-III)                                            |
| Connecting Cable:     | 190130. Combined signal and power cable. Up to 500 ft.                  |

### Indicating Electronics Specifications

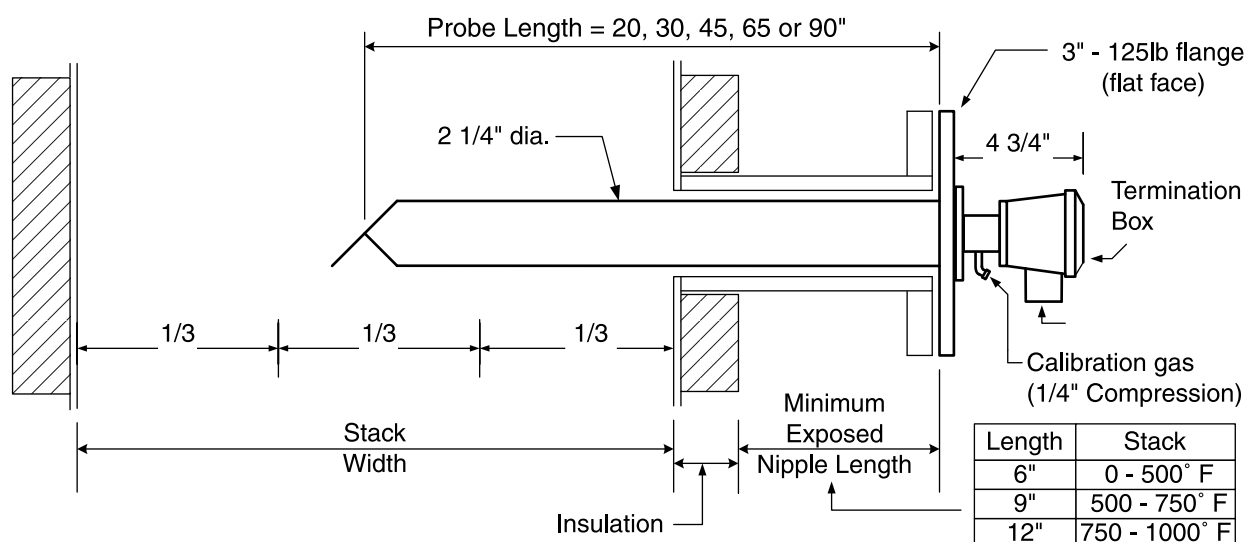
|                      |                                                                          |
|----------------------|--------------------------------------------------------------------------|
| Instrument:          | PCC-III Controller. Up to two probes per PCC-III                         |
| Oxygen Trim Options: | Jackshaft, parallel positioning or fully metered combustion applications |
| Boiler Efficiency:   | Logic included. Optional flue gas temperature T/C required.              |
| Oxygen signal:       | 4-20 mADC, Linear, Modbus RS485.<br>(Blockware dependent)                |
| Ambient:             | 32-130° F                                                                |
| Case:                | Weather-proof front panel                                                |
| Power supply:        | 115 VAC, 60 Hz.                                                          |
| Display:             | 4.5 Digit LED numeric display,<br>6 status LEDs                          |

### PCC-III "Z" Option Board Specifications

|                  |                                                                                 |
|------------------|---------------------------------------------------------------------------------|
| Isolated Inputs: | - Probe mV Input<br>- Probe Heater Type R T/C Input<br>- Spare Type J T/C Input |
| Output:          | Fused 120 VAC heater supply                                                     |

## IN-SITU OXYGEN SENSOR

Model ZP (for use with PCC-III ZXX0 Controller)



Select a probe length that positions the probe tip in the middle third of the stack

### Probe Specifications

|                        |                                                                                                                                                                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Application:           | Natural Gas, Fuel Oils                                                                                                                                                                                                                         |
| Sample gas:            | 0 to 1150° F                                                                                                                                                                                                                                   |
| Flanges:               | ANSI 125 #, 4 bolt, 3 inch flange                                                                                                                                                                                                              |
| Probe lengths:         | 20, 30, 45, 65 or 90 inch                                                                                                                                                                                                                      |
| Wetted parts:          | 304 stainless steel, alumina, quartz, zirconia, platinum                                                                                                                                                                                       |
| Weight:                | Probe of 20 inch length approx. 18 lb.                                                                                                                                                                                                         |
| Life of Zirconia Cell: | Typically 3-4 years (1 year warranty)                                                                                                                                                                                                          |
| Construction:          | NEMA 12                                                                                                                                                                                                                                        |
| Options:               | <ul style="list-style-type: none"> <li>- 190130 Connecting Cable, (requires 1/2" conduit minimum)</li> <li>- 90157 Flame Arrester</li> <li>- 90159 Rain Shield for outdoor installation</li> <li>- EPA CEM Auto Calibration Package</li> </ul> |

### Suggested Specification

Provide a boiler breeching mounted in-situ, zirconium oxide oxygen analyzer for each boiler. Extractive or "wet cell" type oxygen analyzers are not acceptable. The probe shall be of a suitable length to sense the oxygen level in the middle 1/3 of the breeching. All wetted parts shall be stainless steel. The oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults. The system shall automatically send the trim actuator to the 'null' position and trigger the alarm dry contacts in the event of an oxygen analyzer fault. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift. Analyzer calibration shall be pushbutton semi-automatic (no trim pots) with English language prompts and diagnostic messages. Analyzer output shall be field selectable as 0-10% or 0-21% without field re-calibration.

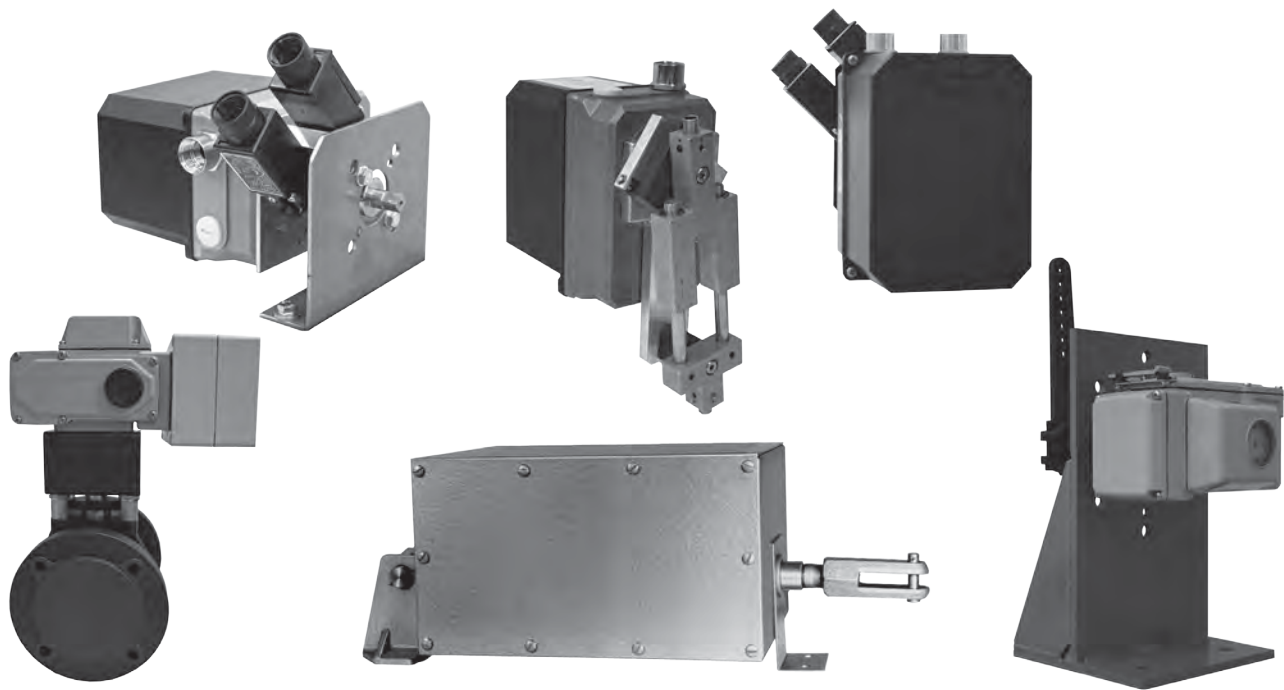
### Ordering Information

1. Specify Probe Length; ZP-20, 30, 45, 65 or 90 inch
2. Specify Special Cable, p/n. 190130 length, maximum length 500 feet
3. Specify PCC-III Controller Model Number PCC-III-Z x x 0
4. Specify optional flue gas temperature element 104087D (required for boiler efficiency calculation)



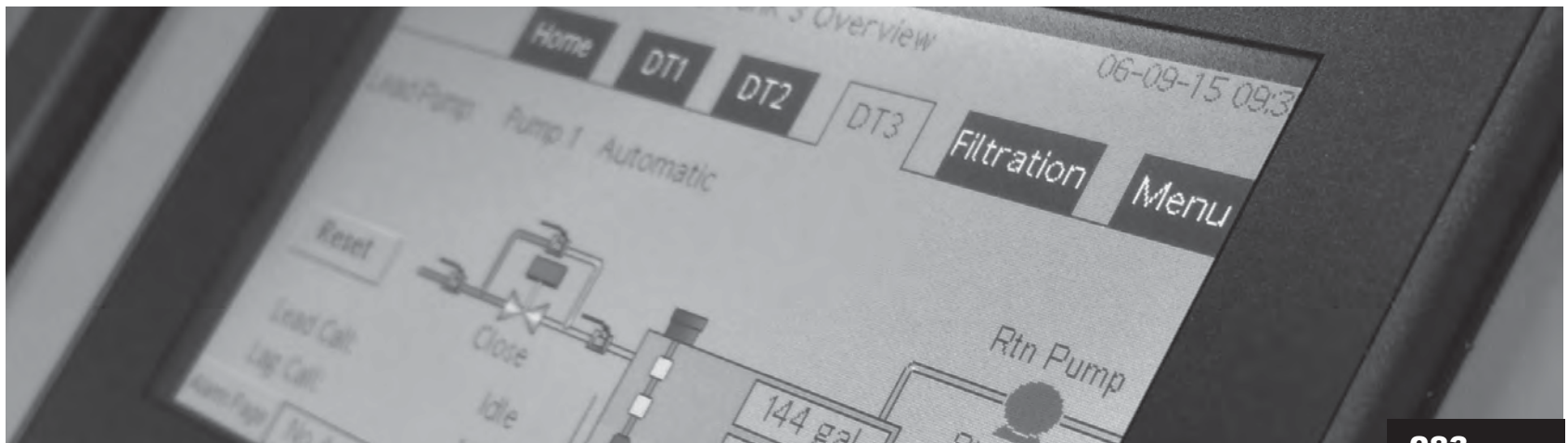


# Controllers and Actuators



**PREFERRED**   
Instruments

Controllers & Actuators



# FLEXIBLE SYSTEM CONTROLLER (FSC)

## Overview

The FSC-120 is a general purpose programmable logic controller that is programmed with function block logic. A single FSC can be used to control a single device or process, or multiple FSC's can be networked together for coordinated distributed control of larger systems.

A single FSC controller, or node, contains:

- 24 Digital Inputs
- 10 Relay Outputs
- 8 Analog Inputs
- 3 Analog Outputs

Up to ten FSC nodes can be linked together using the hardened, redundant, isolated, masterless Preferred NodeNet communication network. Both networks communicate continuously. If one network goes down (broken wire, shorted terminal, etc.) the other network communicates with no loss of function. Additionally, if any node fails, all other nodes continue to function.

Network communication between nodes eliminates the need to run numerous line and low voltage wires between devices or control panels.

Each FSC node can be equipped with a four inch color touchscreen HMI for setup and operator interface.



FSC - Flexible System Controller terminal blocks

### Node Net Operation

The FSC has redundant NodeNet Communication Ports (A & B) that continuously communicate between all FSC controllers wired in parallel (up to 10 FSC's maximum). All of the information from all of the FSC's will travel through both cables to all of the nodes. Both cables are always active and are electrically isolated at each node.

### Address Selection

The FSC has a 10 position address dial which can manually address each FSC. To select an address, turn the dial until the arrow is pointing to the address to be used. The first FSC in line shall always be set at address zero (factory default), and addresses must be in consecutive order without skipping numbers.

### Easy Programmability

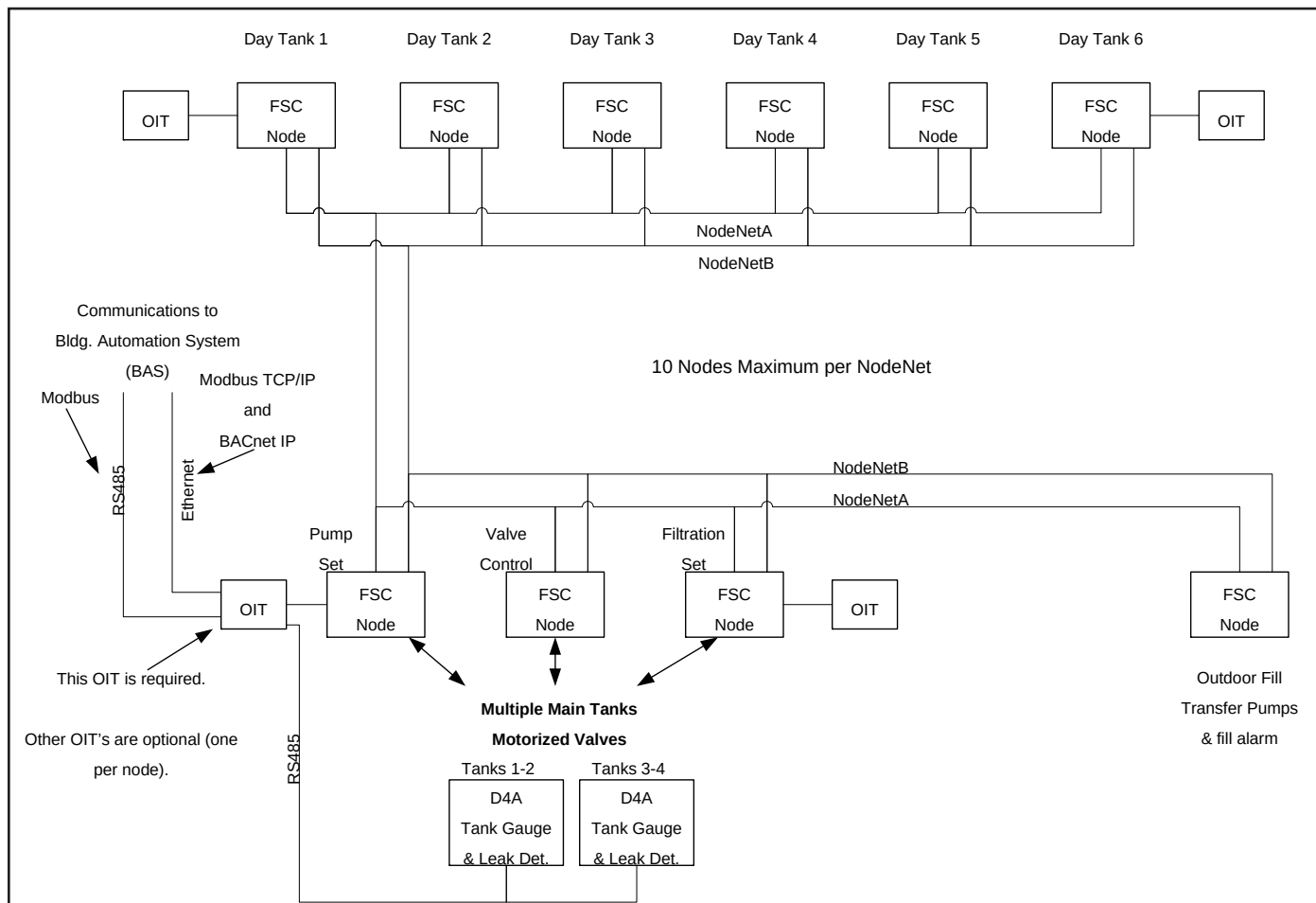
The FSC features a USB programming port for writing configurations to the controller with the FSC Edit software. The FSC can also be programmed using the available SD card slot (no laptop required).

### Modbus RS-485 Communication

The FSC communicates to the OIT the messages and statuses of the FSC via RS-485. Additionally, the FSC controller can communicate via Modbus to building automation systems or energy management systems.

## FLEXIBLE SYSTEM CONTROLLER (FSC)

### Application Example



*Ten FSC controllers in an emergency generator application with six day tanks, two bulk storage tanks, duplex pump set, filtration system, and interface to a building automation system.*

#### Reduced Field Wiring

In this application example, FSC controllers are used to control a duplex pump set, fill station, filtration system, and six day tanks. Instead of pulling up to 6-10 conductors from each day tank back to a centralized controller, these 6-10 wires are landed locally at the day-tank-mounted FSC controller. Each FSC controller is linked via dual redundant cables.

#### Reduced Per Project Programming

In this example, the FSC programs for the day tank controllers, filtration controllers, and pump set controllers are standard programs from a library of Preferred FSC programs. The Preferred D4A tank gauges are provided pre-programmed. Job-specific information for the individual controllers and tank gauges is entered during field commissioning. Standard programs are thoroughly debugged and used over and over again on numerous projects.

#### Color Touchscreen HMI

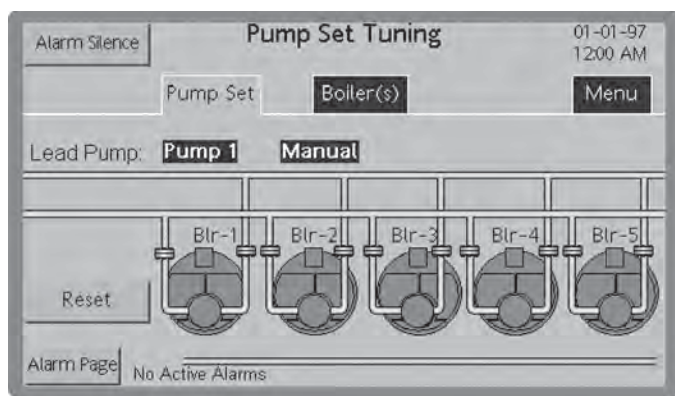
Each of the FSC controllers can be provided with a 4" color touchscreen Operator Interface Terminal (OIT). The touchscreens can be used to configure the controllers and provide operating and trouble-shooting information for service technicians and operators. Examples of touch screen graphics pages are shown on the following page.

#### Building Automation System Interface

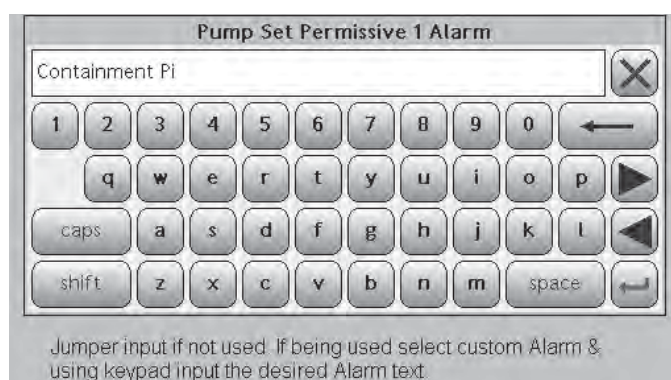
Each of the FSC controllers has Modbus address registers assigned to each of the useful control parameters. This data is shared among all controllers via the redundant NodeNet network. A 4" OIT attached to one of the FSC controllers acts as a gateway and provides Modbus RS-485, Ethernet, or BacNet IP communication of all Modbus register addresses in all the connected FSC controllers to an external building automation system or Preferred SCADA system.

## FLEXIBLE SYSTEM CONTROLLER (FSC)

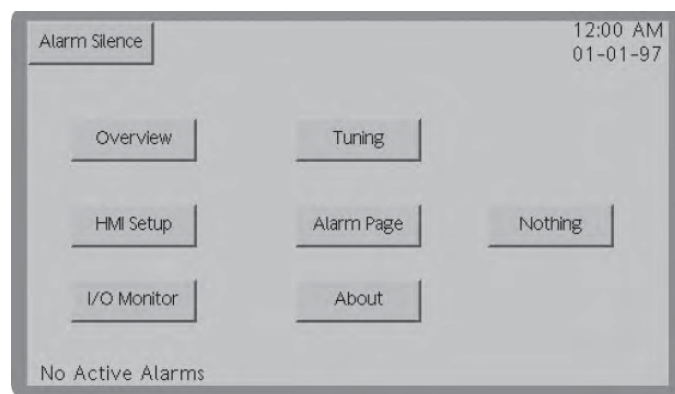
### Touchscreen Graphics



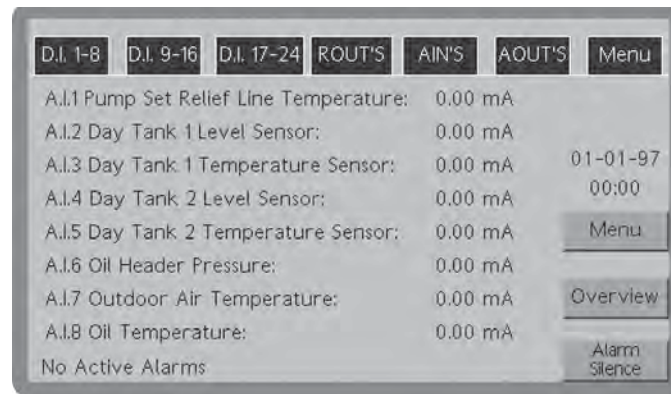
Typical overview screen on the optional 4" Color Touchscreen provides status of controlled equipment and active alarms.



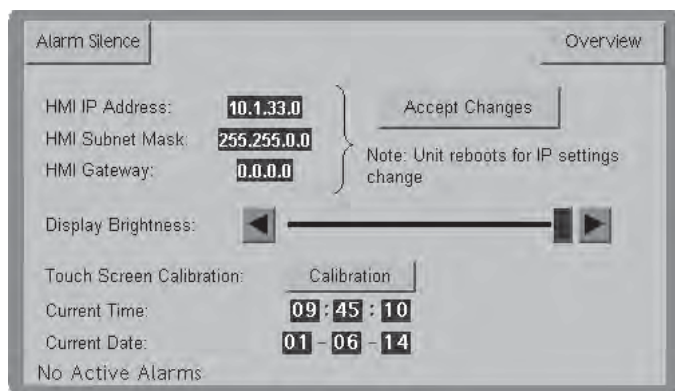
Text editor screen allows users and technicians to input custom messages for each application or jobsite. There are no error codes or diagnostic codes--just plain English.



Typical main menu screen used to navigate between overview, setup, alarm, and other screens.



Typical analog input screen used for setting up engineering units, troubleshooting wiring, and monitoring current readings. I/O can be viewed from any other Node with an OIT-4K2 touchscreen.



OIT setup screen allows the user to input the screens IP address, set the time and date, and change screen contrast.



Typical relay output screen helps troubleshoot controlled devices.



# FLEXIBLE SYSTEM CONTROLLER (FSC)

## Terminal Descriptions

### Line Voltage Terminals

| Terminal | Name      | Description                                                                                                                                                                                                            |
|----------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L, N, G  |           | 120VAC power supply for FSC-120 internal use.                                                                                                                                                                          |
| 1 - 24   | DIN ch. x | 120 VAC Discrete Inputs, Channels 1-24, Terminals 1-24, optically isolated. 120VAC Hot for DIN inputs supplied and fused externally. All DIN channels internally connected to FSC-120 "N" terminal for current return. |
| 25       | C         | Relay Output channels 1-5 Common terminal, 10A max                                                                                                                                                                     |
| 26       | NO        | Relay Output ch. 1 SPST NO, 2A / 250 VAC                                                                                                                                                                               |
| 27       | NO        | Relay Output ch. 2 SPST NO, 2A / 250 VAC                                                                                                                                                                               |
| 28       | NO        | Relay Output ch. 3 SPST NO, 2A / 250 VAC                                                                                                                                                                               |
| 29       | NO        | Relay Output ch. 4 SPST NO, 2A / 250 VAC                                                                                                                                                                               |
| 30       | NO        | Relay Output ch. 5 SPST NO, 2A / 250 VAC                                                                                                                                                                               |
| 31       | NC        | Relay Output ch. 6 SPDT, 10A, 1/2 HP 120/250 VAC                                                                                                                                                                       |
| 32       | C         |                                                                                                                                                                                                                        |
| 33       | NO        |                                                                                                                                                                                                                        |
| 34       | NC        | Relay Output ch. 7 SPDT, 10A, 1/2HP 120/250 VAC                                                                                                                                                                        |
| 35       | C         |                                                                                                                                                                                                                        |
| 36       | NO        |                                                                                                                                                                                                                        |
| 37       | NC        | Relay Output ch. 8 SPDT, 10A, 1/2 HP 120/250 VAC                                                                                                                                                                       |
| 38       | C         |                                                                                                                                                                                                                        |
| 39       | NO        |                                                                                                                                                                                                                        |
| 40       | NC        | Relay Output ch. 9 SPDT, 10A, 1/2HP 120/250 VAC                                                                                                                                                                        |
| 41       | C         |                                                                                                                                                                                                                        |
| 42       | NO        |                                                                                                                                                                                                                        |
| 43       | NC        | Relay Output ch. 10 SPDT, 10A, 1/2HP 120/250 VAC                                                                                                                                                                       |
| 44       | C         |                                                                                                                                                                                                                        |
| 45       | NO        |                                                                                                                                                                                                                        |

### Low Voltage DC Wiring (Terminals 101-106)

| Term. | Name                     | Description                                               |
|-------|--------------------------|-----------------------------------------------------------|
| 101   | 24 VDC +                 | Power for external Touchscreen or other loads. 180 mA max |
| 102   | 24 VDC - / DC Common     |                                                           |
| 103   | RS485 +                  | Com0, RS485, Reserved for Touch Screen Interface          |
| 104   | RS485 -                  |                                                           |
| 105   | DC Common                |                                                           |
| 106   | Shield Tie Point (Isol.) |                                                           |

|     |                          |                                                                      |
|-----|--------------------------|----------------------------------------------------------------------|
| 107 | RS485 + / RS232 Tx       | Com1, RS485/RS232, Reserved for Future Use.                          |
| 108 | RS485 - / RS232 Rx       |                                                                      |
| 109 | DC Common                |                                                                      |
| 110 | Shield Tie Point (Isol.) | NodeNetA, RS485, Node-to-Node Communications Only                    |
| 111 | RS485 + (Isol.)          |                                                                      |
| 112 | RS485 - (Isol.)          |                                                                      |
| 113 | NetA Isolated. Common    | NodeNetB, RS485, Node-to-Node Communications Only                    |
| 114 | Shield Tie Point (Isol.) |                                                                      |
| 115 | RS485 + (Isol.)          |                                                                      |
| 116 | RS485 - (Isol.)          | Analog Output ch. 1                                                  |
| 117 | NetA Isolated. Common    |                                                                      |
| 118 | Shield Tie Point (Isol.) |                                                                      |
| 119 | 4-20 mA Output +         | Analog Output ch. 2                                                  |
| 120 | DC Common / Shield       |                                                                      |
| 121 | 4-20 mA Output +         | Analog Output ch. 3                                                  |
| 122 | DC Common / Shield       |                                                                      |
| 123 | 4-20 mA Output +         | Analog Input ch. 1, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 124 | DC Common / Shield       |                                                                      |
| 125 | 2 wire 4-20 mA Input     | Analog Input ch. 2, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 126 | Switched 22VDC +         |                                                                      |
| 127 | 2 wire 4-20 mA Input     | Connect AIN 2 wire 4-20 mA xmtr shield here                          |
| 128 | Switched 22 VDC +        |                                                                      |
| 129 | DC Common / Shield       | Analog Input ch. 3, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 130 |                          |                                                                      |
| 131 | 2 wire 4-20 mA Input     | Analog Input ch. 4, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 132 | Switched 22 VDC +        |                                                                      |
| 133 | 2 wire 4-20 mA Input     | Connect AIN 2 wire 4-20 mA xmtr shield here                          |
| 134 | Switched 22VDC +         |                                                                      |
| 135 | DC Common / Shield       | Analog Input ch. 5, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 136 |                          |                                                                      |
| 137 | 2 wire 4-20 mA Input     | Analog Input ch. 6, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 138 | Switched 22VDC +         |                                                                      |
| 139 | 2 wire 4-20 mA Input     | Connect AIN 2 wire 4-20 mA xmtr shield here                          |
| 140 | Switched 22VDC +         |                                                                      |
| 141 | DC Common / Shield       | Analog Input ch. 7, 22 VDC/ 30 mA max for 2 wire xmtr, or other load |
| 142 |                          |                                                                      |
| 143 | 2 wire 4-20 mA Input     | Analog Input ch. 8, 22 VDC/ 30mA max for 2 wire xmtr, or other load  |
| 144 | Switched 22VDC+          |                                                                      |
| 145 | 2 wire 4-20 mA Input     | Connect AIN 2 wire 4-20 mA xmtr shield here                          |
| 146 | Switched 22 VDC +        |                                                                      |
| 147 | DC Common / Shield       |                                                                      |
| 148 |                          |                                                                      |



## FLEXIBLE SYSTEM CONTROLLER (FSC)

### Terminal Descriptions

| Mechanical |                                                                                         |
|------------|-----------------------------------------------------------------------------------------|
| Size:      | 10.61" H x 3.50" W x 5.18" D<br>(4) .017" Dia. Mounting Holes in 10.11" x 2.40" pattern |
| Weight:    | 5.5 lbs                                                                                 |

| Environmental |                            |
|---------------|----------------------------|
| Operating:    | 32 to 131 F (0 – 55 C)     |
| Storage:      | -20 to 150 F (-28 to 65 C) |
| Humidity:     | 5 – 95% (non-condensing)   |
| Enclosure:    | NEMA 1                     |

| Electrical       |                                                                                                                                                                                      |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power:           | 120 VAC +15/-20%, 40 VA, 50/60 Hz                                                                                                                                                    |
| Discrete Inputs: | 24 channels<br>120 VAC, 12 mA typical<br>>70 VAC = ON, <2mA = OFF                                                                                                                    |
| Relay Outputs:   | 10 channels<br>Ch. 1-5: SPST NO, 2 A/250 VAC<br>each channel One 'common' for all 5 channels                                                                                         |
| Ch. 6-10:        | SPDT, 10A, ½ HP 120/250 VAC                                                                                                                                                          |
| Analog Inputs:   | 8 channels<br>4-20 mA input, 100 ohm input resistor. 0.2% accuracy, 13 bit resolution 22 VDC / 30 mA supply for each channel (the control logic enables/disables each 22 VDC supply) |
| Analog Outputs:  | 3 channels<br>4-20 mA, 800 ohm max loop resistance 0.2% accuracy, 13 bit resolution                                                                                                  |

| Communications |                                                                                                                                                                                                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Com0:          | Reserved for Touch Screen Interface<br>RS485, Modbus RTU, Device = 1 for all Nodes, 38.4k baud, 8/1/N DC common connected to FSC DC common, but isolated from frame ground.<br><br>OIT-4k2 power output: 24VDC/ 180 mA steady state / 250 mA start-up |
| Com1:          | Shared Port for USB interface and RS485/RS232 interface.                                                                                                                                                                                              |
| NodeNetA:      | Node-to-Node Communications only. Redundant Auto Fail Over: A->B or B->A<br>Isolated RS485, Custom Protocol, 38.4k baud<br>NetA data & common is isolated from: NetB, FSC DC common, and FSC frame ground.                                            |
| NodeNetB:      | Node-to-Node Communications only. Redundant Auto Fail Over: A->B or B->A<br>Isolated RS485, Custom Protocol, 38.4k baud<br>NetB data & common is isolated from: NetA, FSC DC common, and FSC frame ground.                                            |
| Firmware:      | Upgradeable via SD Memory Card (must be <1GB size)                                                                                                                                                                                                    |

## FLEXIBLE SYSTEM CONTROLLER (FSC)

### Suggested Specification

#### 1. General

Supply a distributed control system composed of up to ten individual microprocessor-based controllers communicating via a redundant masterless digital network. Individual controllers shall be programmed using function block language. Devices mounted in close proximity to each controller shall be hard-wired to the controller's analog inputs, analog outputs, digital inputs, or relay outputs. Multiple controllers shall communicate digitally using a pair of redundant three-wire communication networks. If either communication network loses communication, the other network will resume communication and provide uninterrupted control to the entire network. If any controller, or node, in the network shuts down or stops communicating, the other controllers will continue to operate. The control system logic and calibration data shall be stored in a non-volatile memory that does not require battery backup.

#### 2. Controller Hardware

Each microprocessor controller shall include the following inputs and outputs:

- (24) 120 VAC digital inputs
- (5) 2 A relay outputs
- (5) 1/2 HP (10 A) relay outputs
- (8) loop-powered 4-20 mA analog inputs
- (3) 4-20 mA analog outputs

Each controller shall include two RS-485 NodeNet communication ports for communicating to the other controllers in the distributed control system. In addition, each controller shall include two RS-485 communication ports for connection to a color touchscreen or other external device.

#### 3. Operating Displays

Each microprocessor controller may be equipped with a 4" color touchscreen Operating Interface Terminal (OIT). The touchscreen communicates to the controller via RS-485 Modbus protocol. The touchscreens shall be pre-programmed at the factory with graphic pages for operation, setup, trouble-shooting, and alarm indication. Each touchscreen shall be capable of displaying information from any of the controllers in the distributed control system. The touchscreens can communicate to an external controller, building automation system, or energy management system via RS-485 Modbus, Ethernet TCP/IP, or BacNet IP protocol.

#### 4. Reliability

The controllers shall communicate using two NodeNet Communication Ports (A & B) that continuously communicate between all controllers wired in series (up to 10 controllers maximum). All of the information from all of the controllers will travel through all of the units. Upon start up, NodeNet A will be the lead communication port, with NodeNet B being the back up. In the event of a loss of communication, NodeNet B will become the lead communication port. If one controller in the network fails, a common alarm will be activated and the other controllers will continue to function.

#### 5. Quality Assurance

The control enclosure shall be manufactured and labeled in accordance with UL508A (CSA C22.2 #14 for use in Canada). Simply supplying UL recognized individual components is not sufficient. The assembled control enclosure, as a whole, must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL508A. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). Lack of an NRTL certified UL508A wiring methods inspection and labeling will be grounds for control enclosure rejection.

## SERVO ACTUATOR

### Model SM

- 90° rotary electric actuator (adjustable over 270°)
- 3, 15 or 37 ft.-lb. torque output
- Designed for modulation service
- Self-locking drive system to hold in last position
- Electrically isolated feedback potentiometer provides indication of shaft position
- Two (2) auxiliary limit switch position output

#### Description

The Model SM Servo Actuator provides directly connected and precise modulating control of fuel valves and combustion air & flue gas control dampers. The actuator opens, modulates, and closes the valves and/or dampers in accordance with the integrated combustion control and burner management system programs. An integral interlock switch provides proof of open or closed position for safe burner operation. In addition, the feedback potentiometer provides indication of the motor's shaft position. The SM Actuator is used on boiler control applications that have a maximum of 37 ft.-lbs torque required. For heavier-duty service consult the factory.

#### Operation

The Model SM Actuator utilizes an instantly reversible motor to rotate a hardened steel output shaft through a reduction of precision hobbled gears. The output shaft actuates four adjustable cam operated switches: two (2) travel limit switches to stop motor operation at pre-selected positions and two (2) auxiliary switches to provide valve and damper position proving interlocks. The motor has an integral brake for positive positioning, and can be stopped, started, or instantly reversed at any time within its travel without overheating or loss of power. For maximum durability, the motor and gear train are sealed in an oil filled compartment.

#### Suggested Specification

Provide a separate direct acting Servo Actuator for the fuel gas and fuel oil flow control valves and the combustion air damper. The servo actuator shall modulate the fuel valves without the use of linkage. The actuator shall be totally enclosed in a dust-tight, splash-proof housing, have two (2) integral, snap-action, travel limit proving switches, electrically isolated shaft position feedback potentiometer, integral brake, 90° rotation in 30 seconds and maintenance-free oil immersed motor and gear train. The actuator shall be capable of being stopped, started, or instantly reversed without loss of power or overloading. The actuator shall be a Preferred Instruments, Danbury, CT, Model SM-x [ 'x' = 3, 15 or 37 rated torque in ft.-lbs].

#### Ordering Information:

1. SM-[3, 15 or 37] Specify 3, 15 or 37 nominal torque rating
2. Consult Factory for mating valves and mounting options.



Model SM Servo Actuator

#### Specifications:

|                                |                                                        |
|--------------------------------|--------------------------------------------------------|
| <b>Power:</b>                  | 120 Vac - 50 / 60 Hz<br>SM-15 11VA<br>SM-37 21VA       |
| <b>Ambient Temperature:</b>    | 14° F to 104° F<br>(-10° C to + 40° C)                 |
| <b>Input:</b>                  | Switching SPDT or floating contacts                    |
| <b>Torque:</b>                 | 3, 15 or 37 ft.-lbs<br>(depending on model selected)   |
| <b>Duty cycle:</b>             | 100%                                                   |
| <b>Linearity</b>               | ± 1%                                                   |
| <b>Rotation:</b>               | 90° in 30 seconds,<br>maximum rotation 270 degrees     |
| <b>Feedback Potentiometer:</b> | 500 ohm change for 270° stroke                         |
| <b>Auxiliary Switch:</b>       | Two (2) Integral SPDT, adjustable                      |
| <b>Integral Brake:</b>         | Fail-safe, self locking                                |
| <b>Installation Position:</b>  | Any                                                    |
| <b>Output Shaft:</b>           | Hardened Steel (3/8" Sq-Dbl. Ended)                    |
| <b>Motor:</b>                  | Reversible, split phase, capacitor type, oil submerged |
| <b>Enclosure:</b>              | SM-3: NEMA 2<br>SM-15 & SM-37: NEMA 4                  |

## SERVO ACTUATOR

### Model UM

- 90° rotary electric actuator
- 72, 140, 280, 430 or 720 ft-lb. torque output
- Designed for modulation service
- Self-locking drive system to hold in last position
- Electrically isolated feedback potentiometer provides indication of shaft position
- Two (2) auxiliary limit switch position output

#### Description

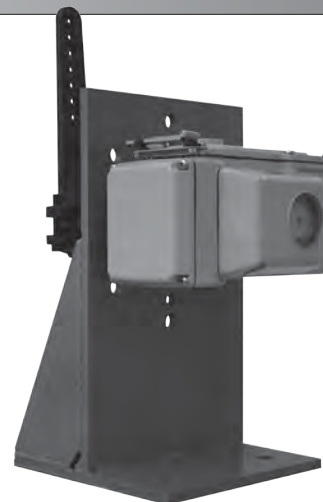
The Model UM Servo Actuator provides directly connected and precise modulating control of fuel valves and combustion air and flue gas control dampers. The actuator opens, modulates, and closes the valves and/ or dampers in accordance with the integrated combustion control and burner management system programs. An integral interlock switch provides proof of open or closed position for safe burner operation. In addition, the feedback potentiometer provides indication of the motor's shaft position. The UM Actuator is used on boiler control applications that have a maximum of 720 ft-lbs torque required. For heavier equipment service – consult the factory.

#### Operation

The Model UM Actuator uses an instantly reversible motor to rotate a stainless steel output shaft through a reduction of precision worm gears. The output shaft actuates four adjustable cam operated switches: two (2) travel limit switches to stop motor operation at pre-selected positions and two (2) auxiliary switches to provide valve and damper position proving interlocks. The actuator incorporates 'Built-in Motor Design', by which the stator of motor is directly inserted into the body housing, which works as a heat sink – efficiently radiating motor heat to atmosphere therefore the actuator can be stopped, started, or instantly reversed at any time within its travel without overheating or loss of power. For maximum durability, all the major parts of the actuator are lubricated with long life molybdenum disulfide grease (MOS2) at assembly therefore re-lubrication is in principle not required.

#### Suggested Specification

Provide a separate direct acting Servo Actuator for the fuel gas and fuel oil flow control valves and the combustion air damper. The servo actuator shall modulate the fuel valves without the use of linkage. The actuator shall be totally enclosed in a dust-tight, splash-proof housing, have two (2) integral, snap-action, travel limit proving switches, electrically isolated shaft position feedback potentiometer, 90° rotation in 30 seconds and maintenance-free motor and gear train. The actuator shall be capable of being stopped, started, or instantly reversed without loss of power or overloading. The actuator shall be a Preferred Instruments, Danbury, CT, Model UM-xxx [ 'xxx' = 072, 140, 280, 430 or 720 rated torque in ft-lbs].



Model UM Servo Actuator with Floor Stand

#### Specifications:

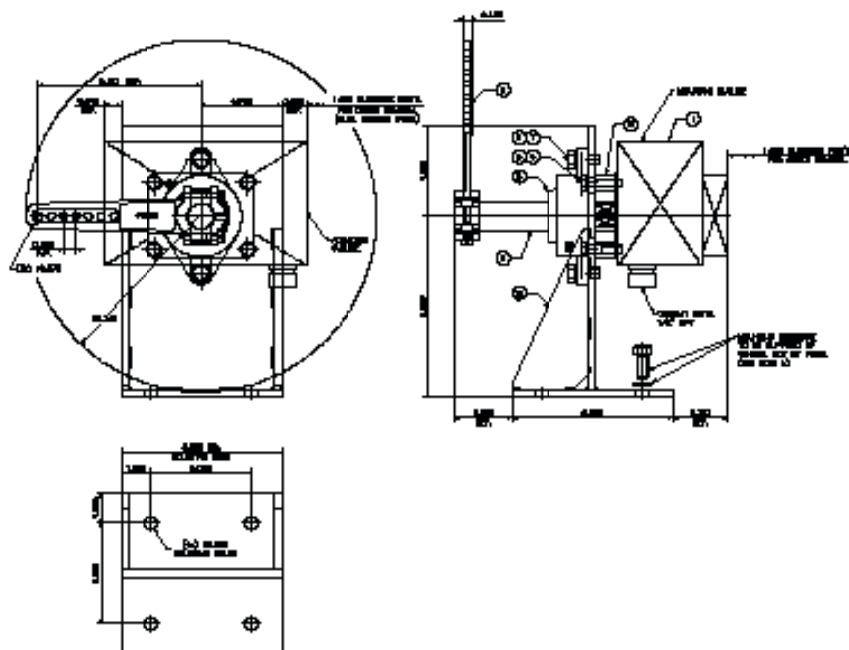
|                                |                                                                                                  |
|--------------------------------|--------------------------------------------------------------------------------------------------|
| <b>Power:</b>                  | 120 VAC - 50 / 60 Hz<br>UM-072 20VA<br>UM-140 30VA<br>UM-250 90VA<br>UM-430 95VA<br>UM-720 100VA |
| <b>Ambient Temperature:</b>    | -13° F to 131° F<br>(-25° C to + 55° C)                                                          |
| <b>Input:</b>                  | Switching SPDT or floating contacts                                                              |
| <b>Torque:</b>                 | 72, 140, 280, 430 or 720 ft-lbs (depending on model selected)                                    |
| <b>Duty cycle:</b>             | 100%                                                                                             |
| <b>Rotation:</b>               | 90° in 30 seconds                                                                                |
| <b>Feedback Potentiometer:</b> | 1000 ohm                                                                                         |
| <b>Auxiliary Switch:</b>       | Two (2) Integral SPDT, adjustable                                                                |
| <b>Installation Position:</b>  | Any                                                                                              |
| <b>Output Shaft:</b>           | Stainless Steel (SUS303)                                                                         |
| <b>Motor:</b>                  | Reversible, split phase, capacitor type, oil submerged                                           |
| <b>Enclosure:</b>              | UM-072, 140, 280, 430 & UM-720: NEMA 4/4X Watertight                                             |
| <b>Manual Operation:</b>       | Detachable Crank Handle                                                                          |

#### Ordering Information:

1. UM-[072, 140, 280, 430 or 720] Specify 72, 140, 280, 430 or 720 nominal torque rating
2. Consult Factory for mating valves and mounting options.

# SERVO ACTUATOR

Model UM



| Catalog Number                                          | Description                                                                                                                   |
|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <b>120 VAC Triac Control Signal Input</b>               |                                                                                                                               |
| <b>UM-072-FS</b>                                        | Actuator, 72 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.591" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand  |
| <b>UM-140-FS</b>                                        | Actuator, 140 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.906" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UM-280-FS</b>                                        | Actuator, 280 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.906" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UM-430-FS</b>                                        | Actuator, 430 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 1.182" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UM-720-FS</b>                                        | Actuator, 720 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 1.182" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>4-20 mADC Control Signal Input / Feedback Output</b> |                                                                                                                               |
| <b>UMP-072-FS</b>                                       | Actuator, 72 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.591" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand  |
| <b>UMP-140-FS</b>                                       | Actuator, 140 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.906" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UMP-280-FS</b>                                       | Actuator, 280 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 0.906" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UMP-430-FS</b>                                       | Actuator, 430 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 1.182" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>UMP-720-FS</b>                                       | Actuator, 720 Ft Lbs Torque, 90° / 25 Seconds, 1K Potentiometer 1.182" Square Shaft, (2) SPST Auxiliary Switches, Floor Stand |
| <b>Model UM Optional Hardware</b>                       |                                                                                                                               |
| <b>107372</b>                                           | Pipe Linkage Kit, 1" NPT with Ball and Socket                                                                                 |
| <b>107373</b>                                           | Pipe Linkage Kit, 1½" NPT with Ball and Socket                                                                                |
| <b>20054</b>                                            | Damper Lever Arm                                                                                                              |



## SHAFT POSITION SENSOR

Model SPS

- 0 - 100 % Boiler Firing Rate Signal
- Sensor used by Oxygen Trim, Furnace Draft or other control that require a boiler load index
- 45 to 160 degree stroke input allows installation flexibility

The Shaft Position Sensor (SPS) is a general purpose feedback pot for applications that require firing rate feedback as a basis for establishing setpoints for other control loops such as Oxygen Trim or FGR Flow.

### Specification

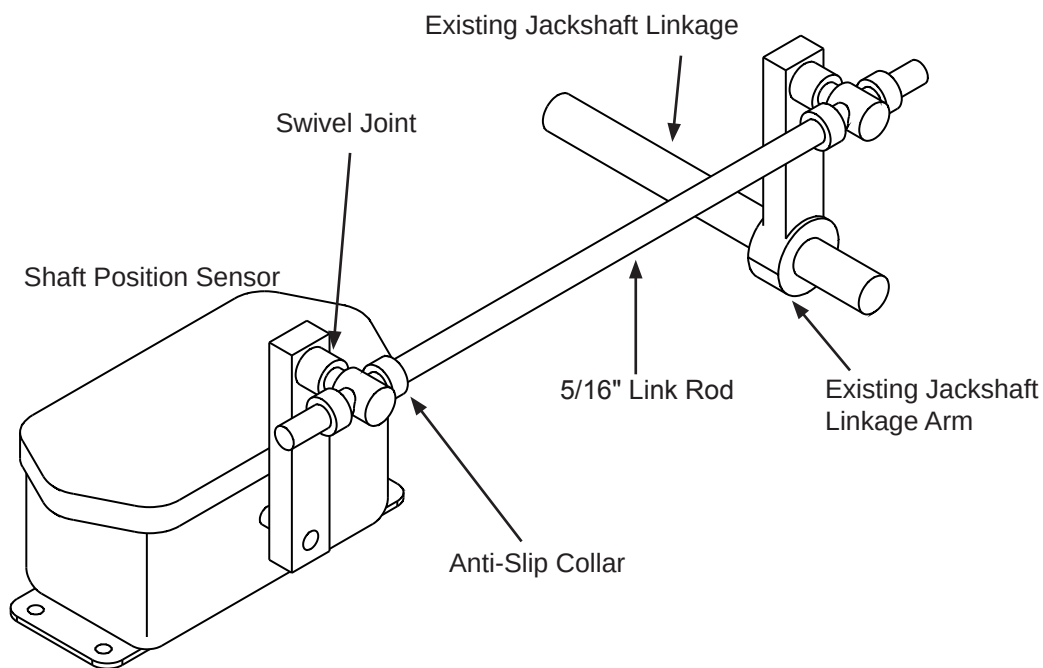
Stroke: 45 to 160 degree  
Output: 1K ohm Potentiometer  
Enclosure: NEMA 12  
Linkage Rod: 5/16" 6" x 3' linkage  
Swivel Joint  
Connection: 1/4" - 20 threaded

### Ordering Information

Model SPS



Shaft Position Sensor Model SPS



Typical Linkage Assembly

## POWER ARM LINEAR ACTUATOR

Model PL, R-AL & R-ALP

- Adjustable 1" - 6" travel electric actuator
- 100 or 200 lbs output thrust
- Designed for modulation service
- Self-locking drive system to hold in last position
- Two infinitely adjustable auxiliary limit switches
- Isolated position feedback available with R-AL & R-ALP Models
- Integral 4-20 mAdc positioner circuit board available with R-ALP Models

The Preferred Instruments series PL, R-AL and R-ALP "Power Arm" actuators are self-contained, electro-mechanical, linear actuators for use in remotely controlled manual or fully automatic control systems. The units may be started, stopped or instantly reversed at any point within the stroke without damage, overheating or loss of power. The "Power Arm" actuator has a solid performance history earned by years of continuous operation in thousands of unattended boiler room combustion installations.

### Application

The "Power Arm" actuators provide a positive linear thrust for positioning dampers, louvers, jackshaft mechanisms, rotary valves, or other mechanisms. The R-AL and R-ALP are used for closed loop positioning control in a combustion control system application while the PL is used for 3-wire floating control in boiler draft control cases. Though these actuators are generally used in positioning applications, they are equally suited for on/off control.

### Operation

In response to a SPDT control switch with a neutral position, (or analog input signal on R-ALP Models) a reversible gear motor (A) rotates an Acme threaded lead screw (B) to drive a traveling nut (C) and extend or retract the actuator ram (D). Sealed, snap-action switches (E) are opened by ram mounted cams (I & J) to stop the motor and positively limit ram travel. The standard actuator includes two normally open auxiliary switches (F) that trip immediately prior to the full open or closed ram position. A potentiometer (not shown) provides a ram position feedback signal in the R-AL and R-ALP Models.

### Installation

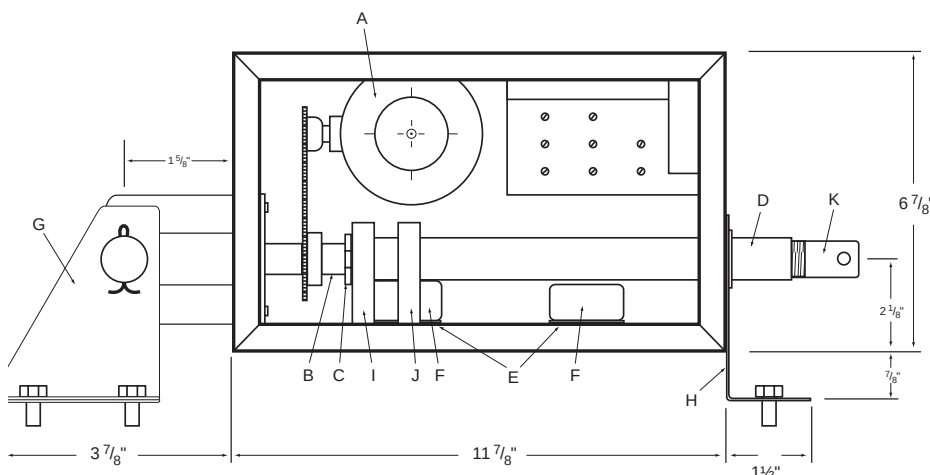
Stationary or pivot mounting is available. Stationary mounting uses base (G) and stabilizing bracket (H). Attached to the ram eye (K) is a clevis that pivots as the ram extends and retracts. Pivot mounting uses only base (G). The ram eye and clevis are replaced by a length of 1/2" pipe threaded into the ram end. As the ram extends and retracts, the actuator is free to pivot on the base. Pivot mounting permits the use of straight line, push-pull linkage that reduces ram friction with resultant prolonged ram and bearing life.



Power Arm Linear Actuator

### Specifications

|                            |                                                                                                                        |
|----------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Power:</b>              | 120 Vac, 50/60Hz, 60VA                                                                                                 |
| <b>Ambient Temp.:</b>      | 150° F (65° C) Maximum                                                                                                 |
| <b>Input:</b>              | Switching SPDT or floating contacts (Models PL & R-AL), or 4-20 mAdc, 0-5Vdc, 0-1000 ohms or 0-135 ohms (Model R-ALP). |
| <b>Load:</b>               | 100 lbs. or 200 lbs. thrust                                                                                            |
| <b>Stroke:</b>             | 1" - 6" adjustable                                                                                                     |
| <b>Speed:</b>              | 6" in 30 or 60 seconds                                                                                                 |
| <b>Auxiliary Switches:</b> | Two integral, enclosed, 15A, 1/8 HP @ 120 Vac (switches available on PL & R-AL)                                        |
| <b>Position Feedback:</b>  | Precision potentiometer, 1000 ohm on Models R-AL & R-ALP (consult factory for other output values)                     |
| <b>Manual Operation:</b>   | Handwheel (optional on PL & R-AL)                                                                                      |
| <b>Linkage:</b>            | Ram eye, catalog number 20040 included; connecting linkage optional                                                    |
| <b>Motor:</b>              | Sealed, permanently lubricated, continuous duty, capacity start and run, 3 wire reversible                             |
| <b>Dimensions:</b>         | 6 7/8" H x 11 7/8" L x 8 3/4" D                                                                                        |
| <b>Enclosure:</b>          | 14 gauge stainless steel, fully gasketed                                                                               |
| <b>Installation:</b>       | Stationary or pivot mounting                                                                                           |

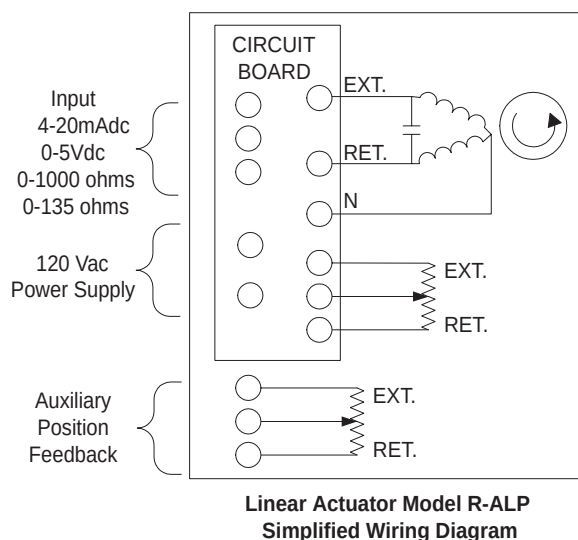
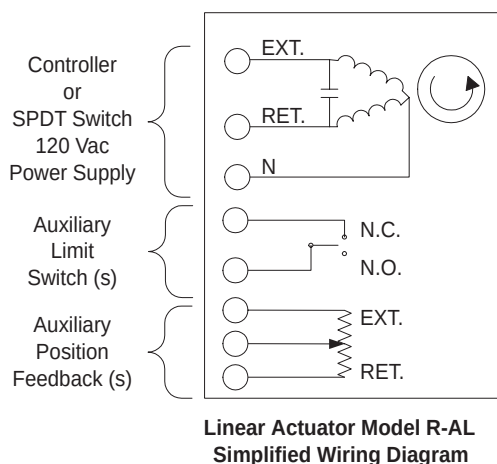
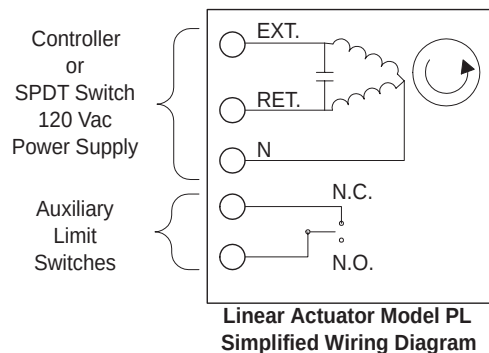


# POWER ARM LINEAR ACTUATOR

Model PL, R-AL & R-ALP

## Suggested Specifications

The actuator shall be totally enclosed, have a six inch stroke and 100 lbs (200 lbs) of push or pull thrust. The drive mechanism shall include a permanently lubricated, continuous duty rated, ball bearing type gear motor to drive an Acme threaded lead screw, traveling nut and thrust ram. The actuator shall be installed so as to pivot on its base as the ram extends and retracts. Linkage shall include an adjustable drive rod and cast iron crank arm. The actuator shall be Preferred Instruments, Danbury, CT, Model PL, R-AL or R-ARP.



## Ordering Information

### Actuator:

To order the basic model with switched inputs, specify the catalog number as follows:

- PL-2-B3 200 lbs., 60 second travel speed, 120 Vac switching input actuator, two auxiliary limit switches and ram eye, swivel and stabilizing brackets (-W to include Hand Wheel).
- PL-2-3-B3 100 lbs., 30 second travel speed, 120 Vac switching input actuator, two auxiliary limit switches and ram eye, swivel and stabilizing brackets (-W to include Hand Wheel).

To order the model with switched input and position feedback, specify the catalog number as follows:

**Catalog No.:** R-AL-2- [ 3/6 ] - P [ 1/2 ] - [ 4/X ] - S2 - [ 0/W ]  
 100 lbs., 30 sec. 3 |  
 200 lbs., 60 sec. 6 |

### Auxiliary Potentiometer:

- 1 Auxiliary pot. 1 |  
 2 Auxiliary pot. 2 |

- 0 - 1000 ohm (std. ) 4 |  
 other, consult factory X |

### Auxiliary Switches:

- 2 Auxiliary Switches 2 |

None 0 |

Hand Wheel W |

To order the positioner model with analog or potentiometer input and position feedback, specify the catalog number as follows:

**Catalog No.:** R-ALP- [ 3/6 ] - [ 0/3/4/8 ] - P [ 0/4/5/X ]  
 100 lbs., 30 sec. 3 |  
 200 lbs., 60 sec. 6 |

### Input Signal:

- 4 - 20 mA dc 0 |  
 0 - 5 Vdc 3 |  
 0 - 1000 ohms 4 |  
 0 - 135 ohms 8 |

### Aux. Position Feedback:

- None 0 |  
 0 -1000 ohm aux. pot 4 |  
 0 - 5 Vdc 5 |  
 Other, Consult Factory X |

### Linkage:

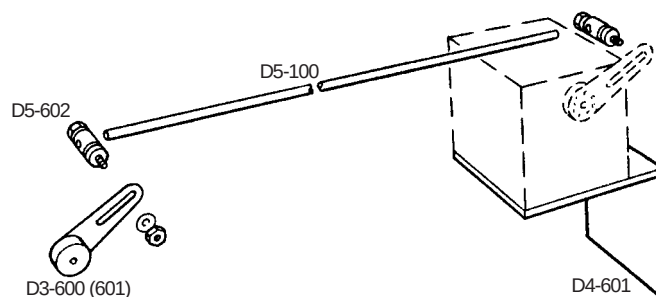
Specify: Lever arm (catalog # 20054) and extension drive rod assembly (catalog # 107232). Order extra Clevis (catalog # 20021) for stationary mounting.

## ACTUATOR LINKAGE

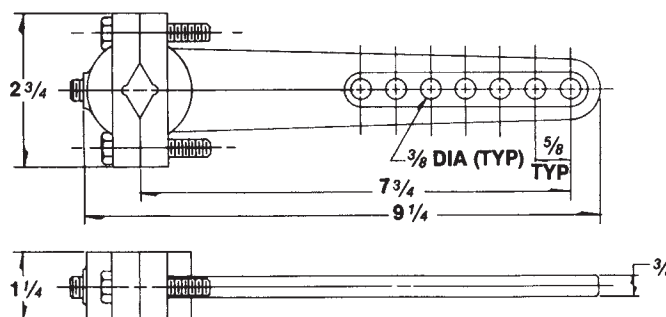
For Actuator Model DM, DM-1E, PL, R-AL, R-ALP & LTA

### Linkage for Model DM Actuators Only:

- A-22 **Linkage kit** for mounting of actuator to top of duct or any flat surface, including:  
 One 48" push rod (catalog number D5-100)  
 Two ball joint connectors (catalog number D5-602)  
 One damper lever arm for 1/2" shaft, (catalog number D3-601).
- A-22C **Linkage kit** for mounting of actuator to side of duct or wall, includes linkage kit A-22 and right angle mounting bracket (catalog number D4-601).
- D3-600 **Lever Arm:** One piece construction. Adjustable radius from 1-13/16" to 2 7/8".
- D3-601 **Lever Arm:** One piece construction. Adjustable radius from 1/4" to 4 1/2".
- D5-602 **Ball Joint Connectors:** One piece construction. Adjustable radius from 1-13/16" to 2 7/8".
- D5-100 **Push Rod:** 5/16" Dia. X 48" long plated steel shaft.
- D4-601 **Mounting Bracket:** Right angle mounting bracket with 7-3/4" D x 5" W mounting area.



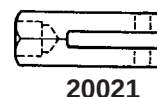
A22-C Set



20054

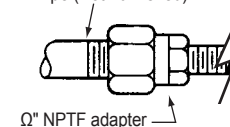


20040

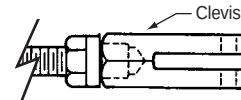


20021

Ω" Pipe (Not Furnished)



Ω" NPTF adapter

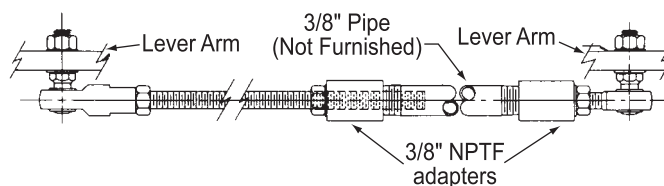


Clevis

107232 - 3/8" X 3/8"

### Linkage for Model PL, R-AL, & R-ALP Actuators:

- 20054 **Lever Arm:** Heavy duty two piece cast iron assembly, seven 3/8" holes, adjustable from 1/2" to 1 1/4" shaft.
- 20040 **Actuator Eye (ram eye):** Included with PL, R-AL & R-ALP actuators. Used to attach actuator ram to clevis assembly catalog number 20021.
- 20021 **Clevis Assembly (adapter):** Aluminum, 3/8" clevis pin, for 1/2" standard pipe thread.
- 107232 **Adjustable Extension Drive Rod & Clevis Assembly:** Drive rod length is 1" to 6" adjustable, has a 1/2" NPTF adapter and 20021 clevis assembly.
- 107334 **Adjustable Extension Drive Rod & Ball Joint Assembly:** Drive rod length is 1" to 6" adjustable, has two 3/8" NPTF adapters and two rugged 0.719" diameter, self cleaning, permanently lubricated ball joints.



107334

Specifications subject to change without notice.

## VARIABLE SPEED DRIVE (VSD)

Used with UtilitySaver and BurnerMate Combustion Control System

- Danfoss VLT Variable Speed Drive (VSD)
- Substantial Electrical Energy Savings - compensates for oversized fans, oversized motors, partially loaded boilers and helps minimize damper losses.
- NEMA 12 Packaging - for worry free boiler room installation
- Built in "DC Link" Line Reactor - for reduced electrical system total harmonics distortion (THD)
- "Soft Turn On" IGBT Transistors - for reduced motor stress (insulation failure)
- Accepts "STEP" Speed Increase from 0 to 100% without tripping - the drive automatically limits the rate of fan speed increase to that which will prevent an over-current trip
- Full Combustion System Interface – 4-20 mAdc demand input, 4-20 mAdc feedback and VSD Running and No Fault Contacts



Variable Speed Drives

### Description

UtilitySaver and Combustion Control Systems use Variable Speed Drives to provide variable speed fan combustion air flow control. Fan speed control minimizes damper pressure drop related to fan power usage. Variable speed fan control is a proven electrical energy savings technique that has been applied to thousands of HVAC installations.

### Specifications

|                     |                                                                                                                                                                                                                     |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Enclosure:          | NEMA 12                                                                                                                                                                                                             |
| Humidity:           | 95% non-condensing for operating, 93 % for storage/transport                                                                                                                                                        |
| Efficiency:         | 95 - 97 %                                                                                                                                                                                                           |
| Type:               | Pulse Width Modulation (PWM)                                                                                                                                                                                        |
| Control Method:     | "Soft Turn-On" IGBT PWM for dv/dt reduction                                                                                                                                                                         |
| Protection:         | Thermal overload, short-circuiting, ground fault, motor phase is missing, over temperature, high and low voltage and Total Harmonic Distortion (THD) protection built in. High speed, semiconductor fuses external. |
| Optional Bypass:    | Full Speed / Variable Speed, 3 Phase Transfer Switch, NEMA 12 enclosure                                                                                                                                             |
| Input:              | 4-20 mAdc                                                                                                                                                                                                           |
| Feedback:           | 4-20 mAdc                                                                                                                                                                                                           |
| Auxiliary Contacts: | No Fault and Running                                                                                                                                                                                                |

### Suggested Specification

#### 1. Variable Speed Drive (VSD)

Provide a Pulse Width Modulation (PWM) type VSD suitable for microprocessor-based digital control. The VSD shall accomplish stepless speed control by adjusting both the output voltage and frequency to the motor. The VSD shall utilize IGBT power semiconductor technology in the inverter section. VSDs must be UL listed. Provide a NEMA 12 enclosure for the VSD to protect it from dust and splashed water. VSD shall be sized for 104° F continuous ambient air temperature conditions. The enclosure shall be completely self-ventilating with powered fans as required. A NEMA type 1 rated enclosure will not be accepted. The VSD shall automatically limit the rate of fan speed increase to that which will prevent an over-current or over-voltage trip in the event of a "STEP" speed increase of 0 to 100 %. The VSD shall include a line reactor or DC Link Choke to reduce rectifier peak currents, and reduce total harmonic distortion (THD). In order to extend motor insulation life, the VSD shall limit peak voltages. The "dv/dt" shall be limited to 900V/microseconds on a 500 foot cable length between the VSD and motor. VSD's that do not include internal dv/dt limiting shall be provided with external filters.

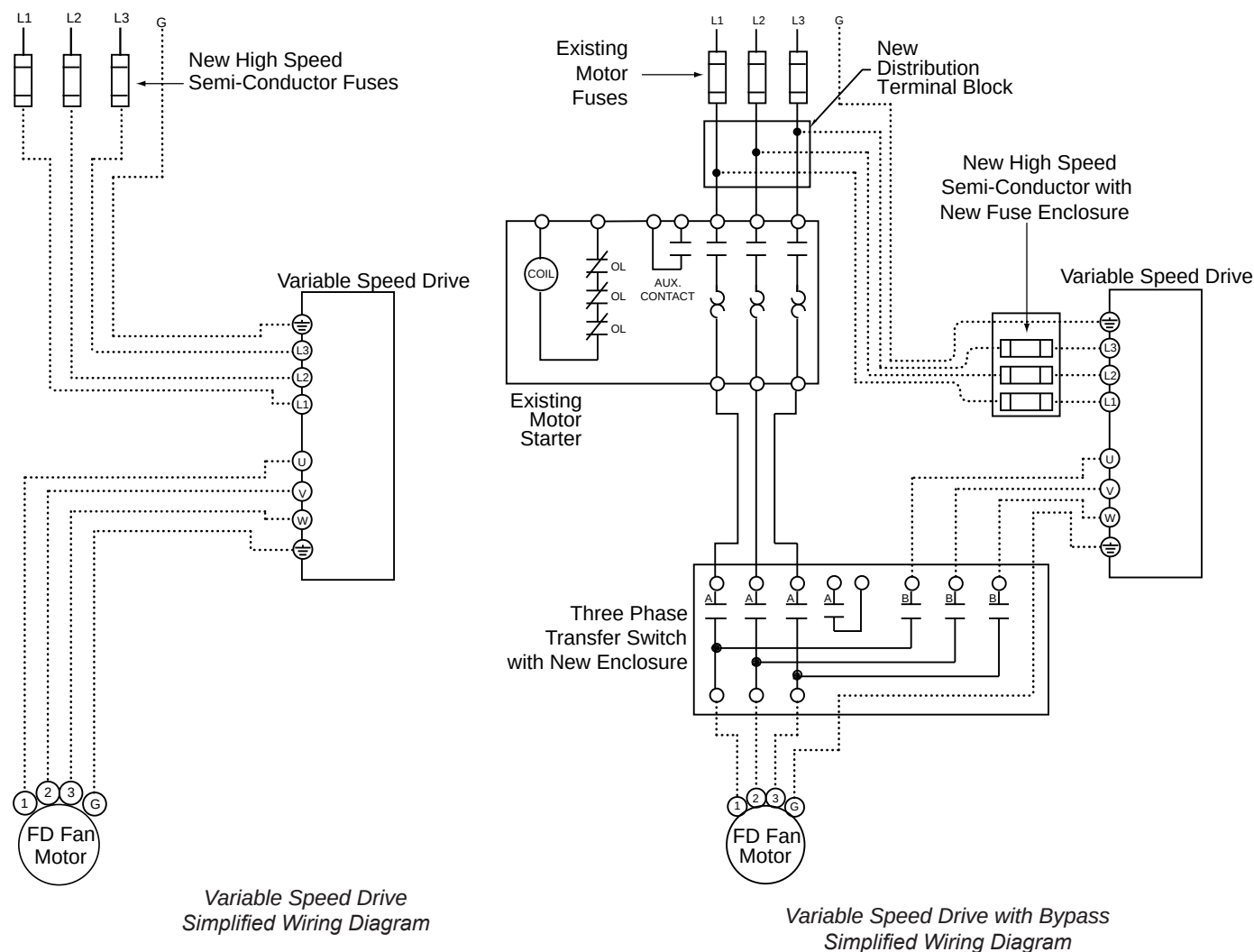
#### 2. Variable Speed Drive (VSD) Bypass

The control system shall include Operator selectable variable speed fan and full speed fan (VSD bypass) air flow control modes. Under "Variable Speed" control, both the forced draft fan speed and the air flow control damper shall be used to regulate combustion air flow. Under "Full Speed" control, only the air flow control damper shall be used to regulate combustion air flow. The controller shall contain independent variable and full speed fan setup curves for each fuel. In the event of a Variable Speed Drive (VSD) failure, the burner shall trip, the operator shall be able to transfer the VSD bypass transfer switch and restart the equipment. The power transfer switch shall be interlocked with the controller for automatic selection of the setup curves. This function shall not require a service engineer to implement the change-over.



## VARIABLE SPEED DRIVE (VSD)

Used with UtilitySaver and BurnerMate Combustion Control Systems



Variable Speed Drive  
Simplified Wiring Diagram

Variable Speed Drive with Bypass  
Simplified Wiring Diagram

### VSD Kit

The VSD Kit includes a microprocessor-based VSD drive with a NEMA 12 enclosure and three (3) high speed semiconductor fuses and fuse holders. Fuses are included to replace the existing motor fuses and should be mounted in existing Motor Starter Panel.

### Standard Equipment

- VSD with NEMA 12 Enclosure
- VSD semi-conductor fuses and fuse holder(s) (shipped loose for mounting in existing motor starter enclosure or VSD Bypass kit fuse enclosure)

### Mounting Kit

The VSD mounting kit includes unistrut, brackets, and mounting plate sized for one VSD. Parts are shipped loose for field assembly. The UtilitySaver Mounting Kit is sized for mounting the UtilitySaver Panel and VSD Bypass Transfer Switch.

### VSD Bypass Kit

The VSD Bypass Kit allows the boiler operator to change from variable speed to constant speed control by a simple control switch selection. Both full speed and variable speed operation are pre-set in the PCC-III controller configuration. The following equipment is included:

### Standard Equipment

- Three (3) phase transfer switch with NEMA 12 enclosure
- High speed semi-conductor fuse with NEMA 12 enclosure
- Three (3) phase distribution terminal block (shipped loose for mounting in the existing motor starter enclosure)

## VARIABLE SPEED DRIVE (VSD)

Used with UtilitySaver and BurnerMate Combustion Control Systems

### VSD Selection

When ordering please verify that the VSD Hp that you have selected is the correct size for your installation. VSDs derate as ambient temperature rises. For the ambient conditions expected, use the table below to compare Maximum Continuous Amps to the motor Nameplate Full Load Amps (FLA). If the motor FLA are lower, your VSD selection is correct.

If the motor FLA are larger than the VSD Maximum Continuous Amps, select the next larger VSD size. On retrofit applications, actual motor amps can be measured. Fan motor amps at high fire are typically lower than motor FLA. Measure the FD fan motor amps with the flame ON and at high fire to determine if a larger VSD size is actually required (do not measure during purge).

| VSD Kit<br>Catalog Numbers |           |           |                    |       | Nominal<br>Hp | VSD Maximum Continuous Amps @<br>Ambient Temperature |          |          |          | Weight<br>lbs |
|----------------------------|-----------|-----------|--------------------|-------|---------------|------------------------------------------------------|----------|----------|----------|---------------|
| VSD                        | VSD Fuses |           | VSD Fuse Holder(s) |       |               | @ <95° F                                             | @ 104° F | @ 113° F | @ 122° F |               |
|                            | Qty       |           | Qty                |       | 230 Vac:      |                                                      |          |          |          |               |
| 70500-8-240                | 3         | 70501-50  | 1                  | 70503 | 7.5           | 24.2                                                 | 20.6     | 17.5     | 14.4     | 50            |
| 70500-10-240               | 3         | 70501-50  | 1                  | 70503 | 10            | 30.8                                                 | 26.2     | 22.3     | 18.3     | 50            |
| 70500-15-240               | 3         | 70501-60  | 1                  | 70503 | 15            | 46.0                                                 | 39.1     | 33.2     | 27.4     | 60            |
| 70500-20-240               | 3         | 70501-80  | 3                  | 70504 | 20            | 59.4                                                 | 50.5     | 42.9     | 35.4     | 80            |
| 70500-25-240               | 3         | 70501-125 | 3                  | 70505 | 25            | 74.8                                                 | 63.6     | 54.1     | 44.5     | 125           |
| 70500-30-240               | 3         | 70501-125 | 3                  | 70505 | 30            | 88.0                                                 | 74.8     | 63.6     | 52.4     | 125           |
| 70500-40-240               | 3         | 70501-150 | 3                  | 70505 | 40            | 104                                                  | 88.4     | 75.1     | 61.9     | 150           |
| 70500-50-240               | 3         | 70501-200 | 3                  | 70505 | 50            | 130                                                  | 110      | 93.5     | 77.0     | 200           |
| 70500-60-240               | 3         | 70501-250 | 3                  | 70506 | 50            | 154                                                  | 130      | 110.5    | 91.0     | 250           |
|                            |           |           |                    |       |               |                                                      |          |          |          |               |
|                            |           |           |                    |       | 460 Vac:      |                                                      |          |          |          |               |
| 70500-8-460                | 3         | 70501-25  | 1                  | 70502 | 7.5           | 11.0                                                 | 9.4      | 8.0      | 6.6      | 25            |
| 70500-10-460               | 3         | 70501-30  | 1                  | 70502 | 10            | 14.0                                                 | 11.9     | 10.1     | 8.3      | 30            |
| 70500-15-460               | 3         | 70501-40  | 1                  | 70503 | 15            | 21.0                                                 | 17.9     | 15.2     | 12.5     | 40            |
| 70500-20-460               | 3         | 70501-40  | 1                  | 70503 | 20            | 27.0                                                 | 23.0     | 19.6     | 16.1     | 40            |
| 70500-25-460               | 3         | 70501-50  | 1                  | 70503 | 25            | 34.0                                                 | 28.9     | 24.6     | 20.2     | 50            |
| 70500-30-460               | 3         | 70501-60  | 1                  | 70503 | 30            | 40.0                                                 | 34.0     | 28.9     | 23.8     | 60            |
| 70500-40-460               | 3         | 70501-80  | 3                  | 70504 | 40            | 52.0                                                 | 44.2     | 37.6     | 30.9     | 80            |
| 70500-50-460               | 3         | 70501-100 | 3                  | 70504 | 50            | 65.0                                                 | 55.3     | 47.0     | 38.7     | 100           |
| 70500-60-460               | 3         | 70501-125 | 3                  | 70505 | 60            | 77.0                                                 | 65.5     | 55.7     | 45.9     | 125           |
| 70500-74-460               | 3         | 70501-150 | 3                  | 70505 | 75            | 117                                                  | 90.1     | 76.6     | 63.1     | 150           |
| 70500-100-460              | 3         | 70501-200 | 3                  | 70505 | 100           | 130                                                  | 110      | 93.5     | 77.0     | 200           |
| 70500-125-460              | 3         | 70501-250 | 3                  | 70506 | 125           | 160                                                  | 136      | 115.6    | 95.2     | 250           |

### VSD Bypass Kit:

Specify the VSD Bypass Kit based on the Nominal VSD Kit selected above.

| VSD Bypass Kit<br>Catalog Numbers |                             |                                | Nominal Hp | VSD<br>Floor Stand Kit<br>Catalog Number | UtilitySaver Panel +<br>Transfer Switch<br>Floor Stand Kit<br>Catalog Number |
|-----------------------------------|-----------------------------|--------------------------------|------------|------------------------------------------|------------------------------------------------------------------------------|
| Transfer<br>Switch<br>(Nema 12)   | Fuse Enclosure<br>(Nema 12) | Power<br>Distribution<br>Block |            |                                          |                                                                              |
|                                   |                             |                                | 230 Vac:   |                                          |                                                                              |
| 70510                             | 70508                       | 70520                          | 7.5        | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 10         | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 15         | 70517                                    | 70519                                                                        |
| 70510                             | 70508                       | 70521                          | 20         | 70517                                    | 70519                                                                        |
| 70511                             | 70508                       | 70521                          | 25         | 70517                                    | 70519                                                                        |
| 70512                             | 70509                       | 70521                          | 30         | 70517                                    | 70519                                                                        |
| 70513                             | 70509                       | 70521                          | 40         | 70518                                    | 70519                                                                        |
| 70513                             | 70509                       | 70522                          | 50         | 70518                                    | 70519                                                                        |
| 70513                             | 70509                       | 70522                          | 60         | 70518                                    | 70519                                                                        |
|                                   |                             |                                | 230 Vac:   |                                          |                                                                              |
| 70510                             | 70508                       | 70520                          | 7.5        | 70515                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 10         | 70515                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 15         | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 20         | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 25         | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70520                          | 30         | 70516                                    | 70519                                                                        |
| 70510                             | 70508                       | 70521                          | 40         | 70517                                    | 70519                                                                        |
| 70511                             | 70508                       | 70521                          | 50         | 70517                                    | 70519                                                                        |
| 70512                             | 70509                       | 70521                          | 60         | 70517                                    | 70519                                                                        |
| 70513                             | 70509                       | 70521                          | 75         | 70517                                    | 70519                                                                        |
| 70513                             | 70509                       | 70522                          | 100        | 70518                                    | 70519                                                                        |
| 70513                             | 70509                       | 70522                          | 125        | 70518                                    | 70519                                                                        |

## VARIABLE SPEED DRIVE (VSD)

Used with UtilitySaver and BurnerMate Combustion Control Systems

### VSD Component Dimensions and Weights:

| Nominal Hp      | VSD Enclosure |    |    |            | Transfer Switch Enclosure |    |    |            | VSD Fuse Enclosure |    |    |
|-----------------|---------------|----|----|------------|---------------------------|----|----|------------|--------------------|----|----|
|                 | H"            | W" | D" | Weight lbs | H"                        | W" | D" | Weight lbs | H"                 | W" | D" |
| <b>230 Vac:</b> |               |    |    |            |                           |    |    |            |                    |    |    |
| 7.5             | 32            | 14 | 11 | 77         | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 10              | 32            | 14 | 11 | 77         | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 15              | 37            | 16 | 11 | 84         | 10                        | 8  | 6  | 6          | 16                 | 14 | 8  |
| 20              | 37            | 16 | 11 | 108        | 10                        | 8  | 6  | 6          | 16                 | 14 | 8  |
| 25              | 37            | 16 | 11 | 110        | 10                        | 8  | 6  | 9          | 16                 | 14 | 8  |
| 30              | 37            | 16 | 11 | 121        | 14                        | 12 | 8  | 20         | 20                 | 16 | 9  |
| 40              | 37            | 20 | 17 | 229        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |
| 50              | 37            | 20 | 17 | 229        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |
| 60              | 37            | 20 | 17 | 229        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |
| <b>230 Vac:</b> |               |    |    |            |                           |    |    |            |                    |    |    |
| 7.5             | 21            | 11 | 8  | 31         | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 10              | 21            | 11 | 8  | 31         | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 15              | 32            | 14 | 11 | 106        | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 20              | 32            | 14 | 11 | 106        | 10                        | 8  | 6  | 4          | 16                 | 14 | 8  |
| 25              | 32            | 14 | 11 | 106        | 10                        | 8  | 6  | 6          | 16                 | 14 | 8  |
| 30              | 32            | 14 | 11 | 112        | 10                        | 8  | 6  | 6          | 20                 | 16 | 9  |
| 40              | 37            | 16 | 11 | 134        | 10                        | 8  | 6  | 6          | 20                 | 16 | 9  |
| 50              | 37            | 16 | 11 | 147        | 10                        | 8  | 6  | 9          | 20                 | 16 | 9  |
| 60              | 37            | 16 | 11 | 154        | 14                        | 12 | 8  | 20         | 20                 | 16 | 9  |
| 75              | 37            | 20 | 17 | 273        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |
| 100             | 37            | 20 | 17 | 273        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |
| 125             | 37            | 20 | 17 | 273        | 24                        | 20 | 8  | 60         | 20                 | 16 | 9  |

### Ordering Information

The VSD Kit includes VSD, Fuses and fuse holder(s). However, these parts must be listed separately when ordering:

1. Specify the VSD Catalog Number that provides the required Voltage, Hp and Maximum Continuous Amps
2. Specify the fuses and fuse holder(s) quantity and catalog numbers (note: below 65 amps (1) three pole fuse holder is required above 65 amps (3) single pole fuse holders are required)

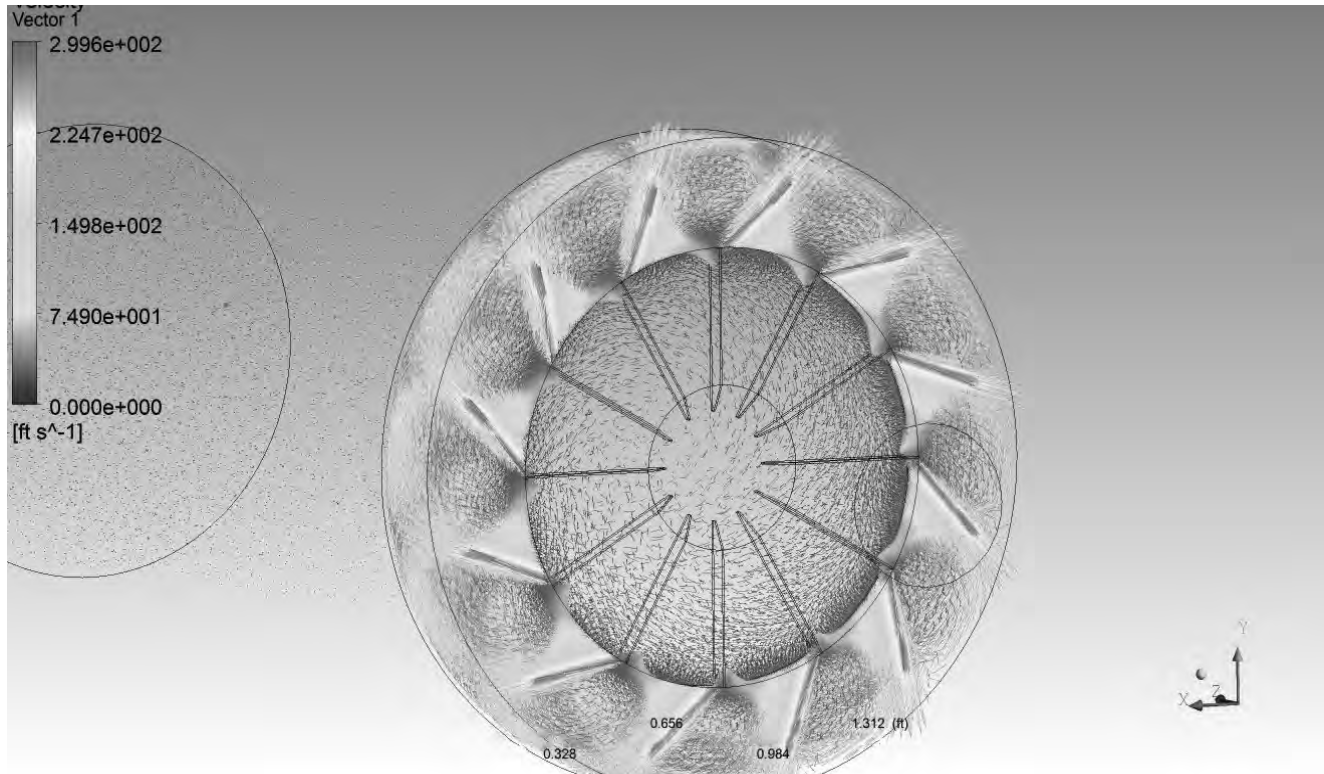
### Additional Ordering Information

1. The Bypass Kit includes Transfer Switch with enclosure, VSD Fuse Enclosure (Fuses and Fuse Holder(s) not included) and Terminal Block. However, these parts must be listed separately when ordering. Specify the Transfer Switch, VSD Fuse Enclosure and 3 Ph Terminal Block Catalog Numbers
2. Specify VSD and UtilitySaver Mounting Kit Catalog Numbers as required

Consult Factory for different voltages, Hp and amp rating requirements.

Consult Factory when applying the VSD Bypass kit to the BurnerMate Control Systems.

# Plant Engineering Data



**PREFERRED**  
UTILITIES MFG CORPORATION





In light of the continued rise in fuel and labor costs, a good understanding of basic combustion theory is more important today than ever before. In addition, increasingly stringent environmental regulations and concerns make the selection, design and maintenance of combustion control systems extremely important. Combustion, in its most basic sense, is the process whereby the hydrogen and carbon in fuels is combined with oxygen from the air to release heat. **Table 3** shows the more common chemical reactions involved. Byproducts include carbon dioxide, water vapor, left-over nitrogen from the air, and possibly unreacted oxygen and/or fuel components. Combustion control, in its most basic sense, is the maintenance of the proper fuel and air flows into this process to produce the amount of heat energy required while consuming the least possible fuel and generating the lowest level of pollutants.

The following pages contain a brief overview of the combustion process, a discussion of factors which determine the efficiency of a boiler or furnace, and some of the traditional strategies used to accomplish combustion control.

### COMBUSTION BASICS

The most common industrial fuels are hydrocarbons. This means that they are predominantly composed of carbon and hydrogen. **Table 1** lists some common fuels and gives typical values for the hydrogen and carbon contents as percentages by weight. Note that there are some other components besides hydrogen and carbon. Some of these, such as sulfur, are combustible and will contribute to the heat released by the fuel. Other components are not combustible and contribute no positive energy to the combustion process.

#### The Chemistry

**Table 3** reviews the basic chemical equations, which represent the most common combustion reactions. Note that nitrogen ( $N_2$ ) is shown on both sides of the equations. Except for the formation of  $NO_x$  (in the parts per million range) nitrogen does not react in the combustion process. The nitrogen must be considered in fan sizing and stoichiometry calculations. Each atom of carbon in the fuel will combine with two atoms of oxygen (or one molecule of  $O_2$ ) from the atmosphere to form one molecule of  $CO_2$ . On a weight basis, each pound of carbon requires 2.66 pounds of oxygen for complete combustion resulting in the production of 3.66 lb of carbon dioxide.

Each pair of hydrogen atoms (or each molecule of  $H_2$ ) will combine with one atom of oxygen (or one half molecule of  $O_2$ ) to form one molecule of  $H_2O$ , or water. On a weight basis, each pound of hydrogen requires 7.94 pounds of oxygen for complete combustion, resulting in the production of 8.94 pounds of water.

#### By the Numbers

The air we breathe is only about 21% oxygen by volume. For all practical purposes, the remaining 79% is nitrogen. Since oxygen is a little heavier than nitrogen, the percentages by weight are somewhat different. The percentage of oxygen by weight is 23%, and the remaining 77% is nitrogen. Thus, it requires about 4.35 pound of air to deliver one pound of oxygen. **Table 2** shows the composition of air.

A typical gallon of No. 6 fuel oil weighs 8 pounds and is 87% carbon and 12 % hydrogen (the missing percent is sulfur, ash, water and sediment). This gallon contains 6.95 pounds of carbon and 0.96 pound of hydrogen. From the data presented earlier, we can compute that 18.49 pounds of oxygen are needed to burn the carbon and 7.62 pounds of oxygen must be provided to burn the hydrogen in this gallon of fuel oil. This represents a total requirement of 26.11 pounds of oxygen. Since air is only 23% oxygen by weight, it will take 113.5 pounds of air ( $26.1 \div 0.23$ ) for the complete and perfect (0% excess air) combustion of this gallon of fuel. Assuming there are 13 cubic feet of air to the pound, 1476 cubic feet of air are required to burn each gallon of fuel. A 50 gallon per hour burner (about 200 boiler HP) would need nearly 74,000 cubic feet of air per hour (or 1230 scfm) to fire without any allowance for excess air.

#### The Real World

In the real world, however, there must always be more air supplied to the combustion process than the theoretical or stoichiometric air requirement. This is because no burner made is this "perfect". This "extra" air is referred to as "excess air." If 20% more than the theoretical air requirement is supplied, we say that the burner is operating at 20% excess air. Another way of stating the same thing is to say that the burner is operating with 120% "total air."

Complete combustion of our one gallon of No. 6 fuel oil with 20% excess air would require 136 pounds of air. The 50 gallon per hour burner would actually require about 90,000 cubic feet of air per hour.

For any particular burner-boiler combination, there is an ideal "minimum excess air" level for each firing rate over the turn-down range. Greater air flows would waste fuel because of the increased mass flow of hot gases leaving the stack. Lesser amounts of air would cause fuel waste because the fuel would not be burned completely. Typically, burners require much higher levels of excess air when operating near their minimum firing rates than they do at "high fire." **Table 4** shows a typical relationship between percent firing rate and the excess air required to insure complete combustion of the fuel. In many cases, even though stack temperature might decrease at low fire, efficiency suffers because so much of the fuel energy is lost to heat this excess air.



## COMBUSTION THEORY

### Fuel Composition (Percent By Weight)

| Component | Symbol | Molecular Weight | No. 2        | No. 4 Light  | No. 4 Heavy  | No. 5 Light  | No. 5 Heavy  | No. 6        | Coal | Wood (Dry) |
|-----------|--------|------------------|--------------|--------------|--------------|--------------|--------------|--------------|------|------------|
| Hydrogen  | H      | 2.02             | 11.8 to 13.9 | 10.6 to 13.0 | 10.6 to 13.0 | 10.5 to 12.0 | 10.5 to 12.0 | 9.5 to 12    | 5.0  | 5.7        |
| Carbon    | C      | 12.01            | 86.1 to 88.2 | 86.5 to 89.2 | 86.5 to 89.2 | 86.5 to 89.2 | 86.5 to 89.2 | 86.5 to 89.2 | 75.0 | 54.9       |
| Nitrogen  | N      | 14               | 0.0 to 0.1   | --           | --           | --           | --           | 0.0 to 0.5   | 1.5  | 25.3       |
| Oxygen    | O      | 16               | --           | --           | --           | --           | --           | 0.0 to 1.5   | 6.7  | 13.1       |
| Sulfur    | S      | 32.06            | 0.05 to 1.0  | 0.2 to 2.0   | 0.2 to 2.0   | 0.5 to 3.0   | 0.5 to 3.0   | 0.7 to 3.5   | 2.3  | trace      |
| Ash       | --     | --               | --           | 0.0 to 0.1   | 0.0 to 0.1   | 0.0 to 0.1   | 0.0 to 0.1   | 0.0 to 0.5   | 7.0  | 2.0        |

Table 1

### Air Composition

| Component      | Symbol          | Molecular Weight | % By Volume          | % By Weight |
|----------------|-----------------|------------------|----------------------|-------------|
| Nitrogen       | N <sub>2</sub>  | 28.02            | 78.09                | 75.47       |
| Oxygen         | O <sub>2</sub>  | 32               | 20.90                | 23.20       |
| Argon          | Ar              | 39.94            | 0.933                | 1.28        |
| Carbon Dioxide | CO <sub>2</sub> | 44.01            | 0.033                | 0.046       |
| Neon           | Ne              | 20.18            | 0.0018               | 0.0012      |
| Helium         | He              | 4                | 0.0005               | 0.00007     |
| Krypton        | Kr              | 83.8             | 0.0001               | 0.0003      |
| Xenon          | Xe              | 131.29           | 9 x 10 <sup>-6</sup> | 0.00004     |

Table 2

### Common Combustion Reactions

| AIR                                  | FUEL                           | FLUE GASES                                                              |
|--------------------------------------|--------------------------------|-------------------------------------------------------------------------|
| 3.76 N <sub>2</sub> + O <sub>2</sub> | + 2 H <sub>2</sub><br>hydrogen | 2 H <sub>2</sub> O + 3.76 N <sub>2</sub> + HEAT<br>water nitrogen       |
| 3.76 N <sub>2</sub> + O <sub>2</sub> | + C<br>carbon                  | CO <sub>2</sub> + 3.76 N <sub>2</sub> + HEAT<br>Carbon dioxide nitrogen |
| 3.76 N <sub>2</sub> + O <sub>2</sub> | + S<br>sulfur                  | SO <sub>2</sub> + 3.76 N <sub>2</sub> + HEAT<br>sulfur dioxide nitrogen |

Table 3

#### RULES OF THUMB

1. Standard air @ sea level and 70° F has a density of 0.07495 lbs/ft<sup>3</sup>
2. 1 lb of standard air @ sea level and 70° F has a volume of 13.34 ft<sup>3</sup>

#### Required Air For Combustion (no excess air)

3. lbs. air/lb. natural gas = 17.5
4. lbs. air/lbs. oil = 14.0
5. lbs. air/lbs. coal = 12.0
6. lbs. air/MMBtu. oil = 750
7. lbs. air/MMBtu. natural gas = 720
8. Required air for combustion increases 4.0% for every 1000 ft. above sea level
9. lbs/hr air = (SCFM) x 4.5 @ 70°F.
10. Required air for combustion in CFM increases 1.9% for every 10° above 70° F.

Table 4

### Varying Oxygen Content of Air

Many factors that influence the actual mass flow of oxygen into a burner for any given air control damper setting. While dirty fan wheels and dampers will reduce the volumetric air flow, changing ambient air conditions also have an effect on the actual input of oxygen into the combustion process.

Starting with “normal” air at a barometric pressure of 30 inches of mercury, a temperature of 60° F, and 45% relative humidity, the actual mass oxygen flow for a constant volumetric air flow can vary greatly with normal seasonal variations. Mass oxygen flow would drop by nearly 20% on a hot humid summer day when the combustion air was 120° F, with a barometric pressure of 29.5 inches of mercury and 95% relative humidity. This is why it seems so hard to breathe on a really hot, humid day. There isn't as much oxygen in each breath as we are used to. Burners have the same problem, except that they smoke, soot and make noxious emissions if allowances aren't made for this “oxygen lean” air.

The oxygen mass flow for a constant volumetric air flow would increase by 10% on a cold dry winter day at 32° F, barometric pressures of 30.5 inches of mercury, and 0% relative humidity. This is why winter air can feel so good to breathe. It is “oxygen rich.”

### Variations in Fuel Flow

Many factors also influence the actual mass flow of fuel into the burner for a given setting of the fuel control valve. Pressure drop across the metering valve and fluid viscosity have the greatest effect on fuel flow. With residual fuels, this is especially important. Viscosity of the fuel at a given, “fixed” temperature can vary from delivery to delivery, and temperature variations above this “fixed” point can cause the viscosity at the fuel valve to vary even more.

Having thick oil in the burner supply line can reduce the pressure at the metering valve while having thick oil in the return line can increase the pressure at the valve. With No. 6 fuel oil, the flow rate through a simple metering valve can vary by as much as +50% as a result of a build-up of “typical” variations in base viscosity, oil temperature, supply pressure and return line pressure.

### Safe Burner Set-Up

To operate cleanly and safely, a burner must be adjusted so that under the worst case fuel and air conditions, sufficient combustion air is supplied for the fuel to be burned. This means that if the burner is set up on a “standard” day with 60° F air, a 30 inch barometric pressure, and 45% relative humidity, an additional 20% excess air must be provided if the burner is to operate cleanly on a hot, humid summer day with the same ACFM air flow, but with less oxygen per ambient cubic foot of air.

In addition, any possibility of the burner fuel delivery to increase at a given control setting must be taken into account by further increasing the excess air.

### The Cost of Excess Air

Since the total amount of air flow is so great, it is easy to see why this “excess-excess air” is so costly. This air must be heated by the fire in the burner, yet the heat is not recovered completely. It is wasted up the stack. In the example of a 50 GPH burner, which must be set up with an extra 30% excess air to allow for variations in fuel and air conditions, the net result is an extra ton of air per hour that is heated and then goes up the stack.

In the following section on boiler efficiency calculation, the effects of varying fuel/air ratios will be discussed in greater detail. At this point, simply, adding air to the combustion process beyond what is absolutely necessary for complete and clean combustion causes a sizable drop in efficiency. Decreasing air flow can result in incomplete combustion, soot, smoking or carbon monoxide generation. This results in an even greater loss in efficiency because the chemical energy in the fuel is not totally extracted. **Figure 2** shows the effects of too much and too little air on efficiency for a typical burner.

## EFFICIENCY CALCULATIONS

The efficiency of a burner-boiler combination is simply the amount of useful energy leaving the system expressed as a percentage of the chemical energy in the fuel entering the system. The efficiency calculation method based on measuring the fuel input and the steam (or hot water) output is called the input-output efficiency method. This method is not used frequently because of the difficulty in obtaining fuel flow, steam flow and steam quality measurements with the required degree of accuracy. Since the efficiency value will typically be around 80% and a change in efficiency of 5% can have a major impact on the operation expense of a facility, the flow measurements used in the calculations would have to have errors significantly less than 5% for these calculations to be useful. This is beyond the capability of the steam and fuel flow metering devices normally found in the boiler room except possibly at maximum boiler output.

Another less obvious but more accurate way of calculating boiler efficiency is the ASME “by losses method.” Here, the boiler-burner is assumed to be a black box. Energy enters the black box in the form of chemical energy in the fuel and sensible heat in the combustion air. Energy leaves the black box in the form of steam and as sensible and latent heat in the flue gasses and in radiation from the boiler surfaces and in the blowdown water. **Figure 5** shows a simple block diagram with various energy flows into and out of the boiler.

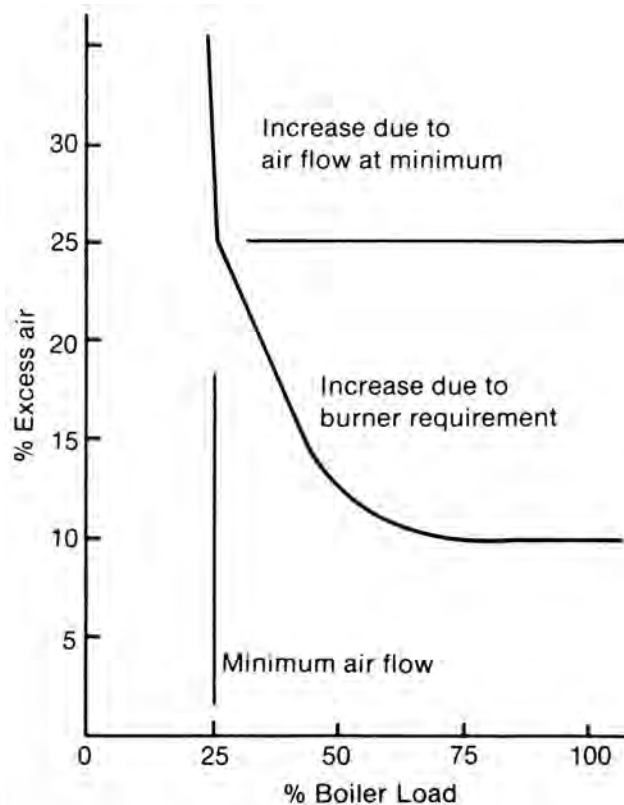


Figure 1  
Excess Air vs. Boiler Load, Typical Curve

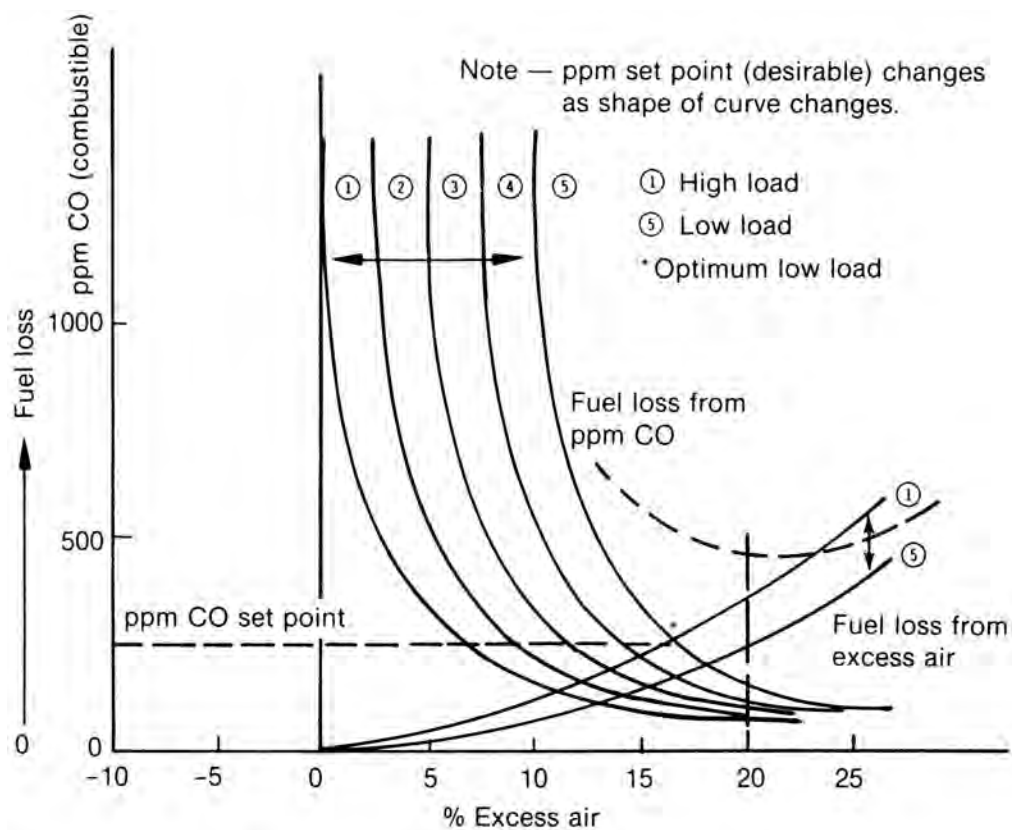
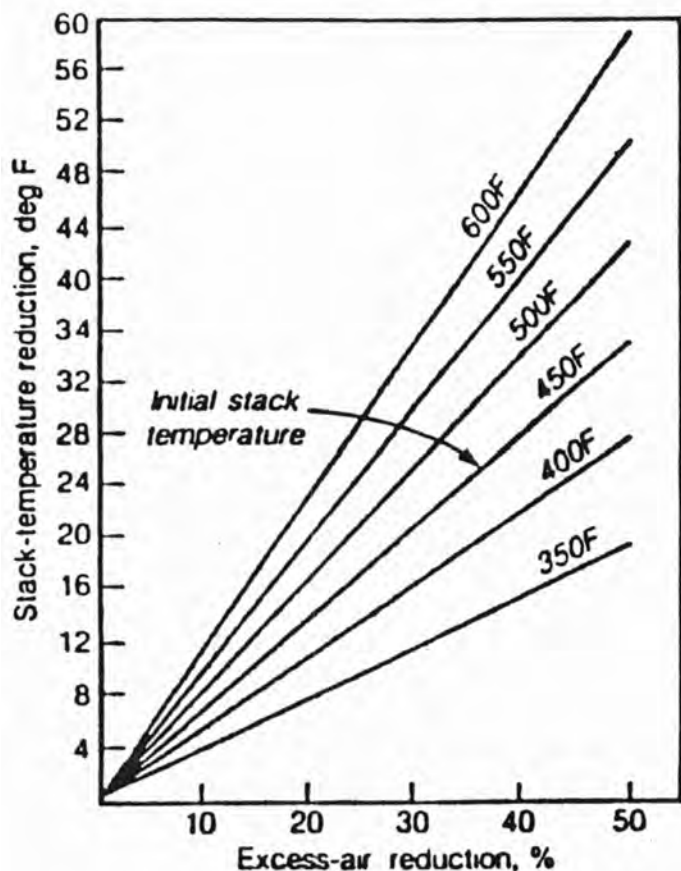


Figure 2  
Excess Air Combustible Gas Relationship

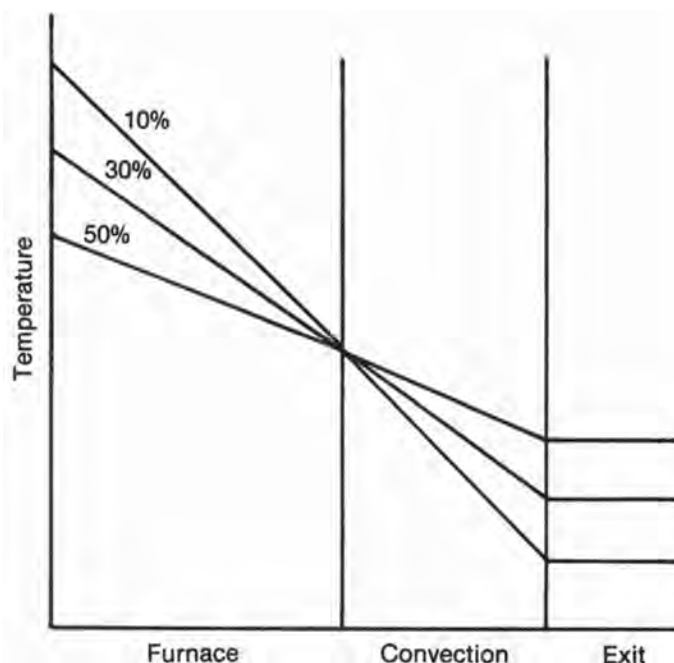
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## COMBUSTION THEORY



Effect of Excess Air on Temperatures

Figure 3



- Reduced excess air improves heat transfer.
- Reduced excess air reduces mass of flue gases.

Figure 4

### Temperature and Barometric Effect on Excess Air%

For a burner originally adjusted to 15% excess air, when the barometric pressure was 29" Hg and air temperature was 80° F, the following table shows excess air changes resulting from changes in air pressure and temperature.

| Air Temperature | Barometric Pressure "Hg | Resulting % Excess Air* |          |
|-----------------|-------------------------|-------------------------|----------|
| 40              | 29                      | 25.5%                   |          |
| 60              | 29                      | 20.2%                   |          |
| 80              | 29                      | 15.0%                   | (Set Up) |
| 100             | 29                      | 09.6%                   |          |
| 120             | 29                      | 01.1%                   |          |
| 80              | 27                      | 07.7%                   |          |
| 80              | 28                      | 11.0%                   |          |
| 80              | 29                      | 15.0%                   | (Set Up) |
| 80              | 30                      | 19.0%                   |          |
| 40              | 31                      | 34.5%                   |          |
| 60              | 30                      | 25.0%                   |          |
| 80              | 29                      | 15.0%                   | (Set Up) |
| 100             | 28                      | 05.0%                   |          |
| 120             | 27                      | -5.5%                   |          |

\*Note: Expressed as a percent of the stoichiometric air required

Table 5

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## COMBUSTION THEORY

Since energy cannot be created or destroyed, and since energy is not stored in the boiler (when operating in the steady state), the amount of energy leaving the system by all available paths must be equal to the amount of energy entering the system. By calculating all of the various energy flows out of the system that represent losses, and expressing them as a percentage of the fuel energy entering the system, the total losses may be calculated. If there were no losses, the efficiency would be 100%. This results in a more accurate estimate of unit efficiency than that obtained by directly measuring the fuel energy into the burner and the steam energy out of the boiler.

### Efficiency Losses

Together, the steam leaving the boiler, and stack and radiation losses account for all but a percent or two of the energy entering the boiler in the form of fuel. Stack losses represent the energy that could be reclaimed from the gases leaving the boiler if these gases were cooled to the temperature of the combustion air entering the system. The lower the stack temperature (all other things being equal) the lower the stack losses. The lower the stack losses, the higher the efficiency.

Stack losses account for nearly all of the wasted energy leaving the boiler. For this reason, the term "combustion efficiency" is often used in place of "efficiency." Combustion efficiency is the number that results when the stack losses are deducted from 100%. This number neglects radiation and miscellaneous losses, so it is generally 3% to 5% higher than the actual efficiency.

### Radiation Losses

Radiation losses represent the heat that escapes from the surface of the boiler into the surrounding air. The better the boiler is insulated, the lower the radiation losses. Radiation losses generally represent a fixed amount of energy lost per unit of time since the surface of the boiler is generally at the saturation temperature of the steam being generated. For field-erected water tube boilers, with significant amounts of refractory furnace wall surface not covered with water tubes, the total quantity of heat lost to radiation might increase with firing rate as the furnace walls would become hotter at higher inputs.

With water-cooled boiler surfaces, (especially fire tube units), since the total amount of heat lost from the surface per hour is a constant (dependent on the temperature of the surrounding air), it is not dependent on firing rate. When expressed as a percentage of the fuel energy input, however, the radiation loss will be higher at reduced firing rates. If a boiler has a 3% radiation loss at high fire (100% input), it will have a 6% radiation loss at half fire because the constant heat flow by radiation is now twice as large compared with the fuel input.

Radiation losses are not affected by changes in combustion and combustion control. Short of insulating the boiler, there is no real way to control this loss. Stack losses, however, may be controlled.

### Stack Losses

Stack losses are composed of sensible and latent components. The latent heat component represents the heat of vaporization of the water (steam) that was formed when the hydrogen in the fuel was burned. This component is a function of the percent hydrogen in the fuel, and may be treated as a constant for any given fuel analysis. For typical fuel oils, the efficiency lost due to latent heat in the stack (steam in stack) is roughly 5%. For natural gas, which contains a higher percentage of hydrogen, the efficiency lost due to latent heat in the stack gases is roughly 9%.

The sensible heat component of the stack loss is a function of the amount of gas leaving the boiler and the difference in temperature between the stack gases and the combustion air entering the burner. The higher this temperature difference, the higher the stack loss. The greater the mass flow of gas through the boiler, the higher the stack loss. Therefore excess air results in lowered efficiency.

The temperature of the gases leaving the boiler is effected by boiler design, the cleanliness of the boiler, the firing rate, and the amount of excess air. The higher the relative air flow, the shorter the residence time of gases in the boiler will be. The gases will have less time to give up heat to the boiler tubes, and the stack temperature will increase, driving the efficiency down. The dirtier the heat transfer surfaces, on both fire and water sides, the higher the temperature of the gases leaving the boiler, causing a loss in efficiency. Typically, a 40° F increase in stack temperature will result in a 1% decrease in efficiency. Of course, high pressure steam boilers will have higher stack temperatures than low pressure steam boilers because the temperature of the water in the boiler is higher for the higher pressures. The combustion gases are being "cooled" by hotter tube surfaces, and they end up hotter. This is why large high pressure boilers are often equipped with feedwater economizers. Here, the relatively cool boiler feedwater is used to cool the stack gases further after they leave the boiler steam generating section.

### Measuring Excess Air

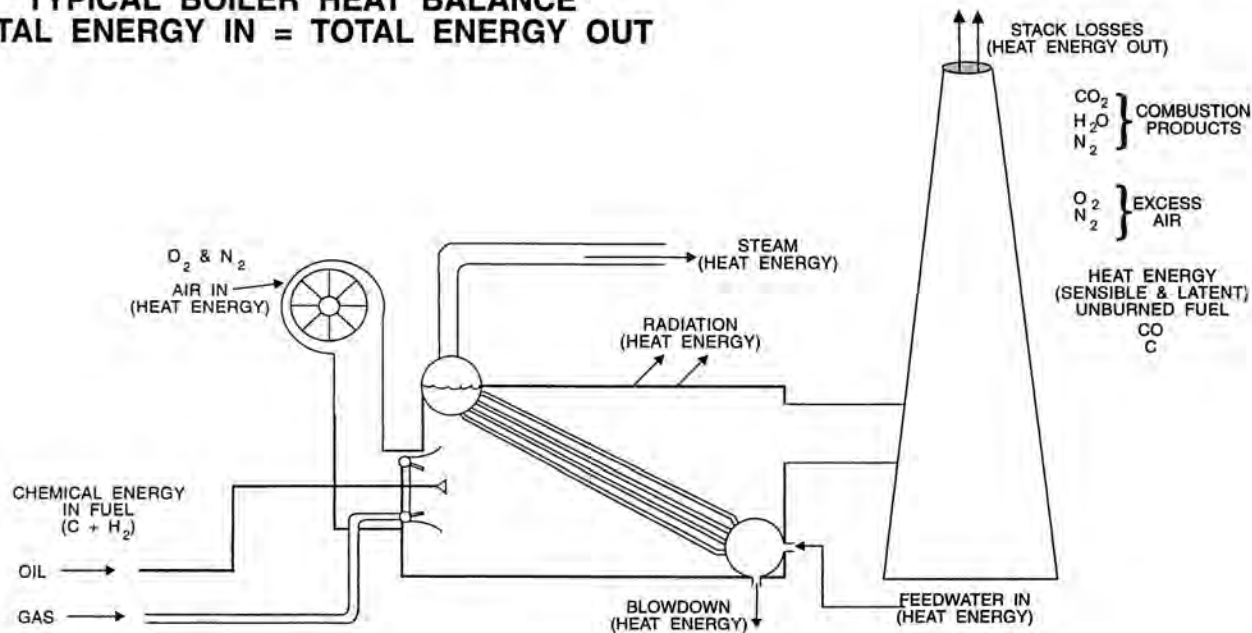
The mass flow of air through the boiler is a function of the amount and composition of the fuel being fired and the amount of excess air provided. For theoretical (stoichiometric) combustion with no excess air (0% O<sub>2</sub> in the flue gas), the amount of air required for each unit of fuel may be determined from the analyses of the fuel and air composition as discussed earlier. It is also possible to calculate the maximum CO<sub>2</sub> content of the stack gases



## COMBUSTION THEORY

### Efficiency Calculation

#### TYPICAL BOILER HEAT BALANCE TOTAL ENERGY IN = TOTAL ENERGY OUT



#### EFFICIENCY:

$$\text{INPUT - OUTPUT EFFICIENCY} = \frac{(\text{ENERGY OF STEAM OUT}) - (\text{ENERGY OF WATER IN})}{\text{CHEMICAL ENERGY IN}} = \frac{\text{USABLE ENERGY OUT}}{\text{FUEL ENERGY IN}}$$

$$\begin{aligned} \text{EFFICIENCY BY LOSSES} &= 100\% - \text{TOTAL OF ALL ENERGY OUT NOT IN STEAM} \\ &= 100\% - \text{TOTAL OF ALL LOSSES} \end{aligned}$$

Figure 5

#### Conservation of Energy

- Fuel energy "in" equals heat energy "out"
- Energy leaves in steam or in losses
- Efficiency = 100% minus all losses

#### Typical boiler efficiency is 80% to 85%

- The remaining 15% to 20% is lost
- Largest loss is a typical 15% "stack loss"
- Radiation loss may be 3% at full input
- Miscellaneous losses might be 1 to 2%

#### RULES OF THUMB

##### To Approximate Operating Cost

1. Cost of Fuel = \$6.25 per thousand lbs. of steam per hour  
(based on gas @ \$5.00/thousand Cu. Ft.)
2. Normal firing hours per year = 8500
3. 10% reduction in excess air = 1% reduction in fuel input
4. On a packaged water tube boiler, each on-off cycle costs an additional \$.50 per thousand pounds of maximum boiler rating (based on heat losses during purge and increased maintenance)
5. Horsepower cost = \$333.00 per horsepower per year  
(based on electricity cost of \$.05/KW hr)

## COMBUSTION THEORY

based on the percent of carbon in the fuel. By taking a reading of the  $\text{CO}_2$  or  $\text{O}_2$  content of the stack gases, the amount of excess air may be calculated as well. The efficiency charts in this section correlate oxygen, carbon dioxide, and excess air levels for various “typical” fuels. Remember that the flue gases contain a substantial amount of water vapor. If this water vapor is allowed to condense, the remaining gases will take up less volume. If the concentration of oxygen or carbon dioxide in a “dry” sample is measured, the percent by volume will be higher than if the water were still present as a vapor.

This is why there are two sets of values for oxygen on the efficiency charts we use. One is for “dry” samples such as one would obtain by using an Orsat or a Bacharach Fyrite. The other is for “wet” samples with the water vapor still present. In-situ zirconium oxide analyzers operate at a high temperature and provide a “wet” reading because the measured oxygen is part of the entire stack gas sample, water vapor and all. “Wet” reading will always be lower than “dry” readings, and it is important to note the method used when taking combustion data, or the wrong excess air levels will be inferred.

### Calculating Flue Gas Composition

The amount of water vapor and carbon dioxide formed per unit of fuel is fixed by the amount of hydrogen and carbon in the fuel as determined by the fuel analysis. The amount of nitrogen leaving the boiler is a function of the amount of theoretical air required for each unit of fuel plus the amount of excess air in the combustion products. For each fuel composition, the measurement of excess air in the stack will uniquely determine the composition of the stack gases. Given the composition of these gases, it is possible to determine the amount of latent and sensible heat energy contained in the gases leaving the boiler for any given temperature reading.

In this way, it is possible to prepare charts for typical fuels relating the stack losses to the excess air levels and to the temperature rise (difference between stack temperature and combustion air temperature). By using temperature rise instead of absolute stack temperature, the energy in the combustion air entering the burner is accounted for. It is also possible to write computer programs, and to configure micro-processor based controllers to calculate the combustion efficiency based on typical fuel analysis, stack temperature, air temperature, and stack oxygen.

The following charts for the calculation of combustion efficiency were developed in this way. **Figures 6, 7, and 8** were developed for calculating the combustion efficiency of boilers firing No. 6 oil, No. 2 oil and natural gas, respectively.

It is important to realize that it does not matter to the efficiency calculation where the excess air came from. It might be supplied to the burner intentionally or it may be “tramp air” which has entered the boiler because of leaks in the setting and/or excessively high draft in the furnace. This is why a tight setting and good draft control is very important to maximize the efficiency of a boiler.

### Other Energy Losses

There is a potential third major loss representing unburned fuel. This can be significant when firing solid fuels as the ash leaving the boiler may contain unburned carbon in the several percentage point range. Since this section deals mainly with gas and oil firing, and since unburned fuel results in smoke, soot, and carbon monoxide, the assumption is made that this condition cannot be allowed to exist regardless of its effects on efficiency. For this reason, unburned fuel losses will be ignored in this discussion.

For high pressure boilers operating with regular or continuous blowdown in order to control dissolved solids, there can be significant energy wasted in the blowdown water. Continuous blowdown controls can minimize this loss by keeping the blowdown rate from exceeding that needed to keep the boiler water conductivity below a predetermined level. On large units, it may be economical to install a heat exchanger to transfer this heat to the feedwater.

In general, the radiation loss, the stack loss, any blowdown loss, and a wild card “miscellaneous loss” account for practically all of the energy lost from the system. Often the radiation loss at high fire, and the “miscellaneous loss” are given in the boiler manufacturers data. By measuring the stack temperature, and excess air (via  $\text{CO}_2$  or  $\text{O}_2$  measurement), a very accurate estimate of total unit efficiency can be obtained if radiation losses and miscellaneous losses are taken into account. Remember that the radiation loss is inversely proportional to the firing rate when taken as a percent figure.

### EXAMPLE

Suppose a 600 HP boiler is firing No. 6 oil. The boiler manufacturer gives the high fire radiation loss as 2%, and the “miscellaneous loss” as 1%. Measurement of the stack gases using a Bacharach Fyrite gives a  $\text{CO}_2$  reading of 12%, and the stack temperature is 580° F. Further, the temperature of the combustion air is 80° F, so the net stack temperature or “ $\Delta T$ ” is 500° F.

Assume that the burner is operating at 75% of the maximum rating of the boiler. This means that the actual radiation loss would be the high fire rating of 2% divided by 0.75, or 2.67%.

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The CO<sub>2</sub> reading is a “dry” reading because the Bacharach, by its nature, condenses the water out of the stack gases in the process of absorbing the CO<sub>2</sub>. From the combustion efficiency chart on **Figure 8**, note that the 12% CO<sub>2</sub> dry reading corresponds to 33% excess air. By drawing a line up to the 500° F net stack temperature or  $\Delta T$  line, the combustion efficiency is estimated at 82%.

Note that this is just combustion efficiency. From this figure, we must deduct the 2.67% radiation loss and the 1% miscellaneous loss. The resulting unit efficiency as determined by the ASME “by losses” method is 78.33%. This number should agree with an efficiency calculation based on fuel in and steam out if all measurements were accurate to within a tenth of a percent or so.

### SAVING FUEL WITH COMBUSTION CONTROLS

#### SUMMARY

Since the burner must be set up to operate cleanly under worst case conditions, enough excess air must be provided to burn any additional fuel that the metering device at the burner may introduce as well as to ensure that there will be sufficient excess air available on a hot, humid summer day. There is no way to prevent heat and humidity, but fuel flow can be closely controlled with the appropriate controls.

To compensate for changes in air quality, a burner will operate part of the year (assuming that there is no seasonal tuning) with more excess air than at other parts of the year. If the air flow must be increased by 20% to accommodate a hot day, then periods with cooler drier air and most boiler load, the burner will waste fuel. On large units of 600 HP or more, oxygen trim can provide a payback by compensating for these changes in air flow. On smaller units, seasonal tuning can be a solution. On residential size burners, the best practice is to live with the excess air, because a burner that runs short of air and builds soot or produces CO is not safe or efficient.

Assume that a particular burner firing No. 6 fuel oil can be adjusted to operate at 20% excess air on a “normal” day with “normal” fuel metering. Further, assume that this boiler will then show a stack temperature of 460° F. **Figure 8** shows that the technician would measure 3.2% O<sub>2</sub> (wet) or 13.4% CO<sub>2</sub> (dry) since the excess air level is 20%. The net stack temperature rise would be 400° F if the ambient air entering the burner was at 60° F. The combustion efficiency would be 85.6%.

Assuming that the air is increased just to cover expected changes in air quality, at least 20% more excess air would have to be added on a “normal” day to compensate for an “abnormal” day. Looking again at **Figure 8**, the efficiency loss due to an additional 20% increase in excess air is about 1.6%. For a 750 HP boiler operating at an average load of 65%, this could represent an actual cost of \$18,800 per year using a fuel cost of \$0.90 per gallon.

If the metering system for the oil had a possible variance of +/- 20%, then an additional 20% excess air would have to be provided to ensure complete combustion when the oil flow was at a high extreme. **Figure 8** indicates that this would result in a decrease to 82.8% efficiency. The additional cost of this excess air would be \$14,400 with the same assumptions as before.

Typically, the efficiency would drop to around 81.5% with an extra 40% excess air because of a corresponding increase in stack temperature. As excess air increases, the residence time of the gases in the boiler decreases, causing a reduced heat transfer.

If a “perfect” control system with oxygen trim and metering fuel flow control could hold this boiler to the ideal 20% excess air at all times, the owner could potentially save \$24,000 per year (taking the change in flue gas temperature in account).

It is these potential savings that justify the installation of sophisticated control systems on larger units, and burners with sophisticated fuel metering systems on smaller units.

# COMBUSTION THEORY

## Combustion Efficiency Table

### Combustion Efficiency Natural Gas

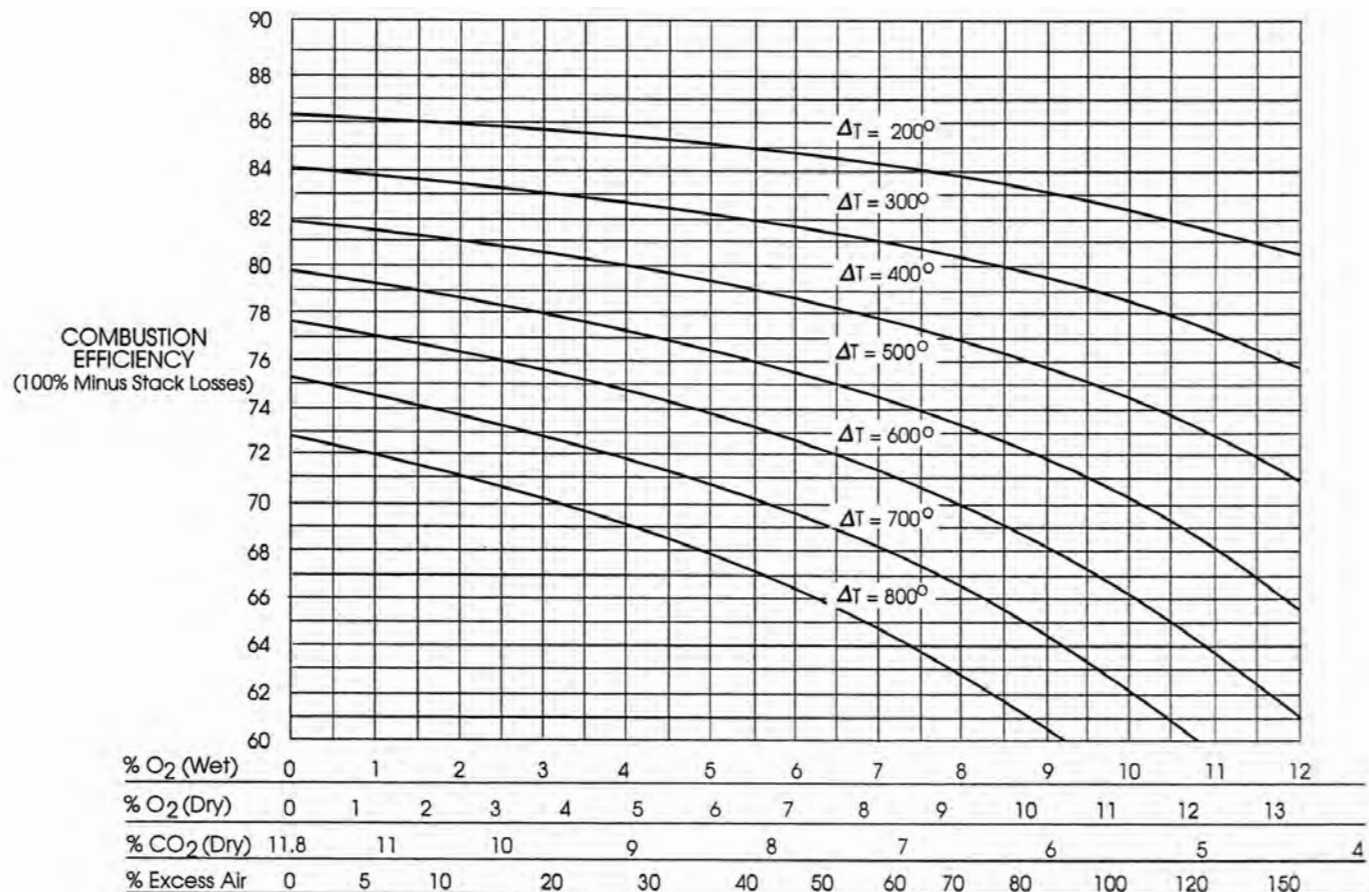


Figure 6

|                     |                                      | Existing   | Projected  |
|---------------------|--------------------------------------|------------|------------|
| O <sub>2</sub>      | %                                    | _____      | _____      |
| Flue Gas            | ΔT°F                                 | _____      | _____      |
| Efficiency          | %                                    | _____ (EE) | _____ (PE) |
| Fuel Consumption    | \$                                   | _____      | _____ (FC) |
| Projected Savings = | $\frac{PE\% - EE\%}{PE\%} \times FC$ |            |            |
| Projected Savings = | \$                                   | _____      |            |



# COMBUSTION THEORY

## Combustion Efficiency Table

### Combustion Efficiency #2 Oil

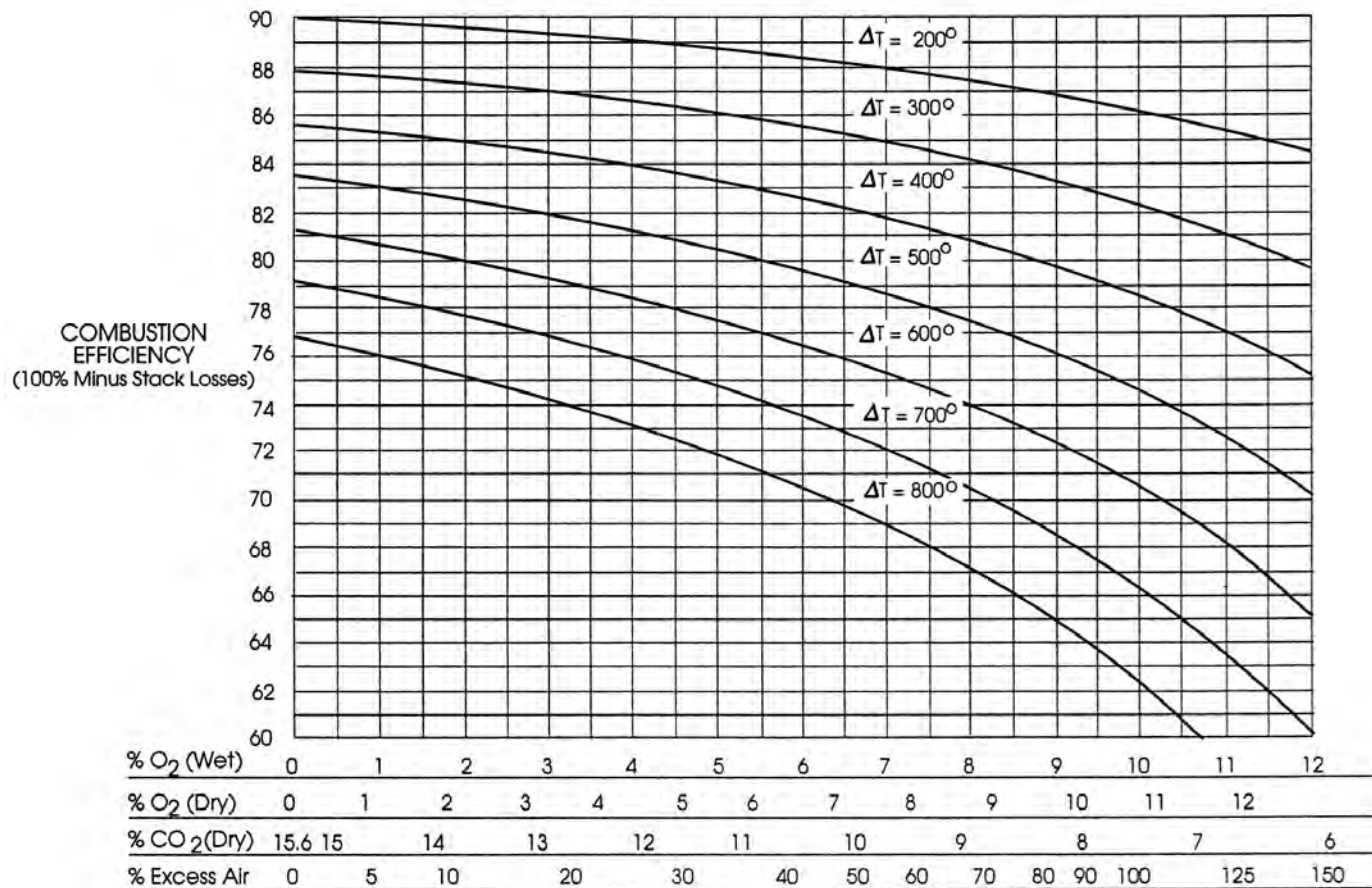


Figure 7

#### Example:

A stack test shows 9.5% CO<sub>2</sub> in the breeching with a 475° F stack temperature. Room temperature is 75° F  $\Delta T = 475 - 75 = 400^\circ$

Drawing a vertical line through the 9.5% on the CO<sub>2</sub> scale to the 400°  $\Delta T$  curve, the combustion efficiency is found to be 84.5%

|                     | Existing                             | Projected  |
|---------------------|--------------------------------------|------------|
| O <sub>2</sub>      | % _____                              | _____      |
| Flue Gas            | $\Delta T^\circ F$ _____             | _____      |
| Efficiency          | % _____ (EE)                         | _____ (PE) |
| Fuel Consumption    | \$ _____                             | _____ (FC) |
| Projected Savings = | $\frac{PE\% - EE\%}{PE\%} \times FC$ |            |
| Projected Savings = | \$ _____                             |            |



# COMBUSTION THEORY

## Combustion Efficiency Table

### Combustion Efficiency #6 Oil

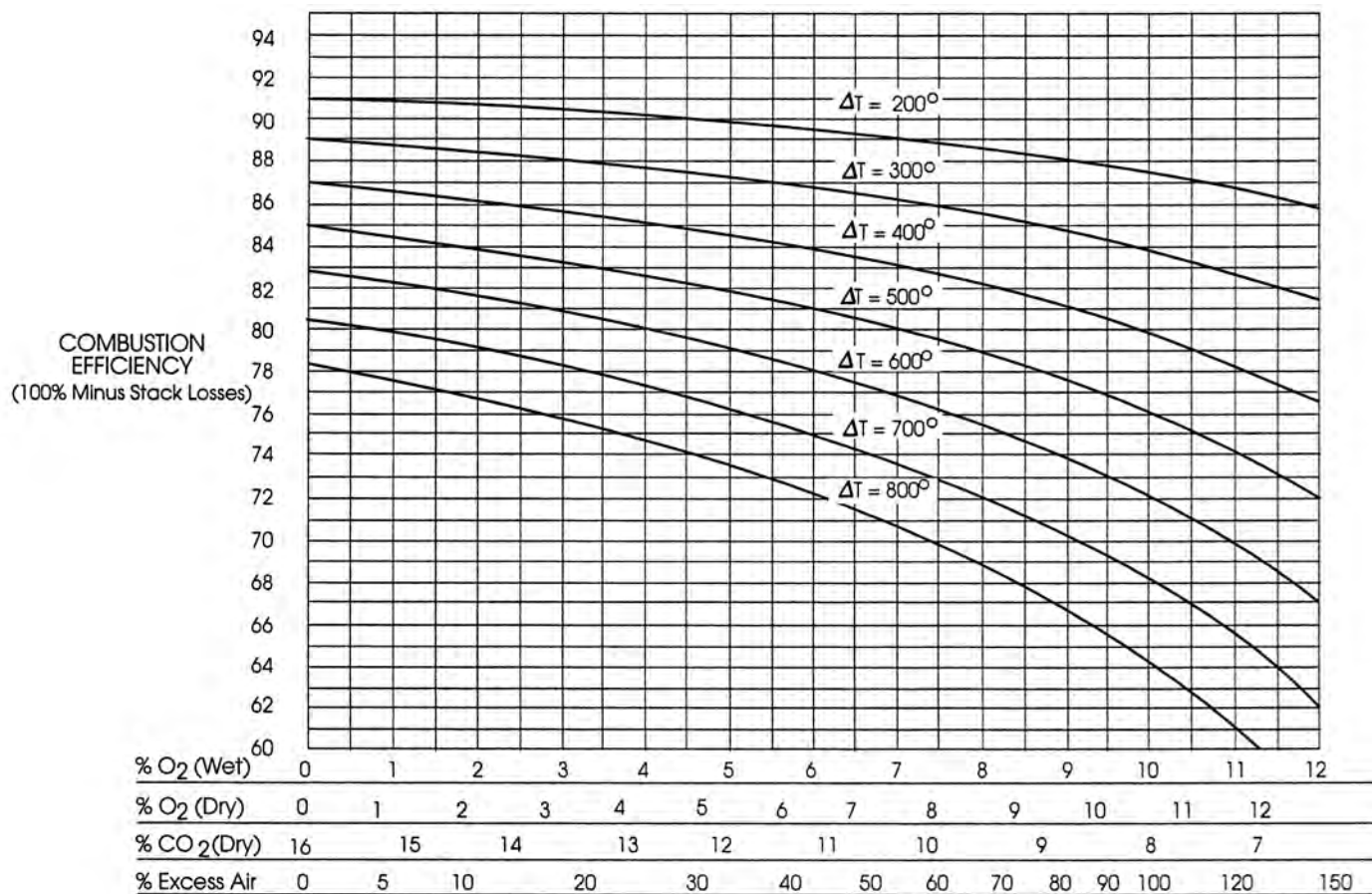


Figure 8

|                     | Existing                             | Projected  |
|---------------------|--------------------------------------|------------|
| O <sub>2</sub>      | % _____                              | _____      |
| Flue Gas            | $\Delta T^{\circ}F$ _____            | _____      |
| Efficiency          | % _____ (EE)                         | _____ (PE) |
| Fuel Consumption    | \$ _____                             | _____ (FC) |
| Projected Savings = | $\frac{PE\% - EE\%}{PE\%} \times FC$ |            |
| Projected Savings = | \$ _____                             |            |

## COMBUSTION SYSTEM DESIGN

### 1. Combustion Considerations - General

Simply stated, it is the Burner's responsibility to accept the input of at least two dissimilar fluids, mix them, ignite them, oxidize all of the combustible material with the least amount of excess air and the least possible emissions, all over the widest range of firing rates without instability and with a flame envelope that does not impinge on heat transfer surfaces. Reduced electrical energy consumption, low fuel and atomizing media supply pressure requirements and reduced atomizing media consumption are other desirable features. To accomplish all of this not only requires that the Burner's mechanical design be optimum but as well the control and fuel handling systems responsible for the flow control and the conditioning of those inputs.

#### Rule #1

Under the exact same conditions it is not possible to achieve a burner performance level over the full range of firing rates while in the "automatic" mode which exceeds that possible when operated in "manual" at each firing rate.

#### Rule #2

A burner is a system of fixed orifices. Without proper fuel handling and preparation systems, a proper control strategy/system and a means by which to monitor performance, it is not possible to achieve and maintain a level of automation which provides repeatable, efficient and safe operation. Applying a simple control strategy to a burner based on an argument of simplicity (and lower cost) ignores the benefits of using a system that provides repeatable performance and a means by which to assure that through monitoring. Nothing is this easy, but, it raises a couple of interesting

#### EXAMPLE

The NO<sub>x</sub> guarantee on an application is 30 ppmc. The current "indicated" NO<sub>x</sub> level is 32 ppm with a corresponding excess O<sub>2</sub> of 2.5% ("dry"). Correcting the "indicated" value to 3% O<sub>2</sub> ("dry") yields  $32 \times (17.9/(20.9 - 2.5)) = 31.13$  ppmc. Our published guarantee is that we can operate with between 1.5 to 2.5% excess O<sub>2</sub> with less than 100 ppmc CO. You reduce the O<sub>2</sub> to 1.5% ("dry"), the "indicated" NO<sub>x</sub> remains 32 ppm and the CO does not increase above 100 ppmc:

$$32 \times (17.9/(20.9-1.5)) = 29.53 \text{ ppmc}$$

questions ...

- Why was the O<sub>2</sub> at 2.5%? You had set the unit up at 1.5% at the same firing rate the other day. ... You are reminded that the air temperature has dropped 50 degrees since the other day and that the control system (provided by others) is without "O<sub>2</sub> trim." How do you prevent this from happening again?
- Why was the O<sub>2</sub> at 2.5%? You had set the unit up at 1.5% at the same firing rate the other day. You note that the regulated gas

pressure at the inlet to the piping train is now 10 PSIG while it was 12 PSIG the other day. You are reminded that there is a single pressure regulator for all three boilers in the plant and that you had set up your burner the other day when the other two boilers were inoperative (the load has now increased and all three units are now online). The control system (provided by others) is without "O<sub>2</sub> trim," and you have no means of measuring gas flow. How do you prevent this from happening again?

The above example and the follow-up issues are presented to convey that the performance of a burner is not a "snapshot" taken at the time of commissioning, rather it is an ongoing process that depends on providing control, fuel handling and monitoring systems that make appropriate adjustments for varying conditions providing a means by which to identify and then correct any deficiencies.

### 2. Pressure and Flow Basic Principles

Most of these have to do with the resistance to a fluid's flow (i.e. pressure drop) imposed by not only the burner, but by piping, ducting, breeching, etc. and the influence of fluid properties on that resistance. The general equation (developed by Darcy) for calculating pressure drop (DP) across any system element and for any fluid is:

$$DP = K \times p \times (((Q/A)/1096.7)^2) \times CF_p \times CF_t \times CF_e$$

DP = Pressure Drop, inches W.C. (Divide by 27.8 for pressure drops in PSI)

K =  $f \times L/D_h$  (See note below)

f = Friction Factor which depends on the Reynolds Number (Re), the Hydraulic Diameter (D<sub>h</sub>) and the flow conduit "roughness" (e). "Re" in turn depends on the fluid mass flow rate (W.), its "actual flowing" viscosity (u) and (D<sub>h</sub>)

L = Length of pipe, or the equivalent length of an elbow, a piping "tee", etc.

D<sub>h</sub> = Hydraulic Diameter ( $4 \times \text{Flow Cross-sectional Area} / \text{Wetted Perimeter}$ ) (Note: The D<sub>h</sub> for any item of a round cross-section is equal to its diameter)

p = The fluid's "standard" density at 60° F, atmospheric pressure and at sea level, lbs/SCF

Q = The fluid's flow rate referenced to "standard" conditions, SCFM

A = The cross-sectional flow area, ft<sup>2</sup>

CF<sub>p</sub> (Pressure Correction Factor) =  $14.7/(P_{inlet} + 14.7)$ ; Where P is in PSIG

CF<sub>t</sub> (Temperature Correction Factor) =  $(T_{inlet} + 460)/520$ ; Where T is in deg. F.

CF<sub>e</sub> (Elevation Correction Factor) – less than 1 for any elevation below sea level

Alternatively, the above equation can be re-arranged to solve for flow:

## COMBUSTION SYSTEM DESIGN

$$Q = 1096.7 \times A \times ((DP/(K \times p \times CFp \times Cft \times CFe))^{1/2})$$

One does not need to remember these equations or know how to use them. But one should remember the following ... for a fixed DP:

- If the site elevation increases, the flow rate in SCFM or lbs/hr. decreases. (Note: this can occur if the burner is on a rental boiler)
- If the inlet temperature of the fluid increases, the flow rate in SCFM or lbs/hr decreases (Note: seasonal change in ambient air temperature).
- If the inlet pressure of the fluid increases, the flow rate in SCFM or lbs/hr. increases (Note: change in pressure regulator setpoint).
- If the "standard" density of the fluid decreases, the flow rate in SCFM or lbs/hr increases. (Note: this could occur if there was a change in fuel oil grade from No. 6 to No. 2)
- If the cross-sectional flow area of the item increases, the flow rate in SCFM or lb/hr increases (Note: this could occur if there was an increase in the number of holes or the hole drill size of the gas injectors or sprayer plate).
- If the viscosity of the fluid increases, the "Re" decreases and the "f" increases whereupon the flow rate in SCFM or lbs/hr. decreases (Note: a change from No. 2 to No. 6 Fuel Oil).

Note: The term "K" is one used by Crane (Technical Paper 410—"Flow of Fluids") to reflect a given device's "resistance to flow." The term "Cv" used by most control valve manufacturers includes an area allowance, while orifice plate calculations use the terms "C" (orifice coefficient) and "Y" (expansion factor). Nonetheless, the conditions affecting the pressure drop across all of these devices is accounted for identically.

### 3. Atomizing Media Considerations

The primary purpose of the atomizing media is to shear the higher viscosity liquid into fine droplets that can then be thoroughly burned. Simply put, it is the role of the atomizing

**Note:** In the guaranteed operating excess oxygen range (1.5-2.5% "dry" O<sub>2</sub> from 50 to 100% firing rate), a change in fuel or combustion air flow by only 5% would produce an approximate 1% excess O<sub>2</sub> change.

media to alter the liquid fuel's characteristics so that they approximate that of a gaseous fuel. The two most common atomizing media are compressed air and steam, though any high pressure gas can be used. If applied properly, either can be used just as effectively. Steam, if available, is generally preferred because it is usually already at a high pressure and the operating cost to differentially produce this steam is lower than that to compress air. The primary considerations using atomizing air versus atomizing steam are as follows:

Similarities ... Moisture: It is well understood that steam must be trapped to remove any condensed moisture. People forget or are simply unaware that there is considerable moisture in atmospheric air, a lot of which is removed with air compressor intercoolers and after coolers. This "plant air" typically used for atomizing media is interestingly unsuitable as "instrument air" because it still contains too much moisture. Moisture of any kind adversely affects the shearing process and as well is very erosive, causing premature wear of all parts in contact with the atomizing media alone or the mixture of it with the liquid fuel. The importance of providing a suitable number of traps and applying ample insulation to piping cannot be understated.

Dissimilarities Change of State: The biggest difference between the two fluids is that compressed air does not undergo a change of state while some steam vapor does condense within the atomizer, either by direct or indirect contact with the lower (relatively) temperature liquid fuel. Note that some of this condensed steam can actually "flash" back into vapor when it exits the sprayer plate due to the expansion that occurs as the stream exits a high pressure area and discharges into atmosphere. The benefits of this condensing and flashing on atomization quality is not the subject of this discussion, rather it is the heat exchange process that influences the selection of the correct atomizer. Recall that Preferred manufactures both the "internal mix" and "external mix" designs. The former applies the shearing at the distributor and the resulting atomizing media/liquid fuel mixture then passes through some number of mixers before exiting the sprayer plate. In addition to the heat exchange that takes place between the oil tube/steam barrel section of the atomizer, there is the subsequent and more significant heat exchange that results because of the direct contact between the two fluids. With the "external mix" design, the shearing process takes place within the Sprayer Plate and the amount of direct contact between the two fluids is limited to the short distance of exposure in the Sprayer Plate "exit hole". For all of these reasons, application of the "Internal Mix" will generally be limited to heavy fuel oil with steam atomization or light oil with air atomization applications, while the "External Mix" would generally be used otherwise. This may not always be the case, as emissions and/or flame shaping issues may dominate as the more important criteria on specific applications.

### 4. Combustion Air Considerations

The largest single input to the fired equipment is the combustion air. Under ideal mixing conditions there is an absolute minimum quantity of combustion air required to incinerate all of the combustible material in any given fuel and any additional amount above this minimum is termed excess air. Usually some excess air is included so mixing is not perfect and as well to serve as a "excess air cushion" during firing rate changes. Many burners operate with



## COMBUSTION SYSTEM DESIGN

excess air levels of 15-25% (2.5 to 4% excess O<sub>2</sub>), while “low excess air” burners operate with 5-10% excess air (1 to 2% excess O<sub>2</sub>). It is advantageous to operate with as little excess air as possible because operation with lower excess air levels generally results in the formation of less NO<sub>x</sub> and because fired equipment efficiency increases when operated with lower excess air (less heated mass flow exiting the unit). Of course the difficulty in operating with less excess air is the potential that some portion of the fuel will not totally be incinerated, resulting in CO and hydrocarbon emissions.

The lowest excess air with which the burner is capable of operating (at each firing rate) can be determined during commissioning when operating the burner in the “manual” mode. If the complete “set-up” is performed within a short period on a given day, factors effecting combustion air flow are fairly constant. Over the course of time the following conditions should be considered:

**Elevation** – for a given site this is not an issue. We bring it up again because if the burner is on a rental boiler, a change in location could result in a change in job site elevation. At an elevation of 3000 feet ASL the density of air is about 10% less than it is at sea level. Therefore there will be an approximate 10% increase in “DP” for the same flow, “Q”, in SCFM or lbs/hr. Alternatively for the same “DP” there will be an approximate 5% reduction in SCFM or lbs/hr. Moving a burner from a lower elevation to a higher one generally results in decreasing its capacity unless a means is provided for capacity compensation. This is one of the reasons why the XPlus Burner is equipped with a VSD.

**Temperature** – this is the one condition that is subject to the greatest variation. If the burner is “set-up” with 50° F combustion air and due to seasonal changes the air temperature can vary by +/- 50° F then there is the potential for the combustion air flow to vary +/-5% from the original “set-up” value. Oxygen trim would provide the needed compensation ... this is one of the reasons why the XPlus Burner is equipped with O<sub>2</sub> trim.

**Draft** – See the following **Section 5, “Flue Gas Considerations.”**

### 5. Flue Gas Considerations

Flue gases are the products of combustion, and exit the fired equipment at elevated temperatures. Besides CO<sub>2</sub>, N<sub>2</sub> and excess O<sub>2</sub> and the emissions of particulate, VOCs, hydrocarbons, NO<sub>x</sub>, SO<sub>x</sub> and CO, flue gases contain considerable moisture that at the elevated temperatures are in the form of vapor. Emissions will be discussed in a later section, while in this section, we will address draft, FGR and moisture.

**Draft:** the furnace of fired equipment is either operated at a positive pressure or a negative pressure usually termed “draft.” Regardless, flue gases are ultimately discharged from a stack. The height of the stack is important, because the taller the stack, the greater the developed “natural draft”. If multiple pieces of fired equipment are breeched to a single common stack, the natural draft will be impacted by the number of units in operation and their individual firing rates. In some cases, even if there is a tall stack, it is necessary to provide an Induced Draft (ID) fan to overcome resistances imposed downstream of the fired equipment and to assure that a negative furnace pressure is maintained regardless of conditions.

The equation for calculating “natural draft” is as follows:

$$\text{Stack Draft} = 7.57 \times L \times ((1/T_a) - (1/T_g)) \times B/30$$

Where:

L = Stack Height, feet

T<sub>a</sub> = Ambient Temperature, deg. Rankine

T<sub>g</sub> = Flue Gas Temperature, deg. Rankine

B = Barometric Pressure, inches Hg

Even on pressurized firing applications, it is possible to have a negative draft in the furnace at reduced firing rates, when the elevated temperature necessary to produce a natural draft exists, while the pressure drop experienced by the flue gas as they pass through the fired equipment is negligible.

There are two potentially serious problems attributable to the existence of draft: if it is not repeatable (i.e. it is not controlled) and/ or it results in uncontrolled air infiltration into the fired equipment, it then leads to misleading information regarding the presumed combustion air flow through the burner(s). The latter problem is referred to as “tramp air” and this is discussed in **Section 8.2 “Common Application-Specific Problems.”** As to the lack of draft repeatability, we offer the following:

- As should be apparent from the above equation, “natural draft” is dependent on the stack height and the temperature of the flue gases and the environment. For 500° F flue gases, the “natural draft” is 50% higher on a 20° F day than it is on a 100° F day. Though this may only represent itself in a “few tenths of an inch W.C.,” consider that on the same cold day (when the draft is higher) more combustion air is capable of passing through the system (See **Section 4 “Combustion Air Considerations”**). The combination may or may not warrant the use of draft control (unless “tramp air” is an overruling issue) but the addition of O<sub>2</sub> trim would be justified. This is one of the reasons why the XPlus Burner is provided with a combustion control strategy incorporating O<sub>2</sub> trim.
- Anytime more than one piece of fired equipment is connected to one stack, draft controls should be provided for each unit. The “net natural draft” depends not only on the conditions described above but also

on the resistance imposed by the stack on the flow of flue gases through it. Therefore, the number of units in operation and their combined firing rate influences the “net natural draft,” draft controls are a standard option available with the XPlus Burner.

- Draft control should be provided anytime the expected “natural draft” is greater than 2.5% of the “Burner Draft Loss” (BDL) For instance, if the “BDL” is 10" W.C. then draft control should be included if the “natural draft” will be greater than or equal to 0.25" W.C. The influence of “natural draft” (which is essentially constant throughout the firing rate range) has a pronounced affect on air flow at firing rates less than 50%.
- Draft control should be provided whenever an “Induced FGR” NOx reduction strategy is provided. The FGR take-off should be upstream of the draft control damper to minimize “tramp air” infiltration.
- Flue gas excess O<sub>2</sub> measurements should also be taken upstream of the draft control damper to minimize “tramp air” bias of the sample.

**Flue Gas Recirculation (FGR):** FGR is effective in reducing NOx emissions despite its elevated temperature, because the additional mass flow inputted to the combustion zone reduces the flame temperature and because it is oxygen deficient. If FGR is withdrawn from a location which is at a negative draft, it is possible, depending on the tightness of the setting, that “tramp air” has infiltrated the flue gas. FGR should always be withdrawn from the area that has the lowest potential for “tramp air” infiltration and where the flue gases are at their lowest temperature.

**Moisture:** the amount of moisture in the products of combustion (resulting from the burning of hydrogen) is considerable (about 10% by volume when burning fuel oils and approaching 20% by volume when burning natural gas). If allowed to collect, moisture can result in misleading indications of draft, beginning with those specific to the measurement of furnace pressure. Refer to **Section 8.2 Common Application-Specific Problems** for further information.

## 6. Gas Fuel Firing Considerations

For a fuel such as natural gas, one’s contract usually stipulates a very narrow range of higher heating value (HHV in Btu/SCF or Btu/lb) and Specific Gravity (SG). In the case of chemical process off-gases, these conditions are likewise fairly constant when the process is being operated normally, but under start-up, shutdown or operational upsets these could change dramatically. A term often used to compare one gas to another is called the Wobbe Index:

**Wobbe Index = Gas HHV/((Gas SG)<sup>1/2</sup>)**

Where the HHV is in units of Btu/SCF

The reason for creating this index is that it combines conditions that impact on the gas flow rate and its density which in turn affects the pressure drop. We don’t expect to encounter gas heating value and specific gravity variations too often, but one should be aware of them.

**Elevation:** Refer to **Section 4 “Combustion Air Considerations.”** At a given site this is not an issue.

**Temperature:** Like combustion air, variations in temperature are very possible though generally not to the same extent.

**Pressure:** There is no reason for pressure variations at the inlet of a burner’s piping train, unless the fuel is a by-product of some process. Regardless, every burner piping train should be equipped with a pressure or differential pressure regulator at its inlet. Referencing the Darcy equation given in Section 2, an uncontrolled increase in inlet pressure will result in an increase in flow and vice versa. Note that this affect applies to every component in the piping train, so application of a flow meter does not by itself compensate for pressure fluctuations unless the meter is a thermal mass type or the reading of an alternative meter is pressure compensated. This is why the standard XPlus Combustion System includes a differential pressure regulator and a thermal mass flow meter.

## 7. Fuel Oil Firing Considerations

Liquids are incompressible fluids, where their density is not influenced by pressure variations. A liquid’s density is affected by temperature, but not to the same extent as that of a gas (water’s density reduces by about 20% for a temperature change of from 100° to 500° F, while any gas will undergo a 40% reduction in density). There are significantly more variables to be considered when burning liquid fuels. These primarily have to deal with its composition, as that influences emissions and other physical characteristics, which in turn impact storage, pumping, preparation and atomization considerations. Some of the more important fuel oil characteristics are:

### Viscosity

Viscosity is a measure of a fluid’s resistance to flow. It is probably one of the most important properties of the fuel to be fired since it relates to its ability to flow through the lines and be properly atomized at the burner nozzle.

A high viscosity fuel like No. 6 oil will thicken considerably at normal room temperature and requires constant heating and circulation in order to flow and be atomized properly. A low viscosity fuel like No. 2 oil will flow and atomize easily at room temperature.

In the combustion industry, viscosity is generally expressed in SSU or Saybolt Seconds Universal. This is determined in a lab and is the length of time in seconds required for the oil, heated to a specified temperature, to flow through a standard orifice. To assure good fuel oil combustion, the



## COMBUSTION SYSTEM DESIGN

maximum value is generally between 100 and 200 SSU for most applications.

Temperature vs. viscosity information is critical in determining the required oil temperature at the burner to achieve the correct SSU for atomization. This data can be obtained from standard viscosity tables. However, some fuels, particularly blends, may require that an analysis be provided by the supplier. Regardless, it is always sensible for the user to draw a sample monthly and have it tested by an independent lab.

Problems with fuel viscosity control can lead to burner performance problems. High viscosity can decrease the ability of the atomizer to properly atomize the fuel and result in incomplete combustion, high CO, smoking, and sooty deposits. Viscosity that is below the recommended levels can cause flashing at the sprayer tip and erratic burning. The viscosity must be carefully controlled because of its potential effect on stack opacity, NOx, CO and particulate emissions.

**Pour Point** - The fuel oil pour point is the lowest temperature at which fuel can be stored and still remain fluid or be pumped.

**Cloud Point** – Normally determined for No. 2 oil, is the temperature at which the wax crystals (paraffin) suspended in the fuel first begin to appear and drop out as a slight haze in the sample.

**Flash Point** – The flash point of the fuel oil is the lowest temperature at which a flash flame can be produced. It is an indication of the maximum temperature at which the fuel can be safely stored or handled without causing a serious fire hazard. Oil should not be preheated to a temperature greater than its flash point.

**Sulfur Content** – Fuel oil loads containing 1% sulfur or more can be troublesome in terms of corrosion to the fired equipment. During the combustion process, free sulfur will combine with oxygen to form sulfur dioxide that, in the presence of water molecules, will combine to form sulfurous acid. Although relatively weak, it can over time cause severe corrosion to exposed parts and components. Sulfur dioxide or SO<sub>2</sub> is also considered a major atmospheric pollutant and contributes to smog and acid rain.

**Nitrogen Content** – Fuel oils with high nitrogen content can contribute significantly to the formation of nitrogen oxides or NOx during the combustion process. Nitrogen atoms located in bonds within the fuel molecule are released into the total nitrogen pool and oxidized leading to an increase in NOx levels. This is commonly referred to as fuel NOx and can greatly affect burner emission performance. 0.2 – 2.0% N in fuel can potentially yield 60-2100 ppm NO.

**Summary** – It is important that operators understand the different fuel oil characteristics and how they relate to burner and fired equipment performance. It is especially critical that these factors be taken into consideration anytime a change in the type or grade of fuel is made.

### Caution!

**You should contact Preferred Utilities before attempting to fire a fuel oil different from that which was fired during initial commissioning. A planned change in suppliers should include receiving confirmation of the new supply's equivalence to the previous fuel supply. Preferred Utilities should also be notified of this proposed change in suppliers.**

Refer to the following Summary of Fuel Problems excerpted from *The Fuel Oil Manual for Boiler Operation*; boiler

Efficiency Institute, Auburn, AL.

| PROBLEM                      | CAUSE                                                                                                         |
|------------------------------|---------------------------------------------------------------------------------------------------------------|
| Atomization Poor .....       | Oil viscosity too high; improper preheat temperature; atomizing media or oil pressure too low                 |
| Boiler Corrosion.....        | Ash contains corrosive elements; oil sulfur and/or salt content is too high; soot has absorbed sulfuric acid  |
| Burner Erosion.....          | High oil sediment or salt content; velocities in eroded areas (liquid or flue gas-side ) too high             |
| Burner Tip Blocked .....     | High oil sludge or lint content; No strainer or strainer mesh not fine enough; Carbonization of Sprayer Plate |
| Carbon Dioxide Low .....     | Too much excess air; poor air and/or fuel cross-sectional distribution                                        |
| Carbon on Furnace Walls..... | Flame impingement; oil too viscous or too light; atomizing media/oil injection velocity too high              |
| Carbon in Preheater .....    | Too high preheating temperature; oil contains sludge and/or asphaltic compounds                               |

## COMBUSTION SYSTEM DESIGN

| PROBLEM                                 | CAUSE                                                                                                                                                                                                                       |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Carbonization of sprayer plate.....     | Carbon residue in oils; high viscosity oil, poor atomization; insufficient, excessive or varying pre-heat temperature; inadequate guidepipe purge air                                                                       |
| Discoloration of ceramics .....         | High sulfur, sediment, or iron in the oil                                                                                                                                                                                   |
| Sprayer plate dripping oil.....         | Oil viscosity too high; incorrect pre-heat temperature; partially plugged sprayer plate; sprayer plate assembly gaskets missing or damaged                                                                                  |
| Flame pulses .....                      | Water, sediment or sludge in oil; oil viscosity too high; non uniform combustion air or oil flow; air infiltration into oil; atomizing media flow irregular or too high; atomizer internal leak of atomizing media into oil |
| Flame leaves sprayer plate .....        | Too much atomization; oil too thin                                                                                                                                                                                          |
| Flashback .....                         | Flash point is too low resulting in pre ignition; water and sludge in oil; fluctuation of atomizing media flow; oil pressure too high                                                                                       |
| Foaming of oil.....                     | Water or extremely light material in oil                                                                                                                                                                                    |
| Heat loss (poor heat transfer).....     | Sediment and/or water in oil; deficient or excessive combustion air flow; poor combustion; oil temperature too high                                                                                                         |
| Plugged lines .....                     | Sludge in oil; congealed oil; wax in oil; high viscosity oil; foreign materials in oil                                                                                                                                      |
| Odor is bad .....                       | Pre-heat temperature too high; high oil sulfur content; contamination by other foreign material                                                                                                                             |
| Oil consumption is excessive .....      | Oil too light, oil of low heat value, excessive combustion air; holes in sprayer plate too large (eroded), water in fuel oil                                                                                                |
| Unable to pump oil.....                 | Oil too cold or too high in viscosity; restricted or blocked passages; strainers plugged                                                                                                                                    |
| Smoke .....                             | Not enough or too much combustion air; poor atomization; oil viscosity too high; flame impingement; excessive furnace draft                                                                                                 |
| Soot excessive .....                    | High ash content in oil; poor combustion; heavy compounds in oil                                                                                                                                                            |
| Spitting, sputtering or sparkling ..... | Water or sediment in oil; oil viscosity too high; high atomizing media flow; leakage of air into oil; atomizer internal leak of atomizing media into oil; wet atomizing media                                               |
| Stack temperature too high .....        | Boiler tubes need cleaning; damaged baffles; too much draft; overfiring of unit                                                                                                                                             |
| Ignition difficulty .....               | No oil; sludge and/or water in lines; viscosity of oil too high; too much atomizing media flow; pre-heat temperature too high, too much combustion air                                                                      |
| Strainer screens blocked .....          | Sludge, wax or lint in the oil; oil viscosity too high; oil temperature too cold; heavy precipitated compounds in oil; tank scale or rust                                                                                   |
| Suction loss .....                      | Oil too heavy and/or cold; leak in oil suction line; slippage of oil pump; pump not primed; oil too hot                                                                                                                     |
| Water .....                             | Water in oil as delivered; condensation from natural sources (atmospheric humidity) and/or from high temperature heating; leaking heating coils; leaking tank or accesses                                                   |

## 8. Overview - Application Troubleshooting

The following is a brief discussion of a number of possible problems that can be encountered on various applications. This is a general listing, so some of these will not be applicable to this specific project. Most will apply to retrofit applications where our Combustion System is being installed on existing fired equipment and/or existing equipment or systems are being reused. Given the retrofit issue the following must be considered:

- Realistically, the retrofit would not be made unless the latest technology was either desired or required. For this reason, operating issues that may not have been significant prior to the change will be afterwards.
- All modern burners must meet strict emissions requirements as well as provide optimum excess air and turndown performance. Most servicemen carry portable analyzers that allow spot checking of emissions levels. Twenty to twenty-five years ago many of today's requirements or the means by which to monitor them did not exist.
- The above being so, there will be conditions uncovered now which were either not evident or simply non-issues prior to the retrofit.
- Simply put, when problems are encountered after the retrofit, which were never evident beforehand, it will be logical to conclude that the burner is at fault because it is the only thing that has changed. However, bear in mind for all the reasons stated above, not only has the burner changed, but performance expectations, operating issues and the means by which to monitor them have all changed as well.

### 8.1 Operational Rules of Thumb

Natural Gas and Fuel Oils – True excess air ( $O_2$ ) levels in the flame zone that are less than the design level tend to lower NOx, increase CO, increase flame length and cross-section and increase opacity (black).

Fuel Oils – Deficient atomizing media flow or higher than design oil viscosities (low oil temperature) tend to lower NOx, increase CO, increase flame length and cross-section, increase the visible level of droplets or “fireflies” or “sparklers”, increase opacity and increase liquid splatter on furnace surfaces.

Natural Gas and Fuel Oils – True excess air ( $O_2$ ) levels in the flame zone that are significantly high (greater than 10-11%  $O_2$ ) tend to increase CO, increase opacity (brownish or white) and potentially create instability due to flame blow off.

### 8.2 Common Application-Specific Problems

- A. “Tramp Air”
- B. “Feed the Grate, Starve the Burner”
- C. “Short-circuiting”
- D. Regenerative Air Heater Combustion Air Bypassing
- E. Location of  $O_2$  Sensor

- F. Oversized FD and/or ID Fans
- G. Moisture in Draft Measurements
- H. Air Infiltration into Fuel Oil Piping on Below Grade Storage Applications
- I. Water in the Fuel Oil
- J. Heating or Cooling of Fuel Oil in Atomizers
- K. Heavy Oil Viscosity Increases at Reduced Firing Rates
- L. Wet Atomizing Steam or Plant Air
- M. Single Pressure Regulator but Multiple Users

A. Tramp Air – Tramp air can be defined as any air that enters the fired equipment unintentionally at a location other than the burner. Tramp air can be either a known input i.e. observation port cooling and purging air; soot blower purging air; cooling air to “out-of-service” atomizers; “over-fire” air for grates; “staging air” through “out-of-services” burners; cooling air for “out-of-service” grates, etc or the input can be unaccounted for. Unaccounted for “tramp air” is most common on applications where the furnace is operated at a negative pressure. There is of course the negative heat transfer aspect of an undesirable level of cool air being drawn through the fired equipment. But in addition, there can be the more serious affect resulting from the operation of a burner at an excess air level based on an  $O_2$  measurement which is gathered downstream of and whose reading is then biased by the “tramp air” infiltration. The problems that will arise are defined in the “Operational Rules of Thumb” associated with less than design levels of excess air. The corrective actions are as follows:

1. Check the location of the  $O_2$  sensor. See “Location of  $O_2$  sensor” paragraph in this section. Make the necessary arrangements to relocate the sensor if its position is less than optimal (Note: this may not be possible without a shutdown).
2. Place the burner in the “manual” control mode. Attach a manometer to the burner's high air pressure and furnace pressure connections and measure the “BDL” (Burner Draft Loss). Compare this value to that in this O&M Manual for the same burner firing rate.
3. Increase the combustion air flow to the burner until the BDL equals that listed in this manual for the firing rate. CO, opacity, flame appearance, etc. should all be directionally improved. Note the new operating  $O_2$  level indicated by the sensor.
4. Slowly change the furnace pressure setpoint on the furnace pressure controller to a value that brings the furnace pressure to a slightly positive condition (0.00 to +0.01” W.C.). CAUTION: FLUE GAS INFILTRATION INTO THE OPERATING AREA CAN BE HARMFUL TO

PERSONNEL. Note the reduction in operating  $O_2$  as indicated by the sensor. This difference in excess  $O_2$  represents the amount of “tramp air” infiltration. Return the furnace pressure setpoint to its normal operating level.

5. Note and/ or correct all unnecessary “tramp air” infiltration points. Those that cannot be corrected while the unit is operating should be documented for correction during the next scheduled outage.
  6. Make the necessary control configuration changes and explain to all operating personnel the new excess oxygen, burner air flow and/or furnace pressure operating parameters.
  7. Correct any remaining “tramp air” infiltration points during the next fired equipment outage.
- B. Feed the Grate, Starve the Burner – On grate over-firing applications it is common for the combustion air supply to the over-fire burners to be from the same FD fan as that supplying combustion air to the grate. Under these circumstances, since the grate fuel (wood, coal, bagasse, etc.) is the primary fuel, it is common for the majority of the air to be directed to the grate while the over-fire burner(s) are “starved” for air. In effect, the problem is exactly the same as that encountered with an excess of tramp air. High CO, opacity, larger/ longer fires, and once again a composite flue gas excess  $O_2$  reading can be deceiving. Because two fuels are being fired simultaneously it is not possible to offer a step-by-step procedure as was offered for the “tramp air” problem. In this case one should again check the BDL of each individual burner, compare it to that in this manual for the actual burner firing rate and then adjust overfire burner and grate combustion air flow control points until both the overfire burner's and grate's performance are optimal. Since grate firing furnaces are typically operated at negative draft conditions tramp air should be considered in any “combustion tuning” efforts.
- C. Short-circuiting – Short-circuiting is the premature exiting of combustion products from the fired equipment's furnace to its convection section or exit. Since combustion requires time (as well as temperature and turbulence) to be completed, this short-circuiting of combustion products is characterized by high levels of CO (greater than 500 ppm) and/ or hydrocarbons at operating  $O_2$  levels which should produce less than 100 ppm. This problem is not a progressive one; rather, it will occur immediately upon initial burner start-up. Short-circuiting results because of leak paths through the furnace sidewall separating the furnace and the convection section. Sidewall constructions of either

the “tangent tube” or “studded tube” type are notorious for short-circuiting. On the other hand short-circuiting is unlikely when furnace sidewall construction is either of the “welded tangent tube” or “membrane wall” type. Regardless, combustion products must travel the entire furnace length to assure complete oxidation of the combustible material and any leak path, no matter how small, should be scrutinized. If the leak is fairly easy to correct ... such as replacing a refractory plug that has fallen out of a tube inspection port ... then proceed with the change. Alternately, if gaps between tubes need to be filled, the boiler manufacturer must be contacted for recommendations. Burner changes are not warranted unless the high CO is the result of flame impingement (reference that paragraph in this section). Operating at higher excess air levels (where the preceding burner likely operated) is a short-term fix to minimize the exiting CO level. However, this will adversely impact on the ability to meet the performance requirements.

- D. Regenerative Air Heater Combustion Air Bypassing – A regenerative air heater consists of a rotor containing heat transfer “baskets”. This rotor rotates from the combustion air side of the air heater to the flue gas side. While in the flue gas area, the baskets heat and then this heat is subsequently transferred to the combustion air when it has rotated to that side of the air heater. Metal seals (when new) reduce the amount of air leakage to the flue gas side to about 5% of the maximum design combustion air flow. After the seals wear, this leakage rate will increase. Because of this air leakage, one should never sample the  $O_2$  level or locate a continuous  $O_2$  sensor downstream of a regenerative air heater. If an alternate location upstream of the air heater is not available for continuous online sensing, one must at a minimum perform periodic spot checks of the  $O_2$  level on the upstream side (using a portable analyzer) to confirm the level of air leakage and update the operating  $O_2$  parameters based on the downstream sensor.
- E. Location of the  $O_2$  Sensor – Referencing our discussions of tramp air and air heater air bypassing above, it should be apparent that the location of the  $O_2$  sensor with respect to any intentional or unintentional air infiltration points is critical for establishing the burner's true performance. The normal operating excess  $O_2$  levels of the W. N. Best “XPlus” Combustion System from 30% to 100% of capacity is from 1% to 3%. This excess  $O_2$  difference represents itself in an excess combustion air difference of about 10% (recall “as new” regenerative air heater air bypassing is about 5%). For these reasons,  $O_2$  sensors should be located as follows:



## COMBUSTION SYSTEM DESIGN

1. Locate O<sub>2</sub> sensors upstream of regenerative air heaters.
2. Locate O<sub>2</sub> sensors upstream of any purging or cooling air sources (ie. soot blowers, observation ports).
3. The O<sub>2</sub> sensor should protrude into the flue to about 50% of its width. It should also be centered relative to the flue's height.
4. Ideally, the O<sub>2</sub> sensor should be installed in a long straight section of the flue. If the sensor must be installed downstream of an elbow, remember that the flue gas will tend to "hug" the flue face on the "long side" of the elbow.
5. If at all possible establish an O<sub>2</sub> cross-section of the flue using a portable analyzer before installing the permanent sensor.

F. Oversized FD and ID Fans – Many burner retrofit applications involve replacing burners whose design excess air levels are considerably higher than that of the W. N. Best "XPlus" Combustion System or replacing solid fuel firing equipment that most assuredly operated with considerably higher excess air. In addition, at the time the original combustion equipment was installed, it is quite possible that the facility did not require this equipment to have high turndown capabilities. The combination of high air delivery capabilities and a lack of a prior need for high turndown will most often result in the existing FD and ID Fans being considerably oversized for the new retrofit burner. This "oversizing" can have a considerable adverse influence on combustion air flow control, particularly at reduced firing rates. The possible corrective measures are as follows:

a) "Short-stroke" the inlet and/or discharge damper(s) travel (via linkage adjustments) to limit the amount of damper opening at the higher firing rates. Note: this will only improve high firing rate air flow control.

b) Add some form of restriction (such as perforated sheet) at the discharge of the fan(s). The addition of this restriction will likely eliminate the need for "short-stroking". Note: this will only improve high firing rate air flow control.

c) Add "closure" plates (i.e. strips of metal) to open areas of the fan damper or vanes when they are in the closed position. This will minimize air leakage at lower firing rates. Note: this will only improve low firing rate air flow control.

d) A combination of either "a" and "c" or "b" and "c". Note: this will improve both low and high firing rate air flow control.

e) Depending on the level of fan derating, replace the existing motor with a lower speed model. This is the most practical alternative but also the most time consuming. Note: this will improve both low and high firing rate air flow control and electrical energy consumption.

f) Install a Variable Speed Drive (VSD). This is the most desirable alternative and will most often prove to be the most expeditious. Note: this will improve both low and high firing rate air flow control and electrical energy consumption.

G. Moisture in Draft Measurements – Combustion products contain considerable moisture (and humid air can as well). When these gases cool, the moisture condenses. Since the vast majority of combustion air, flue gas pressure and differential pressure measurements will be in inches water column, if the condensed moisture is allowed to collect about the gauge or transmitter diaphragm, the measurement will be faulty. This can have a significant effect on the control of combustion air to the burner and/or the control of furnace draft. Ideally all sensing tubing should slope downwards from the transmitter connection to the duct, flue, burner or fired equipment pressure connection to promote drainage back towards the process connection. Regardless, in close proximity to the transmitter, the tubing from the transmitter connection should run vertically downward with a tee connection on the side for connection to the process and a continuation of the vertical run for at least six inches. This will assure that there is a vertical leg for collecting any moisture. This leg should be equipped with a valving arrangement to allow draining the moisture, without disrupting control, while the fired equipment is online.

H. Air Infiltration into Fuel Oil Piping on Below Grade Storage Applications – When the oil storage tank (or simply the oil level) is below the centerline of the fuel oil pumps, the suction pipe will be at a negative pressure. Any leak in that suction piping will reflect itself as air infiltration into the pipe (i.e. the leak is not visible). Evidence of this problem will be represented by the pump sounding as if it is pumping gravel while both the pump suction and discharge pressure gauge needles will exhibit considerable pressure or vacuum fluctuations. Burner performance will be noticeably impacted because there will be actual fuel oil supply irregularities to it. Depending on the level of air infiltration the fire may have a visible pulse and there will be excess oxygen fluctuations as well. The only cure for this situation is to locate and repair the leak.



- I. Water in the Fuel Oil – There have been known situations in which fuel oil storage facilities have become intentional receptacles for contaminated water (or other products). Besides these situations, it is not uncommon for leaks to develop on in-tank heating coils over time, resulting in the leakage of steam condensate or hot water into the oil. This water absorbs heat from the combustion process and converts to steam and that heat is never recovered (on non-condensing applications) thereby adversely affecting the fired equipment's efficiency. The "water in the oil" problem may reflect itself in a visual increase in sparklers or fireflies (like high viscosity or poor atomization) but will definitely be evidenced by an increase in oil flow input for the same heat output, excess air level and flue gas outlet temperature. The problem can be identified by drawing a sample of oil from the supply line to the burner(s) and having a local lab check that sample for water content. For No. 5 or No. 6 fuel oils, this percentage should be 1-2% or less, while for the other grades this percentage should be no greater than 0.5%. In-tank heating coil leakage can be established by disconnecting the coils from the steam/condensate or hot water sources and checking to see if oil appears on the steam or hot water side of the coil (Note: The higher the oil level, the quicker the leak will appear. Be sure to have a means of isolation to prevent spillage).
- J. Heating or Cooling of Fuel Oil in Atomizers – These conditions have been accounted for in the design of the Preferred XPlus Burner atomizer. They are brought to your attention here, because our design allowances do have limits and operation in excess of these limits will cause problems. Heavy oil requires heating to lower its viscosity to a level desirable for burning. In most cases heavy oil is atomized with steam. Since the Preferred atomizer is a "tube within a tube" design, it works quite well as a heat exchanger, allowing one to run lower oil temperatures to the atomizer than they might if this supplemental heat exchange benefit did not exist. If however during start-up, an atomizing steam source did not exist, and one elected to try using compressed air instead, the atomizer's design would promote cooling of the oil. This would be reflected by a significant increase in sparklers and liquid splatter on heating surfaces (just as would be the case with too low an oil temperature). The only way to compensate for this condition is to raise the temperature of the oil entering the atomizer. Conversely, light oil (#2) requires no heating for viscosity control. We have tested the Preferred XPlus Burner's operation with #2 Fuel Oil heated to 150° F (with compressed air atomization) and know that overall performance is not adversely affected. However, if atomizing steam is used and oil temperatures climb to levels above this point, overheating can occur within the atomizer and unstable pulses can appear in the combustion zone.
- K. Heavy Oil Viscosity Increases at Reduced Firing Rates – Heavy fuel oil systems with a single common pumping and heating set located some distance from the combustion equipment are prone to this problem. Piping systems that are not designed with a return loop or a pressure regulator at the connection point to the return line aggravate the problem. Piping with a given amount of insulation transfers heat to the space about it at a fixed rate depending on the fluid's temperature (and that of the space), but essentially independent of the fluid's velocity. Therefore the same amount of heat is given up to the surroundings whether oil is flowing through the pipe at a rate corresponding to the burner's maximum or its minimum firing rate. However, because the amount of heat transferred is constant, the affect on the fuel oil's temperature is significantly different. On fuel oil systems of the sort described, it is not uncommon for the oil temperature at the burner to be 20 to 40 degrees lower at minimum firing rate (10-15% of maximum rate) than at full load. All of the aforementioned problems attributable to unacceptably high oil burning viscosities will result. Changing the piping system, installation of a back pressure regulator, relocation of the pump and heater set temperature sensing element or installation of a local "trim" heater are the corrective alternatives.
- L. Wet Atomizing Steam or Plant Air – Moisture in either the steam or compressed air atomizing media will be evidenced by sparklers. The more significant problem is that liquid carried by any gas stream is very erosive and can result in "water hammer." Both the atomizer and the atomizing media piping components will undergo premature failure if subjected to these conditions. Orifices on the atomizer sprayer plate will "oval" due to erosion and obviously oil burning performance will suffer. Well insulated atomizing media piping should connect to the top of well trapped main headers and then run vertically downward to a mudleg complete with drain and trap assembly. The connection to the burner piping train should be off the side of the vertical run approximately 12" from the bottom of the mud leg.
- M. Single Pressure Regulator but Multiple Users – A properly designed fuel or atomizing media main piping system should assure that the pressure and temperature (see "Heavy Oil Viscosity Increases at Reduced Firing Rates" above) supplied at the

inlet to the burner piping trains are a constant regardless of the firing rate combinations of all of the fired equipment in the facility. Unfortunately due to plant expansions or other reasons, it is common to encounter pressure “droops” in the fuel pressures at the burner piping train inlets that vary depending on the operating states of all the fired equipment. This results from the existence of only a single pressure regulator responsible for controlling the entire header pressure. Pressure variations at the burner piping train inlet are an unacceptable condition and are particularly unsafe when they occur with gaseous fuels. This is because the actual flow rate and/ or the measured flow rate (via flowmeters) are both affected by pressure (due to compressibility), so variations can lead to both real and measured errors that can be both inconsistent and dangerous. The solution is to install a pressure regulator in the local piping for combustion system being serviced.

The most commonly referenced emissions on boiler or HTHW generator applications are NO<sub>x</sub>, SO<sub>x</sub>, THC, CO, particulates and VOC. Most are familiar with the first five emissions. The definition of “VOC” or “Volatile Organic Compound” is ... “a group of chemicals that react in the atmosphere with nitrogen oxides in the presence of heat and sunlight to form ozone; does not include methane and other compounds determined by EPA to have negligible photochemical reactivity. Examples of VOCs include fumes from gasoline, solvents and oil-based paints.” Since there is no “unburned carbon” resulting from the combustion of natural gas or fuel oils, particulate emissions can be calculated by knowing the percentage of ash in the fuel. Likewise SO<sub>x</sub> emissions can be calculated given the percentage of sulfur in the fuel.

THC or “Total Hydrocarbons” are rare and effectively negligible but one should be aware of the following when considering both THC and CO emissions. Assuming a suitable level of mixing, hydrocarbons will be thoroughly oxidized (i.e. incinerated) if maintained at a temperature of 1460° F for a “residence time” of at least 0.25 seconds while CO will be thoroughly oxidized if maintained at a temperature of 1600° F for a “residence time” of at least 0.33 seconds. The “residence time” (calculated by knowing the “actual” temperature corrected volumetric flow rate of combustion products and the fired equipment furnace volume) in industrial fired equipment furnaces generally exceeds the requirements, and at the normal levels of operating excess air, the combustion temperatures well exceed the above guidelines.

As to NO<sub>x</sub>, it is well documented that NO<sub>x</sub> emissions are maximized when combustion temperatures are at their peak. This peak temperature is achieved theoretically when there is absolutely perfect mixing and only the exact requirement of combustion

air is inputted (no less or no more) to thoroughly oxidize the combustible matter in the fuel. NO<sub>x</sub> is significantly reduced if there is either an excess of combustion air that reduces the combustion temperature by dilution or a deficiency of combustion air that also lowers combustion temperatures by depriving a portion of the fuel of the air necessary to burn it. Regardless, meeting NO<sub>x</sub> and CO emissions requirements, as well as “furnace flame fit” and “turndown” expectations often times leads to the “NO<sub>x</sub>/CO box” which is a condition where the needed reduction in one emission is prevented by the fact that the corrective measure leads to the increase in the other emission.

First, let us review “indicated” versus “dry” versus “corrected” emissions values. Indicated emissions values are as the term implies, simply those displayed by the analyzer. One should never presume that these displayed values are either dry or corrected (some analyzers do have an option for performing the needed mathematics to correct the measured values). To obtain dry values it is necessary to remove all of the moisture from the flue gas sample (recall that the moisture in the products of combustion can be from 10 to 20% depending on the fuel being fired). This can be accomplished by directing the sample to an ice-cooled sample bottle before directing it to the analyzer. A corrected emissions value is one that has been adjusted for an EPA established excess oxygen level, which varies depending on the fired equipment application. The value for industrial boilers and HTHW generators is 3% “dry” O<sub>2</sub> (for duct burner or direct-fired air heaters the value is 15% “dry” O<sub>2</sub>). As an example, a “corrected” NO<sub>x</sub> emissions level for industrial boilers or HTHW generators is calculated as follows:

Corrected NO<sub>x</sub>, ppmc = “Dry” NO<sub>x</sub>, ppm X ((20.9 – 3)÷(20.9 – “Dry” O<sub>2</sub>%))

For a displayed wet emissions level of 50 ppm of CO at an O<sub>2</sub> level of 11% when firing natural gas, the actual emissions will increase to about 60 ppm when the sample is dry and will further increase to over 100 ppmc when corrected to 3% O<sub>2</sub>.

## COMBUSTION SYSTEM DESIGN

Remember to effectively enact “staged combustion” requires that there is a combustion zone that has an excess of combustion air and one that has a deficiency of combustion air, which are then subsequently mixed without residual CO or THC emissions and at a composite excess O<sub>2</sub> level that is as low as possible. Note—what is optimal at higher burner firing rates is not necessarily optimal at lower burner firing rates.

“Rules of Thumb”:

- √ In the design region of operating excess air levels, the corrected NO<sub>x</sub> will decrease with reductions in excess air while the corrected CO will increase.
- √ When excess O<sub>2</sub> levels increase above 12% CO emissions increase. This because combustion temperatures approach the minimum level required for complete oxidation.
- √ At higher firing rates, fuel and combustion air velocities at the point of mixing are at their most optimal (with the appropriate allowance for staging). At reduced firing rates, mixing degrades as the fuel and air velocities decrease. To compensate, either the combustion air input and its velocity can be increased or forced mixing via swirl can be imparted. Though increases in O<sub>2</sub> (up to 12%) and swirl help reduce CO, these tend to increase NO<sub>x</sub>.

**Summary:** *For each specific firing rate there is a low and most efficient excess air level that gives the lowest corrected NO<sub>x</sub> for an acceptable corrected CO level (less than 100 ppmc). As the firing rate decreases, this excess air level increases because of the decrease in velocity promoted mixing.*

## COMBUSTION CONTROL STRATEGIES

### OBJECTIVE

With an emphasis of safety, maintain fuel Btu flow rate and oxygen mass flow rate in the correct ratio at all times.

- ✓ Burners can not perfectly mix the fuel and oxygen. Therefore, excess oxygen (excess air) is required to completely burn all of the fuel.
- ✓ Burners require more excess air at low firing rates, and less excess air at high firing rates. Therefore, the fuel/air (oxygen) ratio must be variable and characterized to the firing rate.
- ✓ Combustion control systems can not perfectly regulate fuel and oxygen flows. Therefore, **extra** excess air must be supplied to the burner to account for control system errors.
- ✓ The **extra** excess air due to control error causes higher operating costs.
- ✓ When selecting a combustion control system; consider safety first, then control system cost vs. operating cost trade-offs.

#### Control System Errors

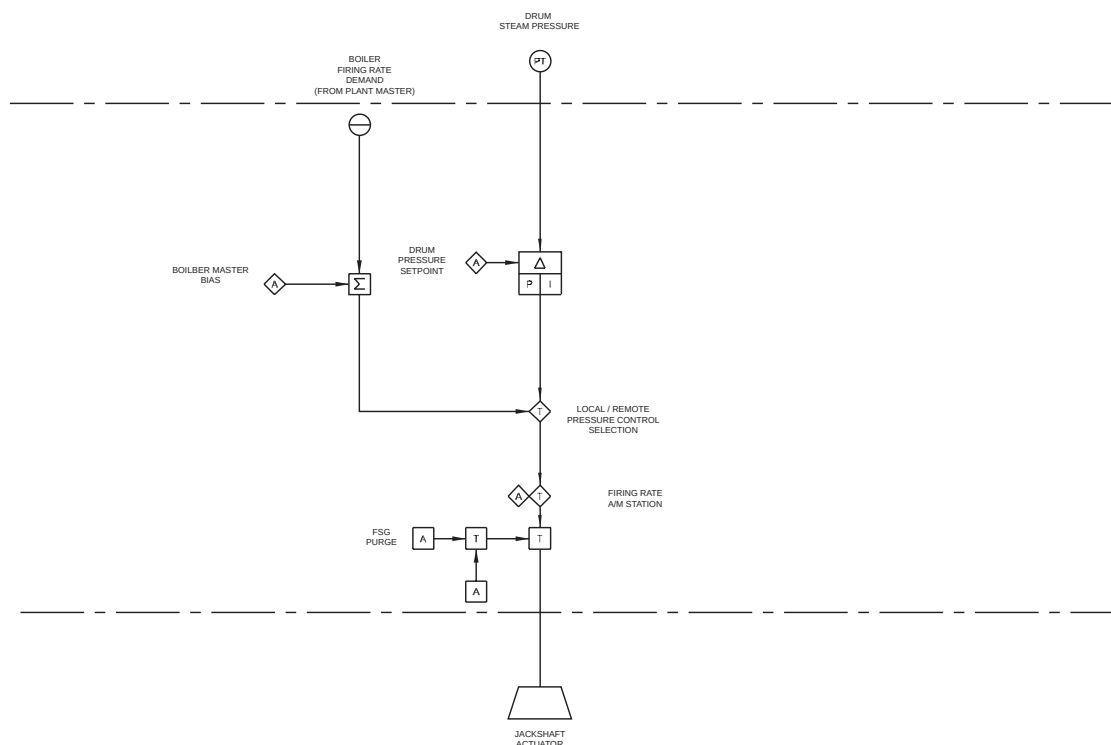
- Boiler draft changes caused by the number of units firing and/or their combined firing rate when they discharge to a common stack, wind effects, etc., change the boiler system's resistance and therefore change the amount of air flow and cause excess air.
- Hysteresis (non-repeatability) due to sloppy linkage, worn damper mechanism, and poor actuator positioning.
- Flow transmitters cannot measure fuel Btu flow rate (Btu/hr) or oxygen mass flow rate (lbs/hr). These rates are inferred from assumptions about fuel and air properties.
- The oxygen content per cubic foot of air changes with humidity. A constant air mass flow rate will yield a variable oxygen flow rate.
- Air temperature and atmospheric pressure change air density. A constant volumetric flow rate produces a varying air mass flow rate.
- A constant fuel valve position will yield a fuel flow that varies as fuel supply pressure and viscosity vary.

#### Combustion Control Strategies

- Single Point Positioning (Jackshaft)
  - Fuel and air are tied together mechanically
  - Simple, low-cost, safe; requires excess air
- Parallel Positioning
  - Fuel valve and air damper are positioned separately
  - Allows oxygen trim of air flow
- Fully Metered
  - Fuel and air flow (not valve position) are controlled

# COMBUSTION CONTROL STRATEGIES

## Single Point Positioning



Single point positioning is shown with local pressure control, remote firing rate demand and bias.

**Major Single Point Positioning Combustion Control** features are listed below and shown in the above diagram:

Fuel control valves and air control dampers are mechanically linked through a jackshaft and linkage arms. One actuator simultaneously moves both fuel and air in order to maintain the desired system pressure. For every particular firing rate demand, there is only one position for the fuel valves and a corresponding position for the air damper. The fuel/ air ratio is “tuned” by adjusting the fuel valve vs. air device linkage during initial commissioning.

The fuel/ air jackshaft actuator is interlocked with flame safeguard to cause the air/fuel jackshaft and the interconnected fuel valve and damper to go to the purge and light-off positions when appropriate during the start sequence.

All control errors affect this system. Typically, 20 - 50% extra excess air must be supplied to the burner to account for control inaccuracies. Oxygen trim systems can reduce the excess air by 15%. Suitable for smaller firetube boilers, and large firetube / small watertube boilers that operate at low capacity factors. Typically the annual fuel expense is too small to justify a more elaborate control system. This system may be suitable for larger boilers with low stack temperatures resulting from the installation of feedwater economizers or air preheaters. In this situation, much of the heat normally lost up the stack due to extra excess air is reclaimed by the economizer or preheater.

### Advantages

Simplicity

Provides large turndown

Inexpensive

Oxygen trim may be added using the Preferred Instruments Link Trim Actuator (LTA)

### Disadvantages

20 - 50% excess air required

Fuel valves and fan damper must be physically close together

Changes in fuel or air pressure, temperature, viscosity, density, humidity affect fuel/air ratio

Only one fuel may be burned at a time

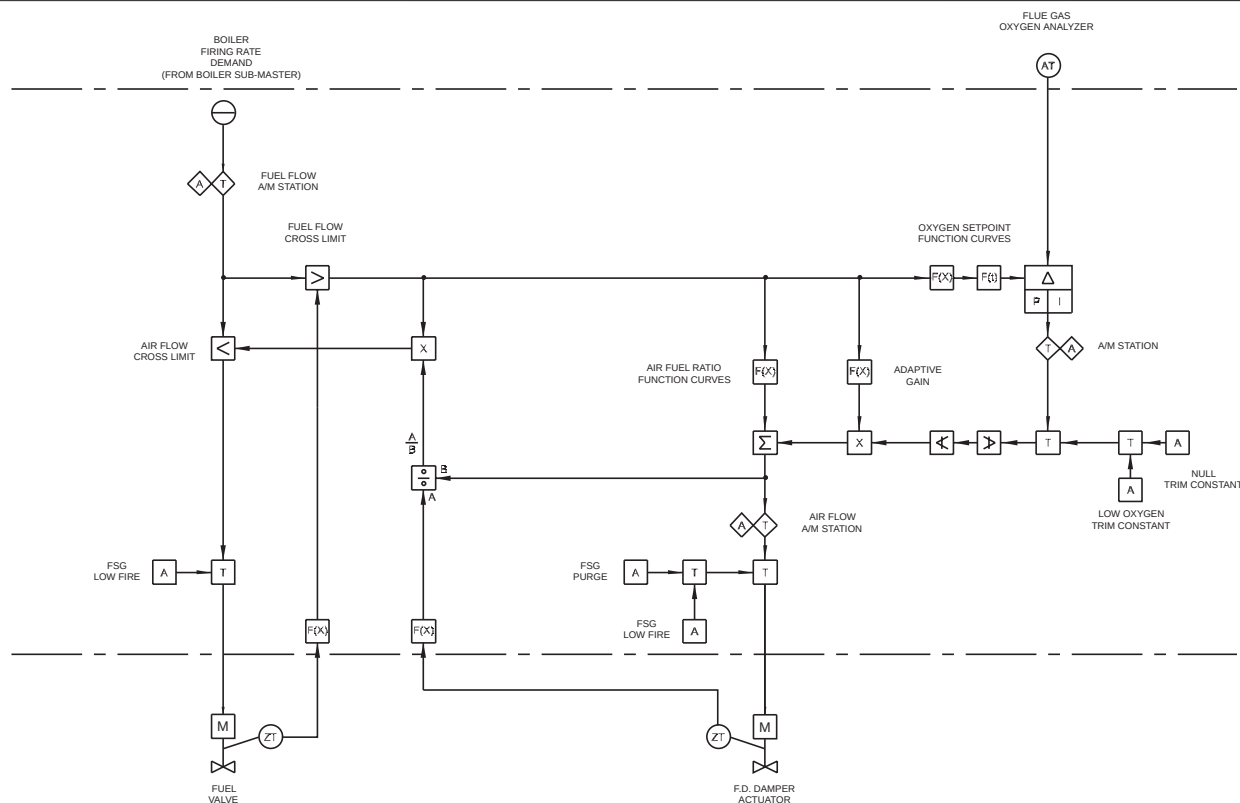
Not applicable to multiple burners

Not applicable to variable speed fan drives



# COMBUSTION CONTROL STRATEGIES

## Parallel Positioning With Cross Limiting



Parallel positioning control diagram is shown with flue gas oxygen trim

**Parallel Positioning Systems** offer key design benefits over single point positioning systems while retaining the benefits of a those systems. Major features are listed below and shown in the above diagram:

- One actuator positions the fuel control valve(s) while a second actuator positions the air control damper. Each actuator is equipped with a position retransmitter. For every particular firing rate demand, there is only one position for the fuel valves and a corresponding position for the air damper. Tuning a “soft” function curve of fuel position vs. air position varies the fuel/ air ratio.
- Preferred Instruments' parallel positioning combustion control strategy includes cross limiting of fuel valve and air damper positions. This “position cross-limiting” is employed for safety and to prevent fuel

rich conditions during load changes. Cross limiting requires an accurate and repeatable position feedback signal from each actuator. The controller constantly monitors the positions of the two actuators. A failure of either actuator or feedback pot will force the air damper to an appropriate position while the fuel valve is directed to minimum position. During load changes, the air leads the fuel on a load increase and the fuel leads the air on a load decrease.

- The air and fuel control outputs are interlocked with the flame safeguard to cause the air and fuel control drives to go to the purge and light-off positions when appropriate during the start sequence.

Many of the same applications, limitations and improvements described for single point positioning apply to parallel positioning.

### Advantages

Allows electronic characterization of fuel/air ratio

Adapts to boilers with remote F.D. fans and/or variable speed drives

Provides large turndown

Allows low fire changeover between fuels

Oxygen trim is easy to accomplish

### Disadvantages

20 - 50% excess air required

Changes in fuel or air pressure, temperature, viscosity, density, humidity affect fuel/air ratio

Only one fuel may be burned at a time

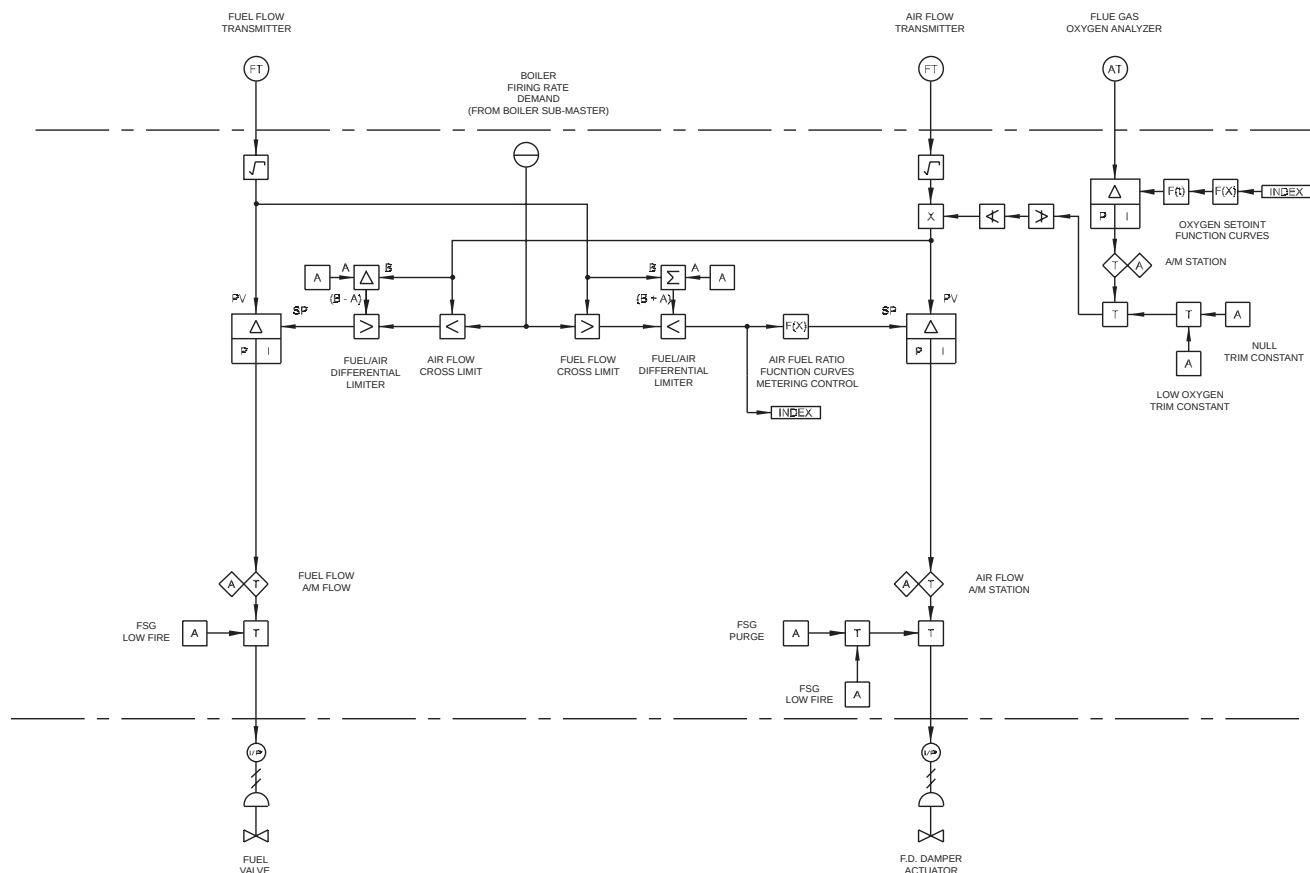
Not applicable to multiple burners

Position feedback is expensive for pneumatic actuators

A failure of either actuator or feedback pot will force the air damper open and the fuel valve to minimum position

# COMBUSTION CONTROL STRATEGIES

## Full Metering With Cross Limiting



Fully metered control diagram shown with flue gas oxygen trim

**Fully Metered Combustion Control Systems** offer key design features that help firing systems meet emissions goals. Major features are listed below and shown in the above diagram:

- Both the fuel flow and the combustion air flow are measured. Separate PID controllers are used for both fuel and air flow control. Demand from a boiler sub-master is used to develop both a fuel flow and air flow setpoint.
- Fully metered combustion control strategy includes differential cross-limiting of fuel and air flows. This feature adds an additional level of protection to the conventional air flow and fuel flow cross-limiting combustion control scheme by preventing the air fuel

ratio from becoming too air rich as well as too fuel rich.

- The air and fuel control outputs are interlocked with the flame safeguard system to cause the air and fuel control drives to go to the purge and light-off positions when appropriate during the start sequence.

Mass flow meters are available that accurately measure lbs/hr mass flow rates for oil, gas, and air flows. This minimizes errors due to variations in pressure, density, temperature, and viscosity. Lower cost, velocity-based flow meters can be adequately compensated with additional sensors by digital controllers. This system has the least control error. Full metering control is suitable for all boiler sizes up through and including electric utility boilers.

### Advantages

Provides extremely accurate control

Compensates for flow variations

Applicable to multiple burners

Allows simultaneous firing of oil and gas

Flow transmitters have no moving parts and require less periodic calibration than position feedback pots

### Disadvantages

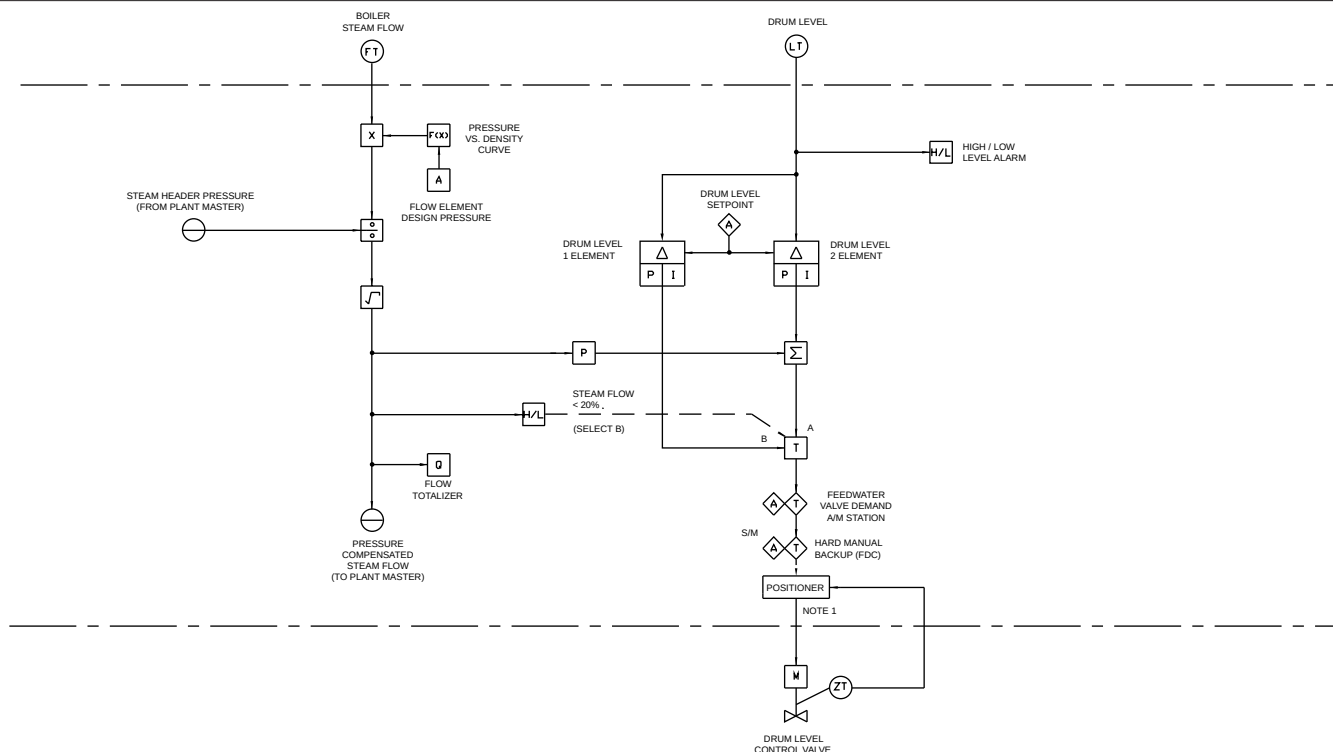
Typically, turndown is limited by flow transmitter turndown capability. (Preferred Instruments' control includes multi-mode auto select air flow control logic to enable 10:1 turn down)

For all types of flow meters, the fuel Btu value and air oxygen content must be assumed

Installation is more costly

# COMBUSTION CONTROL STRATEGIES

## Feedwater Control Systems



*Two Element drum level control diagram*

A feedwater control system that is operating properly has no effect on combustion efficiency. A feedwater valve that is constantly swinging from closed to open will cause the steam header pressure to swing up and down, even when the plant load is constant. This will, in turn, cause the burner firing rate to swing up and down. Burner load swings cause combustion control cross limiting systems and oxygen trim systems to operate the burner with extra excess air, thus lowering efficiency. The objective is to keep the water in the steam drum at an approximately constant level. Never so low as to trip the low water cutoff (this shuts down the burner), and never so high as to cause water carry-over into the steam system. Level changes during load swings are expected and unavoidable.

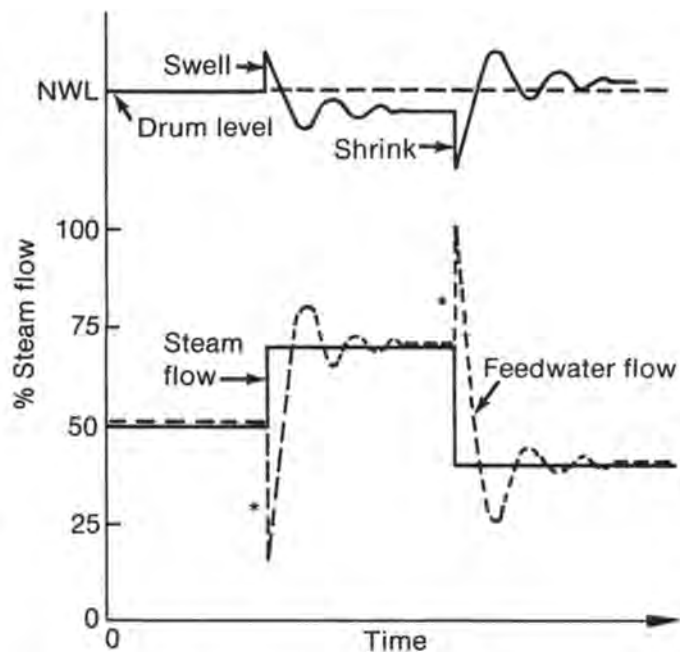
Drum level is subject to “shrink” and “swell” during load changes. Following an increase in steam flow, the drum level will increase (swell) for a period of time. The drum level will decrease after the swell subsides. Load decreases cause a level decrease (shrink). Firetube boilers have a proportionately large volume of water than a corresponding watertube boiler. Firetube boilers exhibit much less shrink and swell than watertube boilers. When the drum level rises, a simple feedwater control system will decrease the flow of water. This is the wrong response during a swell induced by a load increase.

There are four types of feedwater control systems:

- **On-Off** – A water level switch starts and stops the feedwater pump to maintain the drum water level. Suitable only for firetube boilers with slowly changing loads.
- **Single Element** – A drum level sensor causes the feedwater valve to open or close in proportion to the deviation from desired drum level. Suitable for firetube boilers with moderate load swings and watertube boilers with slowly changing loads. Variations in the feedwater supply pressure will cause the drum level to change when the load is steady. Single element feedwater control does not respond well to shrink and swell.
- **Two-Element** – A drum level sensor is the primary controller input, a steam flow sensor is a feedforward controller input. The steam flow signal allows the controller to respond properly during shrink and swell. Feedwater pressure variations also upset the drum level. Two-element feedwater control is suitable for watertube boilers with substantial load swings if the feedwater pressure is repeatable.
- **Three-Element** – A feedwater flow sensor is added to allow the controller to compensate for variations in feedwater supply pressure. Three-element feedwater control is suitable for watertube boilers with the most severe shrink and swell.

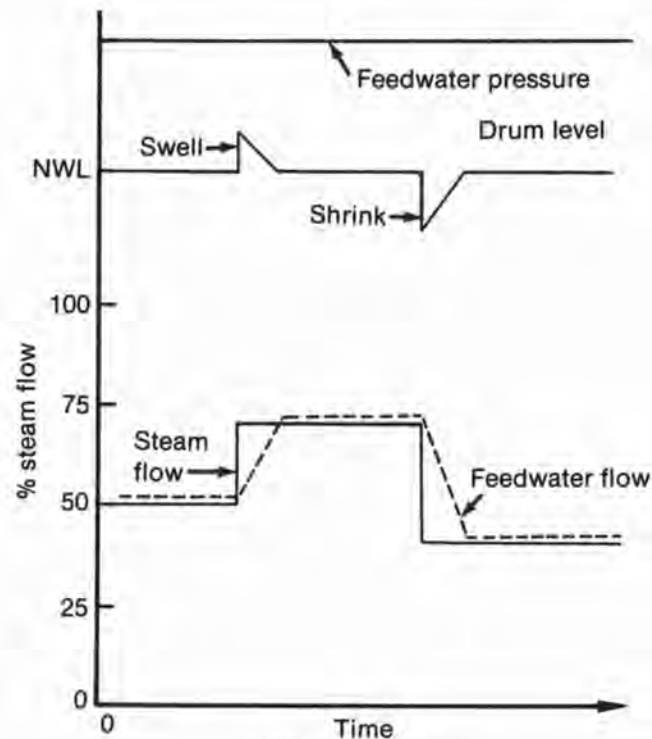
# COMBUSTION CONTROL STRATEGIES

## Feedwater Control Systems



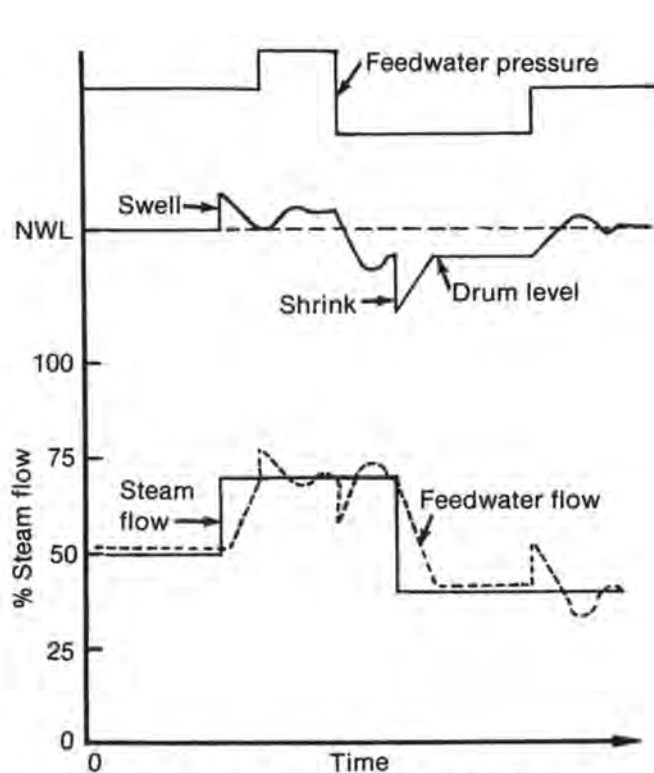
Control Action of Mechanical Single Element Feedwater Regulator

\* Interaction with firing rate control due to imbalance between steam flow and feedwater flow



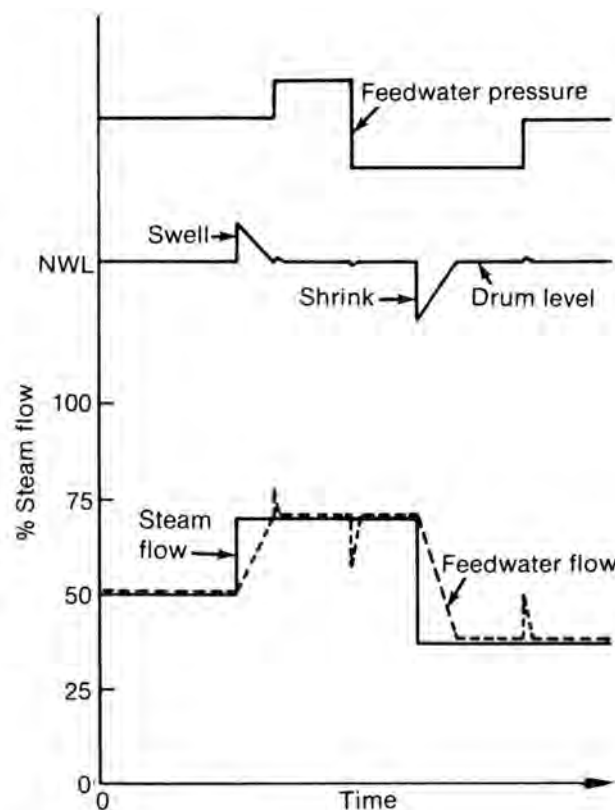
(A) Ideal conditions

Performance of Two Element Feedwater Control



(B) Effect of feedwater pressure variation

Performance of Two Element Feedwater Control

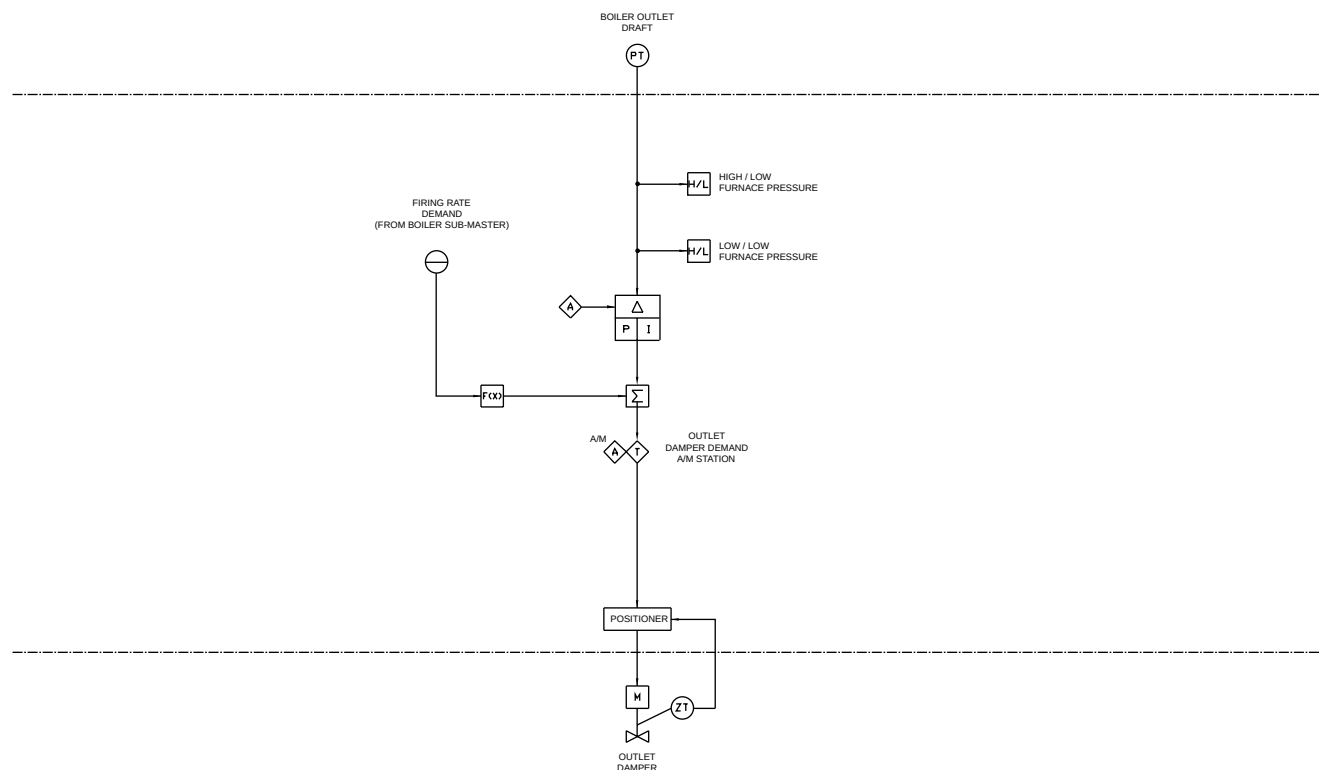


Performance of Three Element Feedwater Control

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# COMBUSTION CONTROL STRATEGIES

## Draft Control



*Draft Control System Diagram*

Draft controllers modulate the boiler outlet damper in order to maintain a constant pressure in the combustion chamber. Any furnace that will be operated at a negative draft should have a draft control system. Draft control is generally not applied to boilers/furnaces with stub stacks that are designed to be fired at an extremely high furnace pressure. However, if that same boiler is going to be fired into an I.D. fan or a tall stack, then draft controls should be applied in order to keep the pressure drop across the burner constant.

- Low draft (high furnace pressure) and proof of purge interlocks should always be incorporated into the burner flame safety system when draft control systems are utilized.

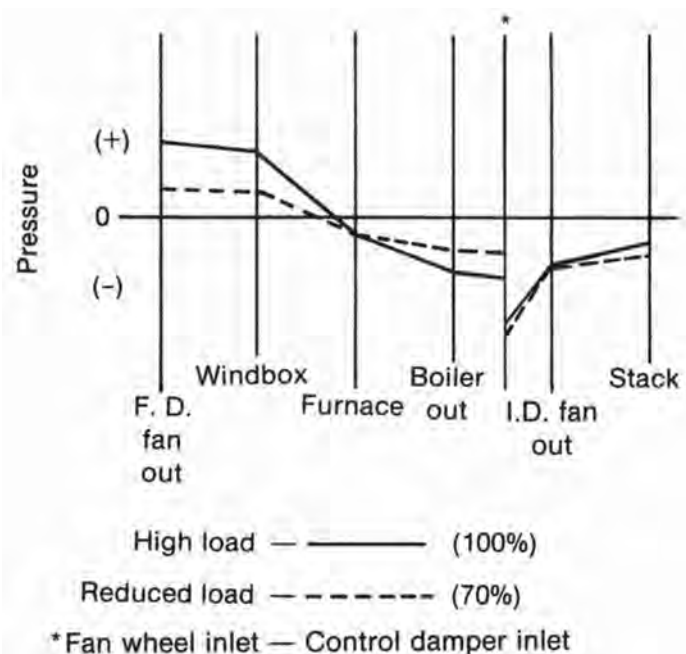
Draft controls lower operating costs in two ways:

- Reducing the air infiltrating into the furnace reduces heat lost up the stack. Uncontrolled furnace draft would result in a more negative furnace pressure, and more cold air would be sucked into the furnace.
  - Positioning burner control systems can operate with less extra excess air if the furnace pressure is constant. At a given F.D. fan inlet damper position, the air flow through a burner will increase when the furnace draft results in more negative furnace pressure.
  - Most draft controllers incorporate logic to close the damper when the burner is off, and to open the damper 100% for pre-purge and post-purge cycles. Energy is saved while the damper is closed by preventing warm boiler room air from traveling up the stack.

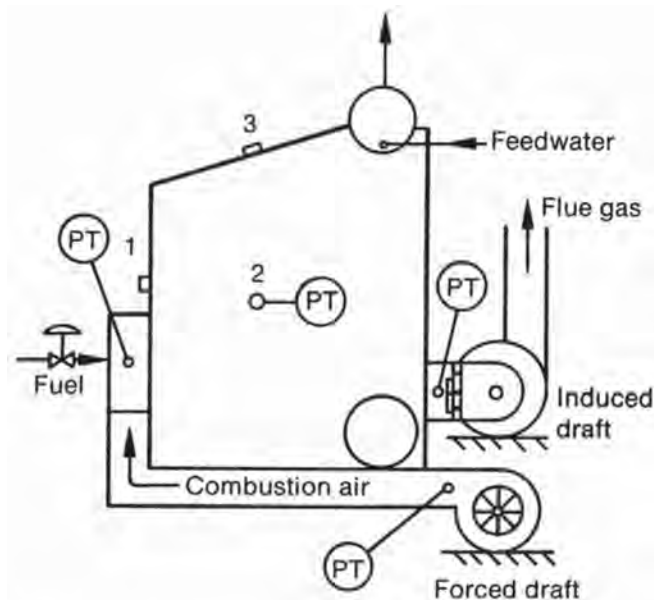


# COMBUSTION CONTROL STRATEGIES

## Draft Control

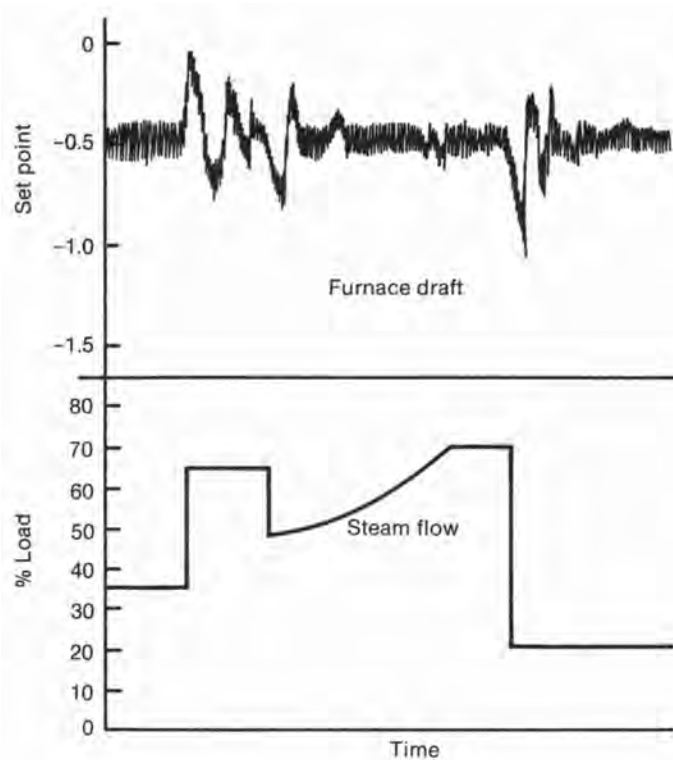


Measurement of Furnace Draft

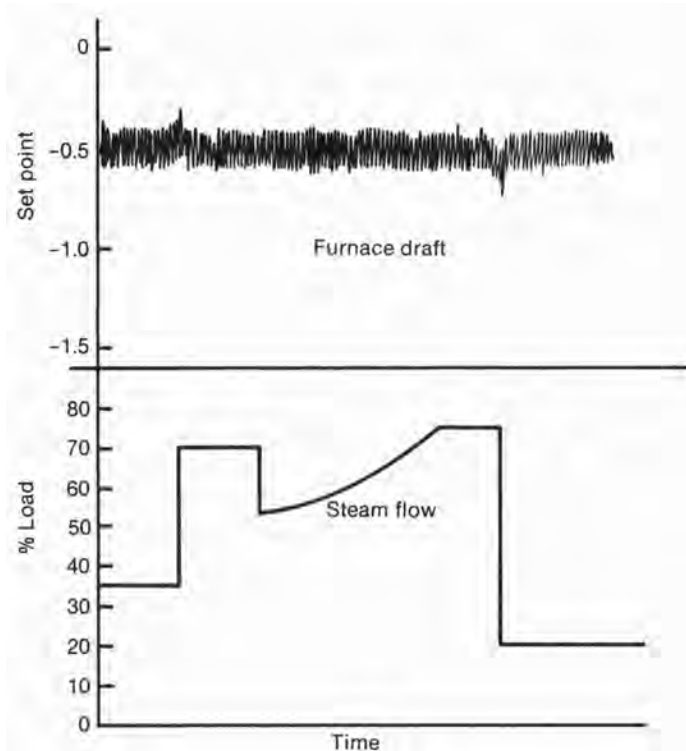


Notes:  
 1, 2, 3 — alternate furnace draft pressure connections.  
 Reading changes approx. 0.01 in. of H<sub>2</sub>O per ft elevation.

Profile of Pressure and Draft of Balanced Draft Boiler



Furnace Draft Control  
 (Single-Element Control of Induced Draft Fan)

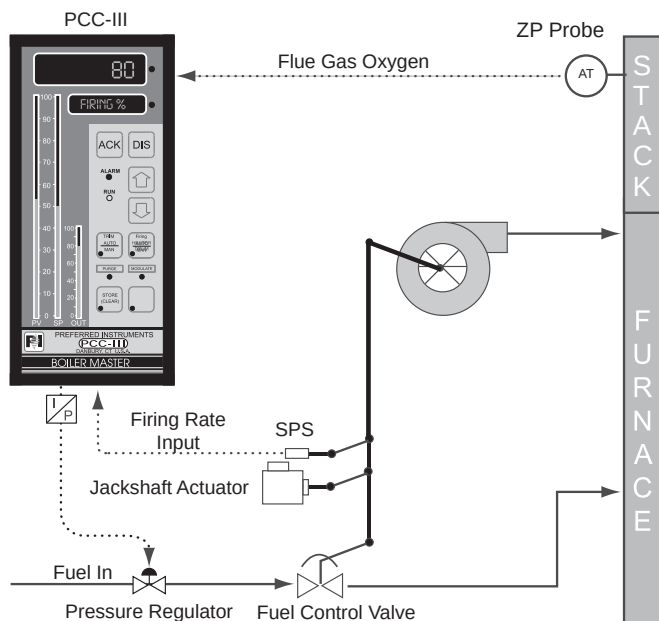


Furnace Draft Control  
 (Feedforward-plus-Feedback Control of an Induced Draft Fan)

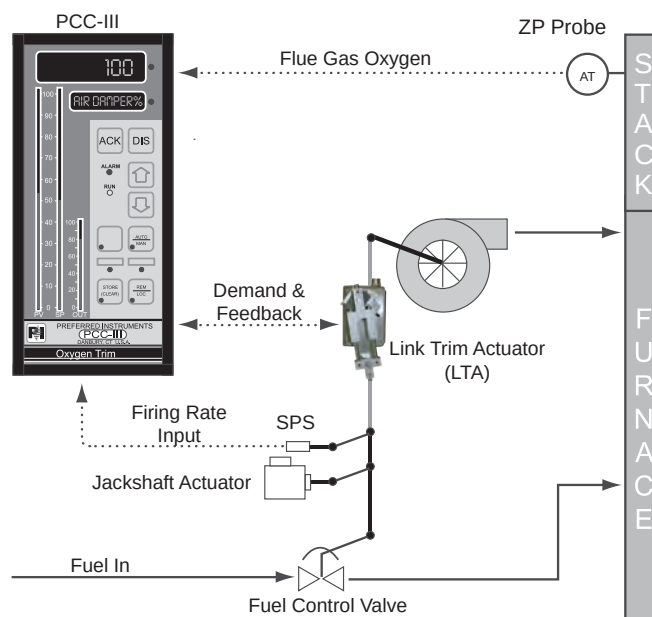
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# COMBUSTION CONTROL STRATEGIES

## Oxygen Trim



Fuel Trim System Diagram



Air Trim with LTA System Diagram

In addition to the jackshaft control shown above, "fuel trim" or "air trim" can also be applied to parallel positioning or fully metered combustion control strategies. "Fuel trim" systems use changes in the fuel pressure regulator setpoint to change the fuel/air ratio and "air trim" systems use changes in the air damper position to change the fuel/air ratio.

An in-situ zirconium oxide analyzer measures flue gas oxygen and a closed loop controller compares the actual oxygen level to the desired oxygen level. The air (or fuel) flow is trimmed by the controller until the oxygen level is corrected. The desired oxygen level for each firing rate must be entered into a characterized setpoint curve generator.

For dual fuel burners, independent curves are entered. The control strategy must include variable gain (ratio trimming) and setpoint lead/lag logic to prevent control oscillation.

To ensure safe operation, control action must be limited to no more than +/-15% excess air trimming.

Oxygen may be applied to any type of control system--single point positioning, parallel positioning, or full metering.

### Advantages

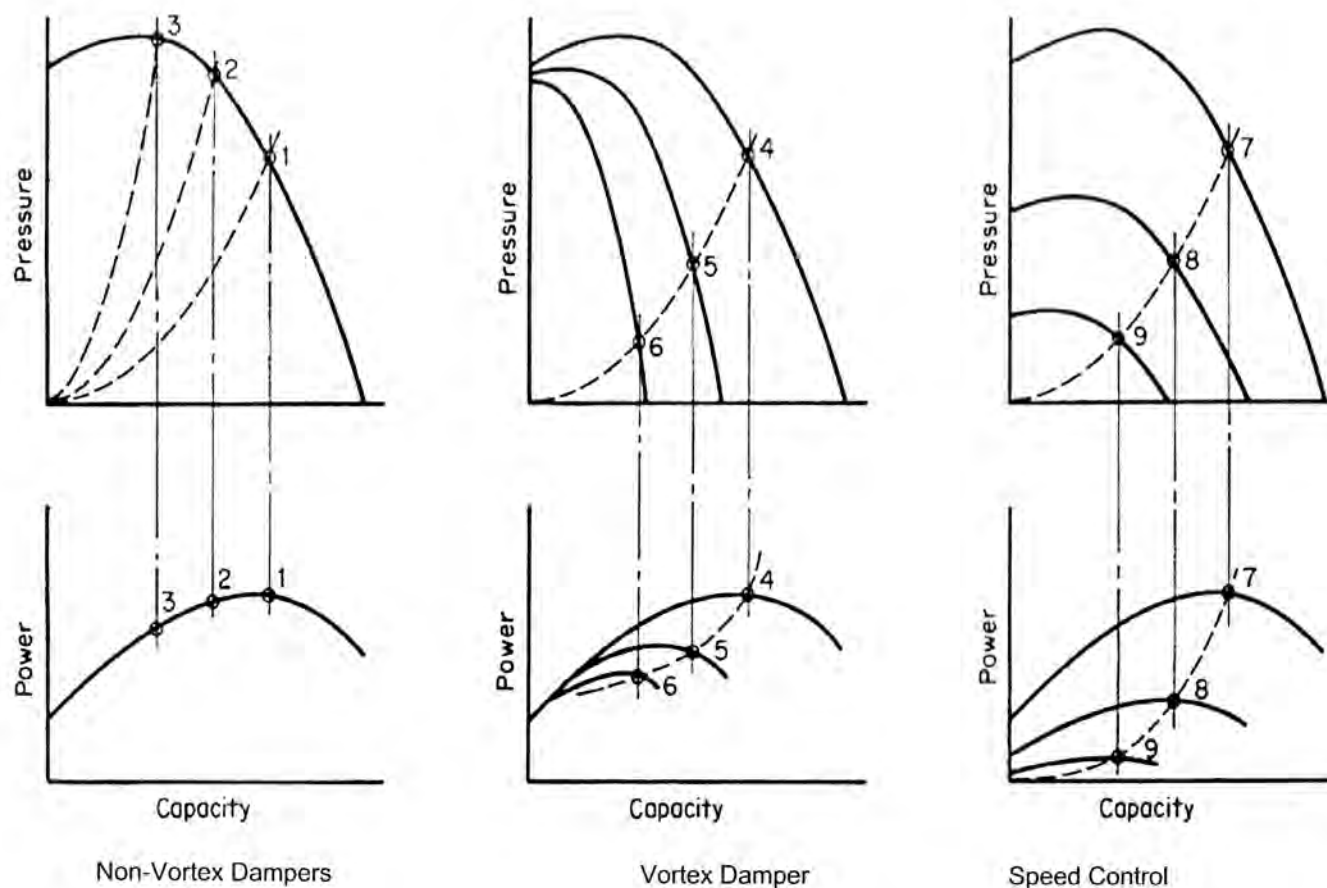
- Compensates for fuel Btu variations
- Compensates for air oxygen content variations
- Permits a reduction in normal excess air levels
- Lowers operating costs
- Allows real time boiler efficiency measurement and display using the ASME "by losses" method when flue gas temperature is also measured

### Disadvantages

- Cannot be applied to furnaces with significant air infiltration
- 3-5 year analyzer cell life
- Is not a "cure-all" for a poorly performing control system
- Constant rapid load changes diminish performance

## COMBUSTION CONTROL STRATEGIES

### Combustion Air Flow Control Techniques



*Pressure vs. Capacity and Power vs. Capacity*

Parallel Blade Dampers – Combustion air flow is controlled by increasing system resistance (pressure).

Vortex Dampers – Combustion air flow is controlled by increasing system resistance (pressure). Vortex dampers spin the air as it enters the rotating fan wheel. These dampers help reduce motor energy (kW-hrs).

Variable Speed Drives VSD – Combustion air flow is controlled by varying fan speed. VSD fan control minimizes fan damper pressure drop which significantly reduces motor energy (kW-hrs). Variable speed fan control is a proven electrical energy savings technique that has been applied to thousands of HVAC installations. VSD basic relationships:

$$\text{Fan HP} = (0.0001573 \times \text{cfm} \times \text{in. WC rise}) / \text{efficiency}$$

Efficiency: 45% - 85%, depends on fan type

#### Affinity Laws:

Used for ( $dP \propto \text{Flow}^2$ ) systems (ie, NO fan damper!)

|                                       |                                   |
|---------------------------------------|-----------------------------------|
| Flow $\propto$ Speed                  | ("α" means "is proportional to:") |
| Pressure $\propto$ Speed <sup>2</sup> | (9 % pressure = 30 % Speed)       |
| Hp $\propto$ Speed <sup>3</sup>       | (2.7 % Hp = 30 % Speed)           |
| Hp $\propto$ Flow <sup>3</sup>        | (2.7 % Hp = 30 % Flow)            |
| Hp $\propto$ Pressure <sup>1.5</sup>  | (16.4 % Hp = 30 % pressure)       |

Fan HP  $\propto$  Motor kW, electrical cost !

## COMBUSTION CONTROL STRATEGIES

### Flue Gas Recirculation (FGR)

FGR is used effectively to reduce NO<sub>x</sub> emissions. Recall that NO<sub>x</sub> can be lowered by reducing flame temperatures. By injecting FGR into the flame zone, the additional mass flow lowers the maximum achievable flame temperature and therefore the NO<sub>x</sub>. The fact that the FGR is low in O<sub>2</sub> also helps because the availability of O<sub>2</sub> in a given volume is lower (Note: as mentioned in the “Burner Operating Principles” section, increased excess air also lowers NO<sub>x</sub> but not as effectively as the same quantity of FGR because the O<sub>2</sub> content is higher). Currently there are four means by which to inject FGR:

#### **Forced Combustion Air/FGR Mixture:**

An additional fan is provided to direct FGR to a point of mixing with the combustion air upstream of the burner windbox or plenum.

#### **Induced Combustion Air/FGR Mixture:**

An additional breeching section is installed from an appropriate point in the flue to the FD Fan inlet. In effect the fan draws in both FGR and combustion air, mixes them and delivers them to the burner windbox or plenum. The advantages are that a mixing device is not required (FD Fan serves that purpose) and the additional FGR fan is not required though the FD Fan must be sized to handle both streams at the temperature of the mixture. Further draft control becomes an issue, otherwise variations in the flue pressure affect how much FGR is actually induced.

#### **“Localized” FGR Injection:**

FGR is directed to a separate burner injection assembly via an FGR Fan. The injection assembly is designed to direct FGR at those areas of the flame where temperatures are the highest. There are many operational benefits resulting from keeping the streams separate and the application of “selective” injection, including a notable savings in overall electrical horsepower consumption.

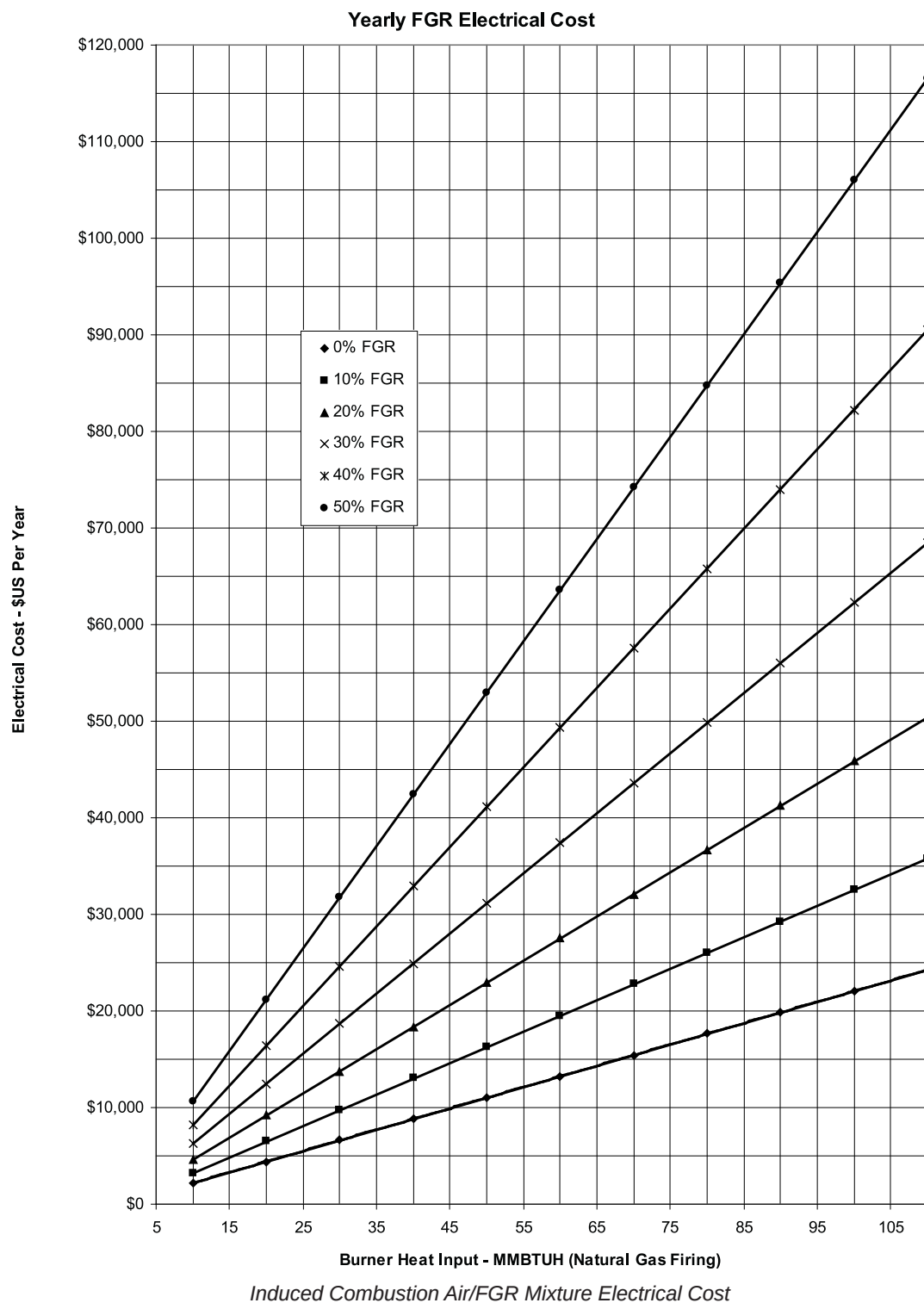
#### **Forced Gaseous Fuel/FGR Mixture:**

This follows the same general philosophy as that of the air/FGR mixture strategy, but involves the use of a compressor or blower to direct the FGR to a point of mixing with the gaseous fuel. Less FGR is necessary because only an amount necessary to effectively change the fuel into a “low Btu gas” is required (blower/ compressor horsepower is higher due to the higher pressure of the fuel that needs to be overcome).

All of these approaches are effective in reducing NO<sub>x</sub>. System complexity and electrical power consumption are the key differences and the best alternative depends on the specifics of the application as well as the customer preferences.

## COMBUSTION CONTROL STRATEGIES

### Induced Combustion Air/FGR Mixture Electrical Cost



#### Chart Data

The chart is based on \$0.07/kW-hr and 24 hour/365 day operation and 7.5" Burner Draft Loss (BDL); 4.5" Furnace Pressure; 15% Excess Combustion Air at 70° F; 450° F Induced FGR



## COMBUSTION CONTROL STRATEGIES

### Multiple Boiler Header Pressure or Temperature Control Recommendation

| Boilers Type                                             | Boiler Horsepower (BHP) | Steam lbs/hr | Control Arrangement            |
|----------------------------------------------------------|-------------------------|--------------|--------------------------------|
| On/Off                                                   | 1                       | 0.033        | Lead/Lag Control               |
|                                                          | 5                       | 0.167        |                                |
|                                                          | 10                      | 0.335        |                                |
| Cast Iron<br>Fintube<br>Firebox<br>Firetube<br>Watertube | 20                      | 0.670        | Modulating<br>Lead/Lag Control |
|                                                          | 50                      | 1.674        |                                |
|                                                          | 100                     | 3.348        |                                |
|                                                          | 200                     | 6.696        |                                |
|                                                          | 300                     | 10.044       |                                |
|                                                          | 500                     | 16.739       |                                |
|                                                          | 600                     | 20.087       |                                |
|                                                          | 800                     | 26.783       |                                |
|                                                          | 1000                    | 33.479       |                                |
| Watertube                                                | 1500                    | 50.218       | Plant Master Control           |
|                                                          | 2000                    | 66.958       |                                |
|                                                          | 4000                    | 133.915      |                                |
|                                                          | 6000                    | 200.873      |                                |
|                                                          | 8000                    | 267.830      |                                |
|                                                          | 10000                   | 334.788      |                                |
|                                                          | 20000                   | 669.576      |                                |

#### Lead/Lag Control:

Multiple boiler "on/off" operation is automatically established to satisfy the overall plant hot water or steam demand. Automatic sequencing ensures that the number of boilers in service meets hot water or steam demand. Tripped equipment is automatically replaced with a standby unit.

#### Modulating Lead/Lag Control:

Multiple boiler firing rates and "on/off" operation are automatically adjusted to satisfy the overall plant hot water or steam demand. Either unison (parallel) or series modulation is used.

#### Plant Master Control:

Multiple boiler firing rates are automatically adjusted to satisfy the overall plant hot water or steam demand. Either unison (parallel) or series modulation is used.

## COMBUSTION CONTROL STRATEGIES

### Firing Rate Control Selection Recommendations

|                                                 | Jackshaft Positioning  | Parallel Positioning   | Fully Metered |
|-------------------------------------------------|------------------------|------------------------|---------------|
| <b>Application Specifics</b>                    |                        |                        |               |
| <b>Dual Fuel Firing</b>                         |                        |                        |               |
| Low-fire changeover only                        | Option                 | Option                 | Option        |
| Full Load Simultaneous Firing                   | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| <b>Single/Multiple Burners</b>                  |                        |                        |               |
| Single Burner                                   | Option                 | Option                 | Option        |
| Multiple Burners                                | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| <b>Furnace Conditions</b>                       |                        |                        |               |
| Pressurized                                     | Option                 | Option                 | Option        |
| Balanced Draft<br>(FD & ID Fans are used)       | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| <b>Air Heater Type</b>                          |                        |                        |               |
| Lungstrom (Rotary)                              | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| Tubular                                         | Option                 | Option                 | Option        |
| <b>Stack Options</b>                            |                        |                        |               |
| Independent                                     | Option                 | Option                 | Option        |
| Common & slight effect on furnace pressure      | Option                 | Option                 | Option        |
| Common & significant effect on furnace pressure | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| <b>F.D. Fan Location</b>                        |                        |                        |               |
| Integral with windbox                           | Option                 | Option                 | Option        |
| Remote                                          | <b>Not Recommended</b> | Option                 | Option        |
| <b>Air Composition</b>                          |                        |                        |               |
| Constant                                        | Option                 | Option                 | Option        |
| Variable but slight                             | Option                 | Option                 | Option        |
| Variable & significant                          | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |
| <b>Fuel Composition</b>                         |                        |                        |               |
| Clean                                           | Option                 | Option                 | Option        |
| Variations                                      | <b>Not Recommended</b> | <b>Not Recommended</b> | Option        |

#### Notes:

1. Jackshaft positioning type systems are a good choice for boilers smaller than 200 BHP. When there is difficulty installing jackshaft linkage or a FD fan Variable Speed Drive (VSD) or oxygen trim is included, a parallel positioning system should be selected.
2. Fully metered type systems are a good choice for boilers larger than 600 BHP (20,000 lbs/hr). Fully metered systems with oxygen trim measure and control air flow, fuel flow and flue gas oxygen to minimize extra excess air.

When selecting a combustion control system, consider safety first, then control system cost vs. operating cost trade-offs.

## COMBUSTION CONTROL STRATEGIES

### Firing Rate Control Selection Recommendations

| Boilers Type | Boiler Horsepower (BHP) | Steam lbs/hr | Variable Speed Drive | Oxygen Trim | Combustion Control                   |                      |               |
|--------------|-------------------------|--------------|----------------------|-------------|--------------------------------------|----------------------|---------------|
|              |                         |              |                      |             | Jackshaft (Single Point Positioning) | Parallel Positioning | Fully Metered |
| On/Off       | 1                       | 0.03         | Yes                  | -           | -                                    | -                    | -             |
|              | 5                       | 0.17         | Yes                  | -           | -                                    | -                    | -             |
|              | 10                      | 0.34         | Yes                  | -           | -                                    | -                    | -             |
| Cast Iron    | 20                      | 0.67         | Yes                  | -           | Yes                                  | Yes                  | -             |
|              | 50                      | 1.67         | Yes                  | -           | Yes                                  | Yes                  | -             |
|              | 100                     | 3.35         | Yes                  | -           | Yes                                  | Yes                  | -             |
| Fintube      | 200                     | 6.70         | Yes                  | Yes         | Yes                                  | Yes                  | -             |
|              | 300                     | 10.04        | Yes                  | Yes         | Yes                                  | Yes                  | -             |
|              | 500                     | 16.74        | Yes                  | Yes         | Yes                                  | Yes                  | -             |
| Firebox      | 600                     | 20.09        | Yes                  | Yes         | Yes                                  | Yes                  | -             |
|              | 800                     | 26.78        | Yes                  | Yes         | Yes                                  | Yes                  | Yes           |
|              | 1000                    | 33.48        | Yes                  | Yes         | -                                    | Yes                  | Yes           |
| Firetube     | 1500                    | 50.22        | Yes                  | Yes         | -                                    | Yes                  | Yes           |
|              | 2000                    | 66.96        | Yes                  | Yes         | -                                    | Yes                  | Yes           |
|              | 4000                    | 133.92       | Yes                  | Yes         | -                                    | Yes                  | Yes           |
| Watertube    | 6000                    | 200.87       | Yes                  | Yes         | -                                    | Yes                  | Yes           |
|              | 8000                    | 267.83       | Yes                  | Yes         | -                                    | -                    | Yes           |
|              | 10000                   | 334.79       | Yes                  | Yes         | -                                    | -                    | Yes           |
| Watertube    | 20000                   | 669.58       | Yes                  | Yes         | -                                    | -                    | Yes           |

## COMBUSTION CONTROL STRATEGIES

### Boiler Size Terminology

| Boiler Horsepower (BHP) (output) | Heat MBtu/hr (output) | Steam lbs/hr (output) | Electrical Power (MW) (output) | Natural Gas ft <sup>3</sup> /hr (input) | #2 Fuel Oil GPH (input) |
|----------------------------------|-----------------------|-----------------------|--------------------------------|-----------------------------------------|-------------------------|
| 1                                | 0.03                  | 34.5                  |                                | 39.86                                   | 0.28                    |
| 5                                | 0.17                  | 172.5                 |                                | 199.28                                  | 1.42                    |
| 10                               | 0.34                  | 345                   |                                | 398.56                                  | 2.85                    |
| 20                               | 0.67                  | 690                   |                                | 797.11                                  | 5.69                    |
| 50                               | 1.67                  | 1,725                 |                                | 1,992.79                                | 14.23                   |
| 100                              | 3.35                  | 3,450                 |                                | 3,985.57                                | 28.47                   |
| 200                              | 6.70                  | 6,900                 | 1                              | 7,971.14                                | 56.94                   |
| 300                              | 10.04                 | 10,350                | 1                              | 11,956.71                               | 85.41                   |
| 400                              | 13.39                 | 13,800                | 1                              | 15,942.29                               | 113.87                  |
| 500                              | 16.74                 | 17,250                | 2                              | 19,927.86                               | 142.34                  |
| 600                              | 20.09                 | 20,700                | 2                              | 23,913.43                               | 170.81                  |
| 700                              | 23.44                 | 24,150                | 2                              | 27,899.00                               | 199.28                  |
| 800                              | 26.78                 | 27,600                | 3                              | 31,884.57                               | 227.75                  |
| 900                              | 30.13                 | 31,050                | 3                              | 35,870.14                               | 256.22                  |
| 1000                             | 33.48                 | 34,500                | 3                              | 39,855.71                               | 284.68                  |
| 1100                             | 36.83                 | 37,950                | 4                              | 43,841.29                               | 313.15                  |
| 1200                             | 40.18                 | 41,400                | 4                              | 47,826.86                               | 341.62                  |
| 1300                             | 43.52                 | 44,850                | 4                              | 51,812.43                               | 370.09                  |
| 1400                             | 46.87                 | 48,300                | 5                              | 55,798.00                               | 398.56                  |
| 1500                             | 50.22                 | 51,750                | 5                              | 59,783.57                               | 427.03                  |
| 2000                             | 66.96                 | 69,000                | 7                              | 79,711.43                               | 569.37                  |
| 4000                             | 133.92                | 138,000               | 14                             | 159,422.86                              | 1,138.73                |
| 6000                             | 200.87                | 207,000               | 21                             | 239,134.29                              | 1,708.10                |
| 8000                             | 267.83                | 276,000               | 28                             | 318,845.71                              | 2,277.47                |
| 10000                            | 334.79                | 345,000               | 35                             | 398,557.14                              | 2,846.84                |
| 20000                            | 669.58                | 690,000               | 69                             | 797,114.29                              | 5,693.67                |

Chart data is based on a steam enthalpy of 970.4 Btu/lb and boiler efficiency of 80% when firing natural gas and 84% when firing oil.

**Boiler Horsepower:** A boiler horsepower is the evaporation of 34.5 lbs. of water per hour at a temperature of 212° F. and a pressure of 14.7 PSIA. into dry saturated steam at the same temperature and pressure. The term "boiler horsepower" started because early boilers were used to drive engines with one engine horsepower.

#### RULES OF THUMB

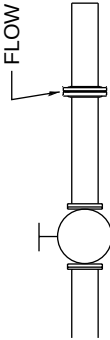
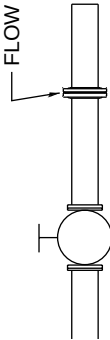
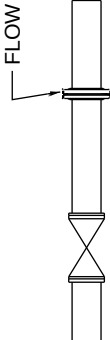
##### Boiler Horsepower

- 10,000 PPH Steam Output = 300 Boiler HP Developed
- Developed HP ÷ 200 = GPM Fuel Oil Burned
- Developed HP x 45 = CFH Natural Gas Burned
- Developed HP x 9 = CFM Combustion Air Required (20% Excess Air)
- Developed HP x 20 = CFM Hot Flue Gases (580° F)  
Used for Sizing I.D. Fan (20% E.A.)

Based on 75% Efficiency

**FLOW METER PIPING REQUIREMENTS**

“Diameters” of straight pipe required for various types of flow meters

| Diameter (D) = Nominal Pipe Size<br><br>Example:<br>13 Diameters of 6" pipe = 78"<br>13 Diameters of 10" pipe = 130"<br><br>Beta = (Bore I.D./Pipe I.D.)<br>Bore is the smallest diameter of an orifice<br>or nozzle<br><br>Up = Upstream Diameters<br>Down = Downstream Diameters |            | Fully Open Gate Valve<br>(Unless Another Upstream<br>Fitting Needs More) | Fully Open Globe or Non-Return Valve<br>(Unless Another Upstream Fitting<br>Needs More) | Partially Open Valve<br>or Regulator                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Orifice/Nozzle                                                                                                                                                                                                                                                                     | Beta = 0.5 | Up<br>6                                                                  |                                                                                         |    |
|                                                                                                                                                                                                                                                                                    |            | Down                                                                     |                                                                                         |                                                                                     |
|                                                                                                                                                                                                                                                                                    | Beta = 0.7 | Up<br>10                                                                 |                                                                                         |                                                                                     |
|                                                                                                                                                                                                                                                                                    |            | Down<br>4                                                                |                                                                                         |                                                                                     |
| Venturi                                                                                                                                                                                                                                                                            | Beta = 0.5 | Up<br>5                                                                  |                                                                                         |   |
|                                                                                                                                                                                                                                                                                    |            | Down<br>2                                                                |                                                                                         |                                                                                     |
|                                                                                                                                                                                                                                                                                    | Beta = 0.7 | Up<br>9                                                                  |                                                                                         |                                                                                     |
|                                                                                                                                                                                                                                                                                    |            | Down<br>4                                                                |                                                                                         |                                                                                     |
| Vortex                                                                                                                                                                                                                                                                             |            | Up<br>25                                                                 |                                                                                         |  |
|                                                                                                                                                                                                                                                                                    |            | Down<br>5                                                                |                                                                                         |                                                                                     |
| Thermal                                                                                                                                                                                                                                                                            |            | Up<br>15                                                                 |                                                                                         |  |
|                                                                                                                                                                                                                                                                                    |            | Down<br>5                                                                |                                                                                         |                                                                                     |
| Turbine                                                                                                                                                                                                                                                                            |            | Up<br>10                                                                 |                                                                                         |  |
|                                                                                                                                                                                                                                                                                    |            | Down<br>5                                                                |                                                                                         |                                                                                     |
| Annubar                                                                                                                                                                                                                                                                            |            | Up<br>8                                                                  |                                                                                         |  |
|                                                                                                                                                                                                                                                                                    |            | Down<br>3                                                                |                                                                                         |                                                                                     |

**Note:**

1. The straight runs shown above are conservative minimums. Longer upstream straight pipe lengths provide better accuracy.
2. If the indicated straight run is not available, consult factory. Detailed factory analysis will require accurate fluid data, flow data, and a sketch detailing the piping system 50 diameters upstream and 10 diameters downstream from the proposed meter location.
3. Internal straightening vanes can be used to reduce straight pipe length requirements, consult factory.
4. **Positive displacement and Coriolis effect meters** are not influenced by upstream and downstream fittings.



## FLOW METER PIPING REQUIREMENTS

"Diameters" of straight pipe required for various types of flow meters

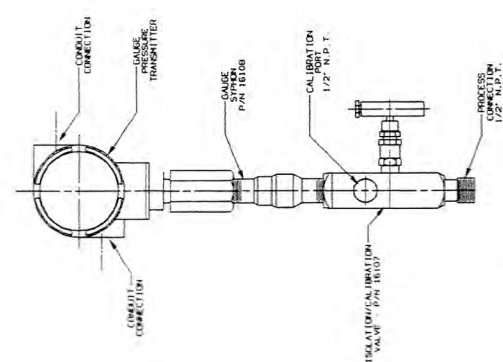
| Diameter (D) = Nominal Pipe Size<br><br>Example:<br>13 Diameters of 6" pipe = 78"<br>13 Diameters of 10" pipe = 130"<br><br>Beta = (Bore I.D./Pipe I.D.)<br>Bore is the smallest diameter of an orifice or nozzle<br><br>Up = Upstream Diameters<br>Down = Downstream Diameters |            |      | Two Elbows, > 10 Diameters,<br>Fittings in Different Planes | Two Elbows, < 10 Diameters,<br>Fittings in Different Planes | Reducer or Expander<br>(Unless Another<br>Upstream fitting Needs<br>More) | Atmospheric Intake |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------|-------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------|--------------------|
| Orifice/Nozzle                                                                                                                                                                                                                                                                  | Beta = 0.5 | Up   | 16                                                          | 20                                                          | 9                                                                         |                    |
|                                                                                                                                                                                                                                                                                 |            | Down | 3                                                           | 3                                                           | 3                                                                         |                    |
| Venturi                                                                                                                                                                                                                                                                         | Beta = 0.7 | Up   | 23                                                          | 30                                                          | 12                                                                        |                    |
|                                                                                                                                                                                                                                                                                 |            | Down | 4                                                           | 4                                                           | 4                                                                         |                    |
|                                                                                                                                                                                                                                                                                 | Beta = 0.5 | Up   | 21                                                          | 21                                                          | 5 (reducer), 2 (expander)                                                 | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 2                                                           | 2                                                           | 2                                                                         |                    |
|                                                                                                                                                                                                                                                                                 | Beta = 0.7 | Up   | 21                                                          | 21                                                          | 8 (reducer), 4 (expander)                                                 | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 2                                                           | 2                                                           | 4                                                                         |                    |
| Vortex                                                                                                                                                                                                                                                                          |            | Up   | 30                                                          | 45                                                          | 25                                                                        | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 5                                                           | 5                                                           | 5                                                                         |                    |
| Thermal                                                                                                                                                                                                                                                                         |            | Up   | 15                                                          | 40                                                          | 15 (reducer), 30 (expander)                                               | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 5                                                           | 10                                                          | 5 (reducer), 10 (expander)                                                |                    |
| Turbine                                                                                                                                                                                                                                                                         |            | Up   | 10                                                          | 10                                                          | 10                                                                        | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 5                                                           | 5                                                           | 5                                                                         |                    |
| Annubar                                                                                                                                                                                                                                                                         |            | Up   | 9                                                           | 19                                                          | 8                                                                         | —                  |
|                                                                                                                                                                                                                                                                                 |            | Down | 3                                                           | 4                                                           | 3                                                                         |                    |

### Note:

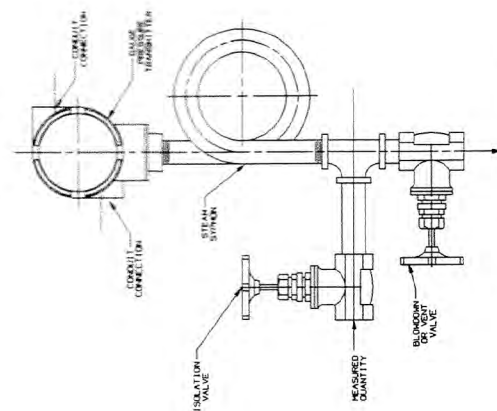
- The straight runs shown above are conservative minimums. Longer upstream straight pipe lengths provide better accuracy.
- If the indicated straight run is not available, consult factory. Detailed factory analysis will require accurate fluid data, flow data, and a sketch detailing the piping system 50 diameters upstream and 10 diameters downstream from the proposed meter location.
- Internal straightening vanes can be used to reduce straight pipe length requirements, consult factory.
- Positive displacement and Coriolis effect meters** are not influenced by upstream and downstream fittings.



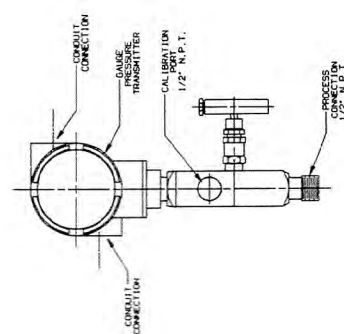
# INSTRUMENT INSTALLATION DETAILS



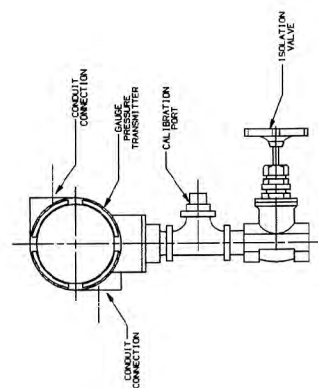
STEAM APPLICATION  
ABOVE PIPE APPLICATION  
(PREFERRED ARRANGEMENT)



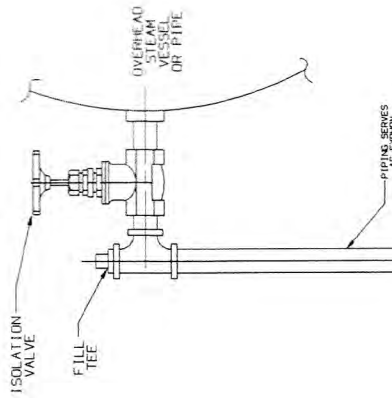
STEAM APPLICATION  
ABOVE PIPE APPLICATION  
(ALTERNATE ARRANGEMENT)



GAS OR LIQUID APPLICATION  
ABOVE PIPE APPLICATION  
(PREFERRED ARRANGEMENT)



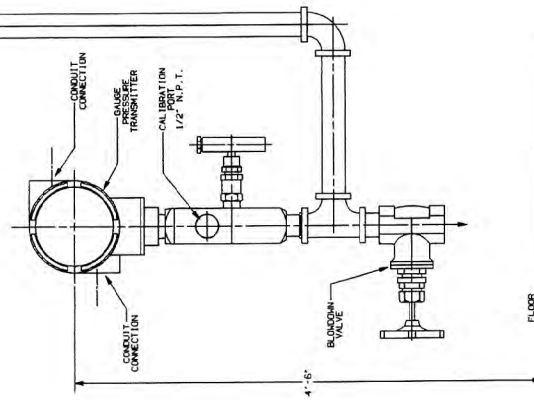
GAS OR LIQUID APPLICATION  
ABOVE PIPE APPLICATION  
(ALTERNATE ARRANGEMENT)



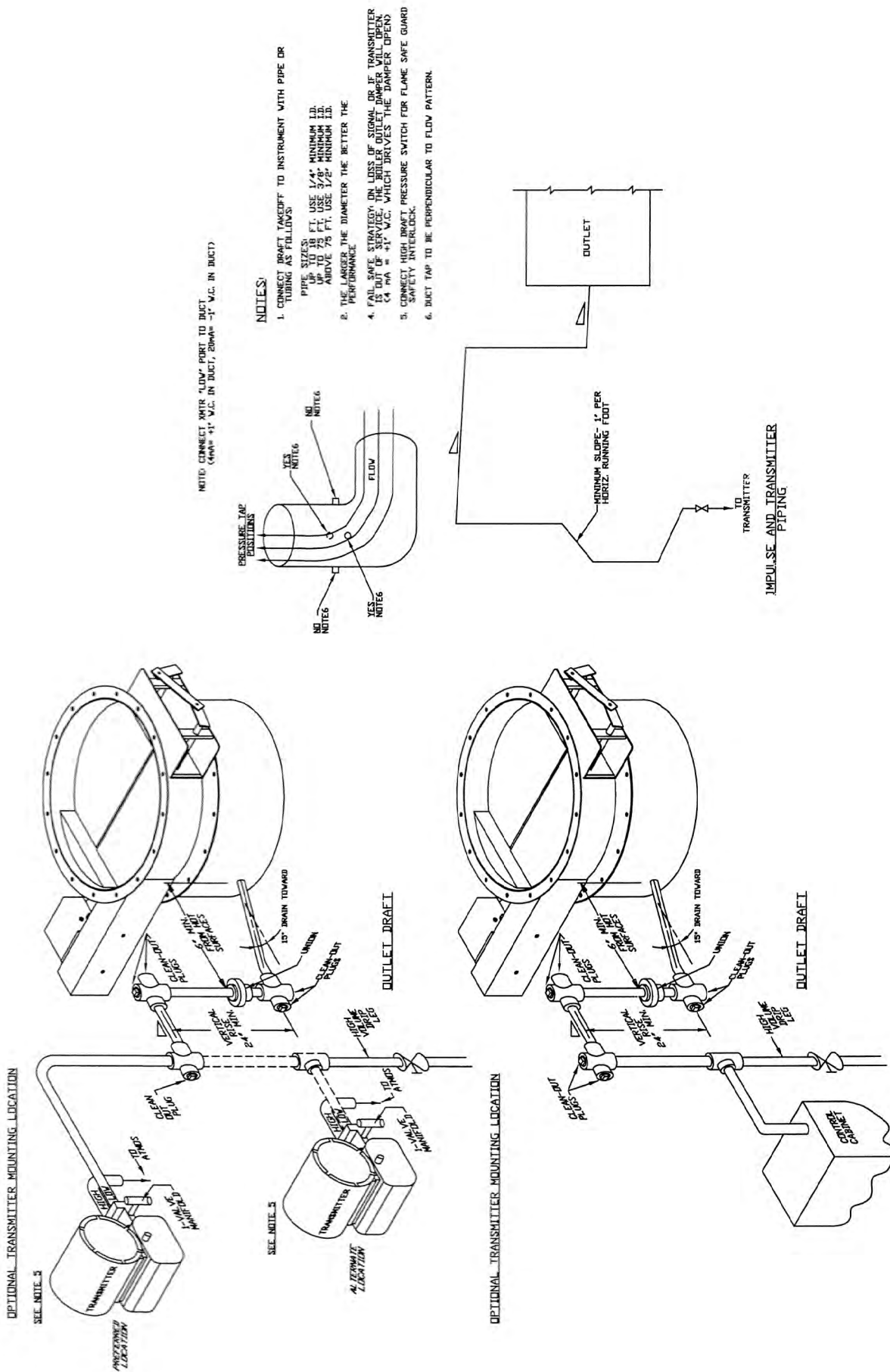
## NOTES:

1. IMPISE PIPE SHOULD ALWAYS BE CONNECTED TO THE SIDE OR TOP OF A PIPE OR VESSEL, NEVER TO THE BOTTOM.
2. TRANSMITTERS LOCATED NEAR HOT SURFACES MUST BE INSTALLED AT A SUITABLE DISTANCE IN ORDER TO STAY WITHIN THE TRANSMITTERS AMBIENT TEMPERATURE LIMITATIONS.

## BELOW PIPE APPLICATION

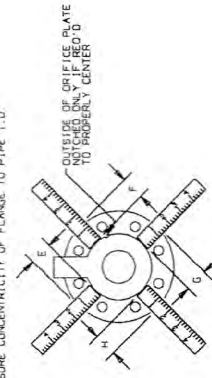
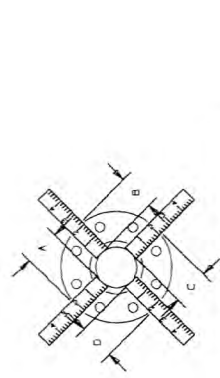
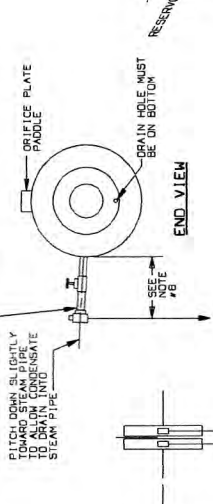
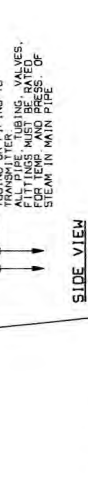
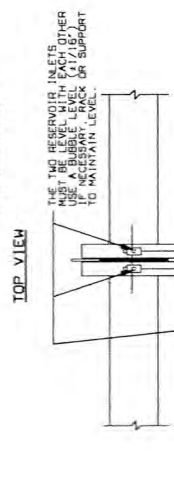
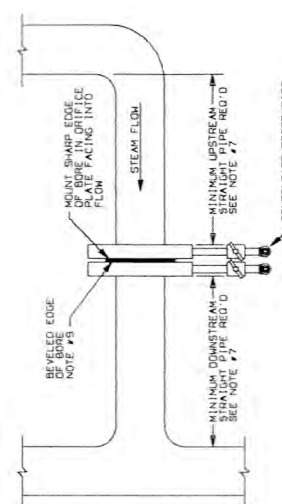


Pressure Transmitter Installation Details



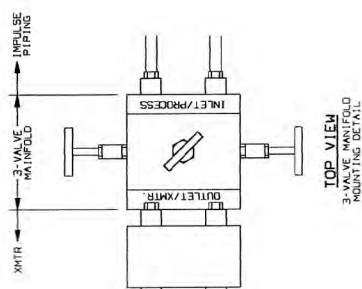
### Boiler Outlet Draft Control Transmitter Installation Details





2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE TO FLANGE. DIMENSIONS CORRESPONDING TO DIFFERENCE BETWEEN CONCENTRICITY TOLERANCE: B" PIPE  $\pm 1/32"$  A-E \* B-F \* C-G \* D-H \* CONSTANT VALUE

**CENTERING OF ORIFICE PLATE OR FLOW NOZZLE**  
CONCENTRICITY TOLERANCE: B" PIPE  $\pm 1/64"$



**TOP VIEW**  
3-VALVE MAINFOLD MOUNTING DETAIL

SEE NOTE #6  
- SEE INSULATION ON ANY IMPULSE TRACING IS REQUIRED.  
- SEE NOTE #6 EXCEPT STEAM LINE BE BELOW TRANSMITTER.  
- OFF FLOOR OR CRAWL IN AN ACCESSIBLE LOCATION.

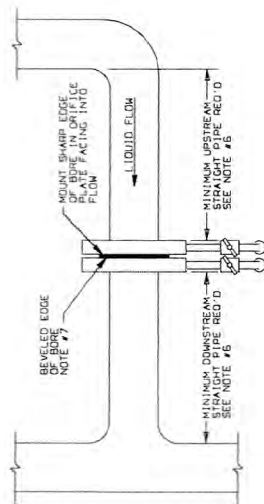
**TRANSMITTER DETAILS**

- NOTES:**
1. IMPULSE PIPING MUST BE SLOPED TO ALLOW AIR BUBBLES TO BE PURGED FROM SYSTEM.
  2. CONDENSATE RESERVOIRS MUST BE LEVEL WITH EACH OTHER.
  3. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MAINFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
  4. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
  5. INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS. 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL HELDING FLUSH TO INTERIOR OF PIPE.
  6. BOTH IMPULSE PIPES MUST BE KEPT AT THE SAME TEMPERATURE. FOR HEAT TRACING INSULATION DETAILS. CONSULT FACTORY.
  7. SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE REDUCERS, ELLS, ELBOUS, OR BENDS. IF SUCH PIPE IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
  8. MINIMIZE THIS LENGTH. FOR LENGTHS OVER 12', INSULATE FIRST FLANGE TAP UP TO WITHIN 12' FROM RESERVOIR.
  9. PIPES AND VALVES MUST BE BUBBLE LEVEL. ORIFICE PLATE STAMPING SHOULD FACE FLOW.

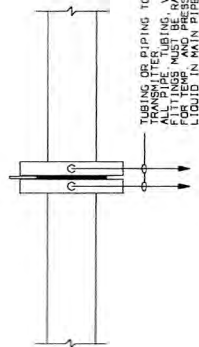
Orifice Plate Installation Details for Horizontal Liquid Pipes with Flange Taps



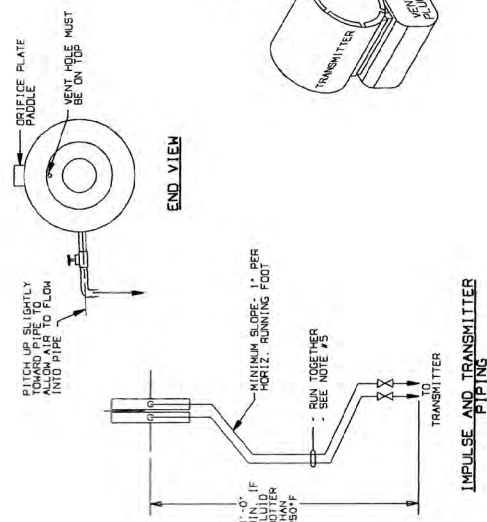
# INSTRUMENT INSTALLATION DETAILS



TOP VIEW

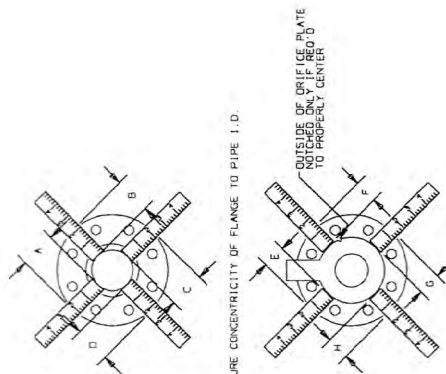


SIDE VIEW



- SEE NOTE #5
- NO INSULATION ON ANY INSTRUMENT PIPING UNLESS HEAT TRACING IS REQUIRED
- PIPING MUST BE BELOW LIQUID LINE
- MOUNT TRANSMITTER 4" - 6" ABOVE ORIFICE PLATE IN AN ACCESSIBLE LOCATION

TRANSMITTER DETAILS



## FLAME SAFEGUARD CODE AND APPLICATION

### FLAME SAFEGUARD INTRODUCTION

Unlike combustion control, which is primarily an analog process concerned with how much air and fuel are supplied to a burner, flame safeguard is a largely digital process that involves monitoring limit inputs and flame scanner inputs, opening and closing valves and dampers to safely start up, shutdown, and monitor the combustion components.

Boiler codes do not strictly define combustion control terms or practices, but flame safeguard functions for boilers larger than 12.5 mmbtu/hr are relatively well-defined and regulated by the National Fire Protection Association Standard 85 *Boiler and Combustion Systems Hazards Code*. The latest edition is the 2011 edition. NFPA 86 covers ovens and furnaces. The flame safeguard principles between the two codes are largely the same, but differ in application for the two industries. The steering committees that write NFPA 85 are made up of senior engineers in the burner/ boiler industry. The committee members come from three main backgrounds—boiler/ burner manufacturers, end-users, and regulators.

NFPA 85 Chapter 5 Single Burner Boilers covers the vast majority of boilers used by industrial, commercial, and institutional end-users.

### TYPICAL BURNER LIGHT-OFF SEQUENCE

#### 1. Pre-firing Cycle

When a burner start sequence is initiated, the flame safeguard controller will go through a self-diagnostic sequence to ensure it is working properly. In addition, the controller will:

- Ensure the fuel valve proof-of-closure switches are made.
- Check to ensure burner safety limits are not bypassed. (The minimum combustion air pressure switch should not be made at this time.)
- Ensure there is no flame in the furnace.
- Cycle fuel and air servos to ensure they are working properly.

#### 2. Purge the Firing Chamber

Even during a normal burner shutdown, combustibles are generated in the furnace. If there is a fuel leak to the furnace, there may be a large amount of combustible material in the firing chamber. These combustibles must be purged out of the furnace prior to light-off. NFPA 85 (section 5.5.2.6.1) requires:

- The forced draft fan to be energized and proven by a fan motor starter interlock switch.
- Purge be proven by a minimum air pressure switch and open damper interlock; or by an air flow interlock.

- Purge air flow must be at least 70 percent of high fire air flow and continue for at least eight air volume changes.

#### 3. Light-Off Cycle

The flame safeguard controller will drive the air damper and fuel valve (and any other servos) to their light-off positions. These positions must be proven by a low fire interlock switch or servo feedback. The controller will then energize the ignition transformer and pilot valves, and prove igniter flame within 10 seconds. This part of the light-off sequence is referred to as Pilot Trial for Ignition (PTFI). If the pilot flame is proven, the controller energizes the main fuel valves and then de-energizes the pilot valves. This is called Main Trial for Ignition (MTFI) and generally lasts 10 seconds, but can be extended to 15 seconds for heavy fuel oil. If flame is not proven continuously through PTFI and MTFI, the controller de-energizes the pilot and main fuel valves, and goes to Post Purge. This is considered a Safety Shutdown Cycle and will require a manual reset to restart the burner. To ensure the flame scanner doesn't see the igniter spark (and open the main fuel valves in the absence of a pilot flame) the flame safeguard controller should have Early Spark Termination that shuts off the ignition transformer and forces the flame safeguard to prove the igniter flame is lit prior to opening the main fuel valves.

Note: single burner boilers generally use Class 3 igniters. A Class 3 igniter is designed to light off the main burner under prescribed (light-off) conditions and have a heat input generally less than 4% of main burner heat input.

#### 4. Run Mode

During Run Mode, the flame safeguard controller turns control of the air and fuel (and any other outputs) to the combustion controller. NFPA requires the flame safeguard controller and combustion controller to be separate processors. Burner safety limit interlocks and main flame must be continuously proven by the flame safeguard controller or a Safety Shutdown Cycle will be initiated.

#### 5. Normal Shutdown Cycle

A normal shutdown cycle can be initiated manually by the operator turning off the burner, or automatically (on recycling boilers) by the operating steam pressure switch or low water cutout switch. During a normal shutdown, the flame safeguard controller (according to NFPA 85 section 5.5.2.6.6) will:

- Shut off the pilot and/ or main fuel valves.
- Perform a post-purge of the furnace for at least 15 seconds at or below the air flow rate at the time the unit was shut down.
- Shut down the forced draft fan.

## FLAME SAFEGUARD CODE AND APPLICATION

Note: During a normal shutdown cycle, the flame safeguard controller does not lockout, and the alarm horn is not energized.

The burner can be restarted manually by the operator, or automatically (on recycling boilers) by the low water cutout or the operating steam pressure switch making. Boilers designed for automatic cycling must be started manually by a trained operator when fired from a cold start condition.

**6. Safety Shutdown Cycle.** A safety shutdown cycle can be initiated manually by tripping the emergency stop input, or automatically by the flame safeguard controller on loss of flame, loss of any running interlock input, or failure of certain flame safeguard controller self-diagnostics. The safety shutdown sequence is essentially the same as the normal shutdown sequence, except that the unit will require a manual reset to be restarted. According to NFPA 85 section 5.5.2.6.9 the burner is not allowed to be restarted until a trained operator “determines the cause of the shutdown and takes the necessary corrective action to ensure that conditions are within specified operating limits.”

### EQUIPMENT REQUIREMENTS

NFPA imposes certain system requirements on the burner and associated fuel trains to ensure safe operation.

#### Oil Burning Equipment

NFPA 85 section 5.3.1.11 requires oil piping materials and design to be in accordance with:

- NFPA 31 for oil piping inside industrial or institutional buildings
- ASME B31.1 for oil piping in power applications
- ASME B31.3 for oil piping in process applications.

It is common for end-users or consulting engineers to specify the more stringent ASME B31.1 or B31.3 codes for applications outside of power and process plants.

NFPA 85 requires a relief valve be supplied to prevent overpressure in the fuel oil supply system. Also, two oil safety shutoff valves with proof of closure switches are required.

#### Gas Firing Equipment

NFPA 85 (section 5.3.2) contains a number requirements specifically for the natural gas supply system to a boiler:

- Both the main gas line and the pilot gas line are required to have two safety shutoff valves in series with

proof of closure switches, and an automatic vent valve between. This requirement for the igniter safety shut off valves is new and contained in section 5.3.4.1.3.

- The automatic vent valves may be omitted when a listed automatic valve-proving system is used in conjunction with the required shut off valves. Valve proving must be performed either after every shutdown or prior to light-off.
- Connections must be provided for annual gas valve leakage tests.

#### Boiler Outlet Dampers

Boiler outlet (stack) dampers are required where two or more boilers are connected to a common stack. They are also used on boilers where draft controls are required for consistent operation. Manufacturers' recommendations vary, but draft controls are generally required on boilers with stacks over 75 feet tall.

- Interlocks must be provided to prevent firing against a closed damper (NFPA 85 section 5.3.4.6.2.3) This usually consists of a position switch on the stack damper or feedback on the stack damper actuator.
- Means must be provided to make the outlet damper switch tamper proof by connecting it to the driven member, or by supplying a furnace pressure switch.

#### Flame Safety Shutdown Systems

The burner flame is required to be continuously supervised (proven lit) by an approved flame sensing device. This typically consists of an ultraviolet or infrared flame detector, or a flame rod assembly. NFPA 85 section 5.3.7 imposes the following additional requirements on the flame safeguard system:

- The flame safeguard controller must de-energize the fuel valves within four seconds of a flame failure.
- The fuel safety shutoff valves must reach full closure within one second of being de-energized.
- Unless the burner is intended to cycle off at least once every 24 hours, flame detectors that can fail in the flame proven mode must be provided with self-checking features. Typically watertube boilers, and firetube boilers that are not intended to cycle, are provided with self-checking UV scanners.
- Flame safeguard controllers are required to Lockout if flame is sensed when the burner is off, or prior to light-off.

NFPA 85 includes a great deal of detail regarding light-off and shutdown sequences for different types of burners operated under varying conditions. It should be consulted prior to any burner/boiler design or modifications.

## FLAME SAFEGUARD CODE AND APPLICATION

### Flame Monitoring

The most common flame detectors used for single burner boilers are infrared and ultraviolet scanner, and flame rectification (flame rods).

### Infrared Flame Sensing

Infrared sensors typically use lead sulfide as the IR sensitive material. Lead sulfide has the property of reducing its internal electric resistance when exposed to infrared light. The effect of this is that the lead sulfide cell acts as a variable resistor that allows more or less current flow proportional to the intensity of the IR radiation impacting the cell.

Infrared detectors respond to infrared radiation, which is over 90% of the radiated energy from a flame. This makes the IR sensor applicable to almost any burner application.

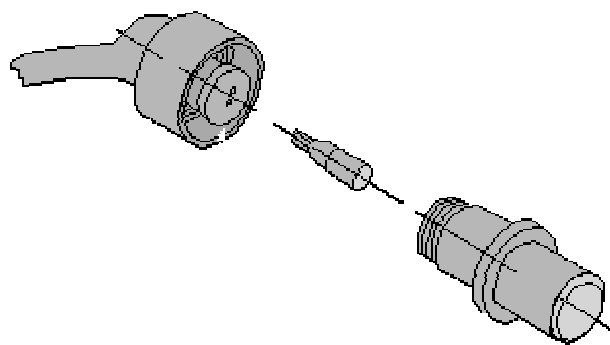
The disadvantage of such a sensor is that it will also react to infrared light emitted from a hot surface such as burner refractory material. This can even be a problem after the hot surface has ceased to visibly glow.

The radiation from a burner flame is rapidly changing, but the refractory absorbs and averages the energy fluctuations. This means radiation from the hot refractory is a much more steady glow than the flicker from the burner flame. The electronic circuitry in an IR scanner amplifier is designed to look for the "flicker," or the variation of intensity of the IR energy. However, the electronic circuitry may react to an apparent flame flicker due to hot gases and particles circulating in front of the sensor, vibration of the sensor and wires, or electrical interference. Every effort should be made to make sure the detector cannot see the hot refractory glow.

### Ultraviolet Flame Sensing

An ultraviolet detector is a tube composed of two electrodes in a quartz glass envelope. Quartz is used because it is more transparent to UV light than glass. The electronic control applies a high DC voltage (in the neighborhood of 400V) across the two electrodes. When struck by UV light, one electrode releases electrons that ionize the gas creating current flow to the other electrode.

The UV radiation in a flame is generally in the first one-third of the flame. UV radiation is about 1% of the total radiated energy in a flame (infrared is 90%). As shown on the facing page, UV sensors have a very narrow spectral response and are unaffected by infrared radiation or sunlight (unlike IR sensors). This makes UV detectors very effective at discriminating between target and background flames. For single burner boilers with Class 3 igniters, the UV scanner should view the area where the pilot flame and the main flame intersect.



*Typical Infrared Scanner Housing, Lead Sulfide Cell, and Sensor Lens Assembly*

A limitation of UV scanners is that the tube can fail in a conductive mode. This tricks the electronics into believing there is a flame present when there actually is not. This condition is referred to as a runaway scanner. For watertube boilers, and firetube boilers not expected to cycle off at least once every 24 hours, a self-checking ultraviolet scanner must be used. Self-checking scanners include a mechanical signal interrupter (shutter) that periodically blocks the sensing tube so that the electronics can detect the runaway condition.

The 5002-01 self-check scanner is directly applicable to NFPA 86- Paragraph A.8.9.2:

"Ultraviolet detectors can fail in such a manner that the loss of flame is not detected. When these detectors are placed in continuous service, failures can be detected by using a self-checking scanner or by periodically testing the detector for proper operation."

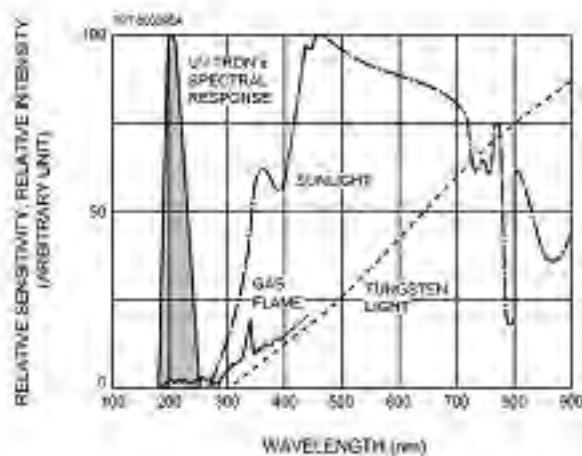
The UV detector has a high output signal, which is easier



*Typical Ultraviolet Tube Assemblies*



## FLAME SAFEGUARD CODE AND APPLICATION



*UV scanners see just a small percentage of the radiative energy of a typical gas or oil flame.*

for an electronic circuit to process. Therefore the distance from burner to electronics can be greater than for flame rods. Also, a magnifying quartz lens can be used to increase the signal strength.

Steam tends to refract ultraviolet light, so UV flame scanners applied to steam atomized oil burners can be problematic. IR scanners are generally recommended for these applications.

A major limitation of UV scanners is the UV tube life, which is limited and scanners must be replaced on a regular basis. Tube life will vary depending on operating and handling conditions. One limiting factor of UV scanner is the short UV tube life. Due to this, scanners must be replaced on a regular basis. Typical life can range from one to four years. The maximum temperature of UV scanners can range from 125° F to 140° F.

### Flame Rectification

High temperatures in a gas or oil flame cause tremendous activity among the gases in the flame. High-energy collisions occur between the molecules that knock electrons out from the molecules causing ionization. When a voltage is placed across the flame, electric current will flow.

The flame rod is actually a metal conductor that is placed in the flame. Current flow is forced from the burner (which is grounded) through the ionized media in the flame, through the flame rod, and back to the electronic flame safeguard circuitry.

If, however, the metal area of the burner that is in contact with the flame is at least four times the area of the flame rod that is in contact with the flame, the current flows more in one direction than the other. This is called flame rectification. The electronic circuitry is set up to look for the DC part of the current flow.

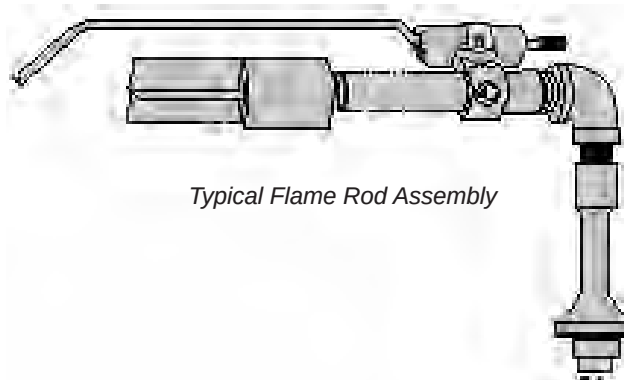
Flame rods have a number of advantages over traditional flame scanners:

- Flame rods and their associated amplifiers are inexpensive.
- Flame rods can withstand very high temperatures—up to 2600°F for the electrode, but only 500°F for the associated insulators.
- Because flame rods require physical contact with the flame, they provide excellent discrimination against other flames and hot refractory.
- Flame rods are easy to troubleshoot and repair.

Flame rods have a number of disadvantages compared to flame scanners that has limited their use in most boiler applications:

- Flame rods can become corroded or dirty and fail to conduct and prove flame.
- Flame rod insulators tend to crack when overheated or exposed to condensation.
- Flame rods are generally considered to be inappropriate for oil-fired burners due to sooting on the flame rod.
- When improperly applied, flame rods can become overheated and bend until they touch the burner and are grounded.

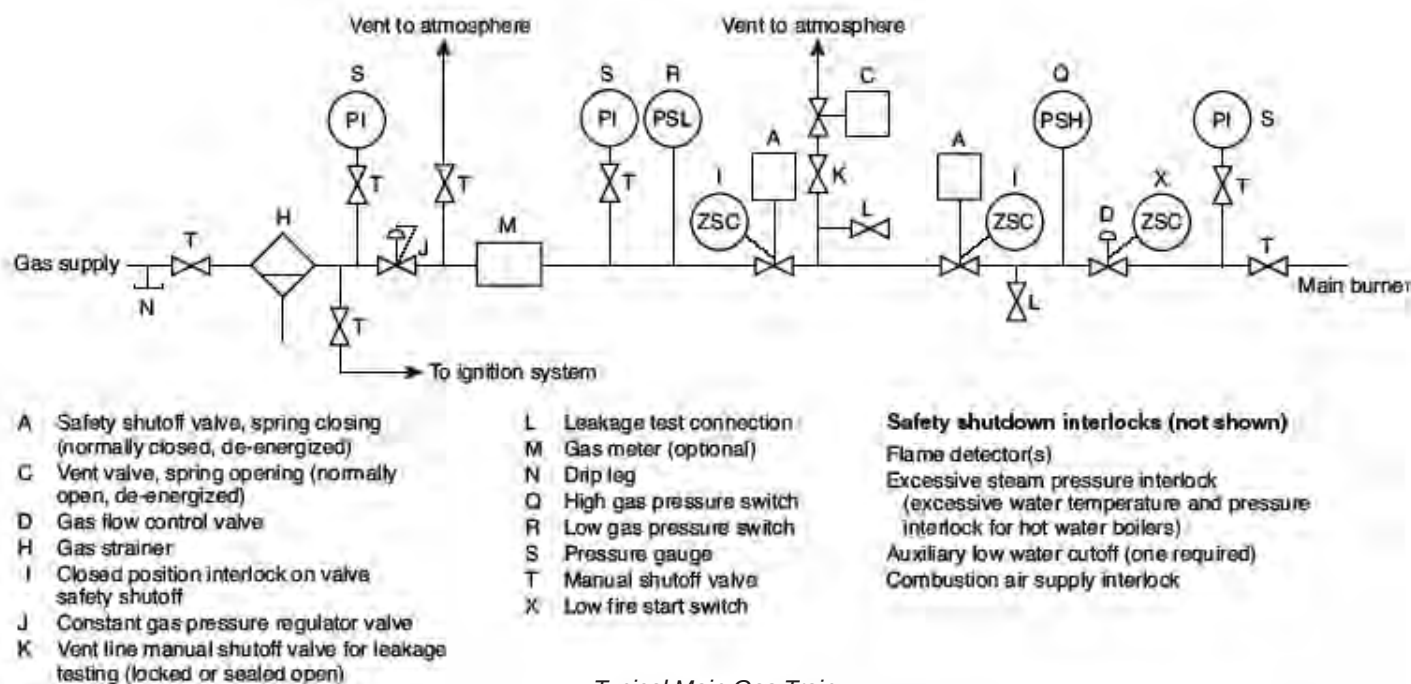
Because of these disadvantages, flame rods are applied mostly to gas-fired equipment, and are more common in process heat applications than boiler applications.



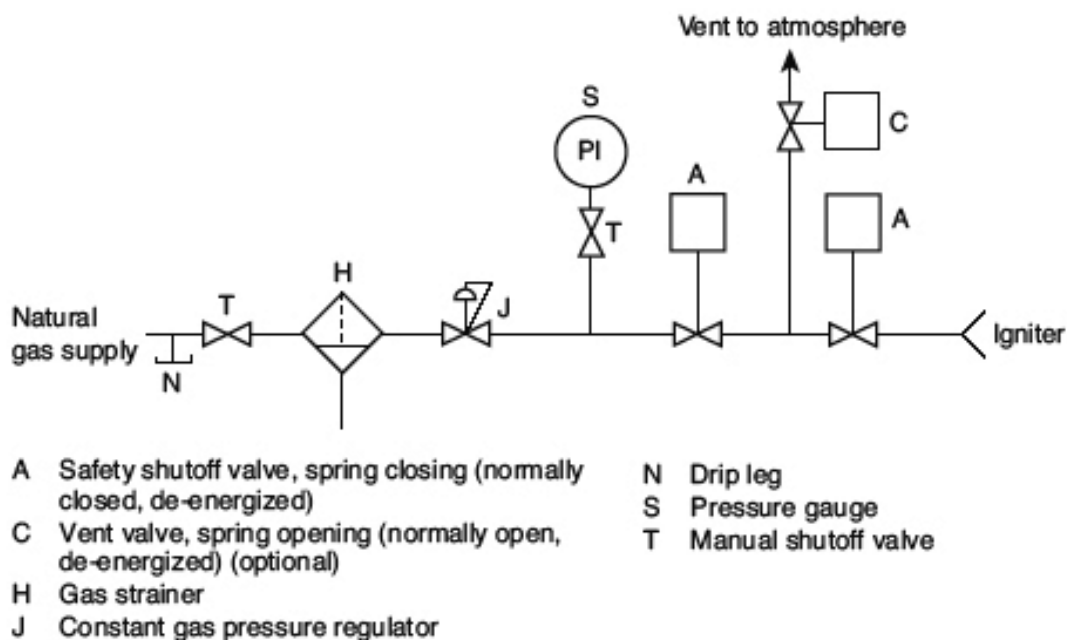
*Typical Flame Rod Assembly*



## TYPICAL BURNER SYSTEM ARRANGEMENTS



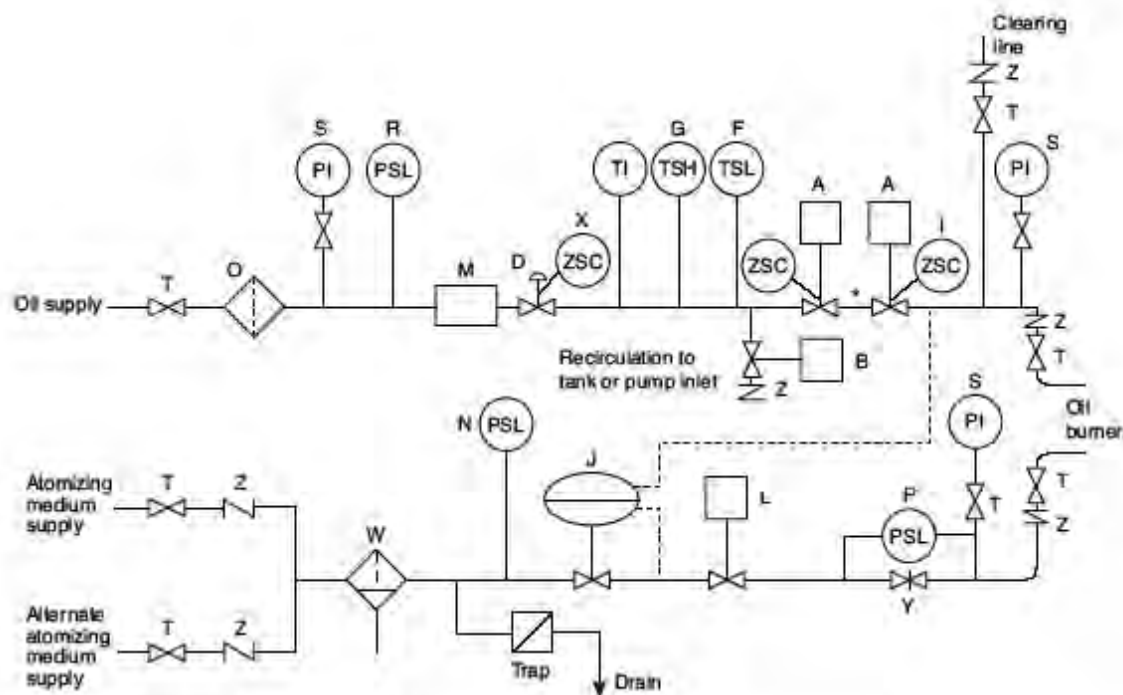
Typical Main Gas Train



Typical Igniter Gas Train

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## TYPICAL BURNER SYSTEM ARRANGEMENTS



\* Caution: Refer to the requirements of 5.3.1.9 and 5.3.1.10.

- |                                                                                               |                                                                                     |                                 |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------|
| A Safety shutoff valve, spring closing (normally closed, de-energized)                        | L Automatic atomizing medium shutoff valve                                          | W Atomizing medium strainer     |
| B Oil recirculation valve atomizing (normally open, de-energized) (optional for unheated oil) | M Oil meter (optional)                                                              | X Low fire start switch         |
| D Oil flow control valve                                                                      | N Low atomizing medium pressure switch                                              | Y Atomizing medium flow orifice |
| F Low oil temperature switch (not applicable for unheated oil)                                | O Oil strainer                                                                      | Z Check valve                   |
| G High oil temperature switch (not applicable for unheated oil)                               | P Atomizing medium flow interlock differential switch, or pressure interlock switch |                                 |
| I Closed position interlock on safety shutoff valve                                           | R Low pressure switch                                                               |                                 |
| J Atomizing medium differential control valve                                                 | S Pressure gauge                                                                    |                                 |
|                                                                                               | T Manual shutoff valve                                                              |                                 |
|                                                                                               | U Oil temperature gauge (optional for unheated oil)                                 |                                 |
- Safety shutdown interlocks (not shown)**  
 Flame detector(s)  
 Excessive steam pressure interlock  
 Auxiliary low water cutoff (one required)  
 Combustion air supply interlock

Typical Main Fuel Oil and Atomizing Steam Train

# FUEL OIL HANDLING SYSTEM DESIGN

## INTRODUCTION

This section is intended to provide insight into the design of fuel oil pumping systems. It is intended to provide only introductory and generic information. For project specific or more detailed engineering support, contact your local PUMC sales office or representative.

This section deals primarily with light fuel oils such as diesel and No. 2 fuel oil, although many of the topics covered are applicable to heavier oils. The design of a light fuel oil transfer system may be broken down into five steps:

1. Determination of required flow rate
2. Determination of maximum inlet suction
3. Determination of required discharge pressure
4. Design of fuel oil piping system
5. Selection of proper control strategy

All of these design tasks are interrelated to some extent, and they all depend on the nature of the application.

### DETERMINATION OF REQUIRED FLOW RATE

The determination of required maximum pumping rate is dependent on the application and the overall piping system, but must be determined as the first step in the design of the entire fuel system. This section treats both day tank systems and burner loops systems, which are different enough to warrant separate discussion.

### Day Tank and Diesel Generator Applications

Day tanks are used for any application where a small gravity head is desirable at the inlet to the generator or burner, and/or it is desirable to have a supply of fuel sufficient for some period of operation without the availability of the remote fuel transfer pumps. Day tanks are used with oil burners, for example, when burners are on the upper floors of a building and the main oil tank is underground. The fuel oil transfer set draws oil from the underground tank and pumps it to the day tank at the burner elevation. The burner mounted pump draws oil from the day tank and returns oil to the day tank. It would not be possible for the burner-mounted pumps in this example to draw oil directly from the underground tank because of the high lift. The use of a vented day tank also ensures that the pressure at the inlet to the burners will not become excessive.

Emergency diesel generators are supplied with day tanks to provide a period of operation without being dependent on the electric pumps in the transfer set to deliver fuel to the engines. In some cases, the injector bypass is piped back to the day tank. In other cases this oil is heated by the engine and must be cooled before it is returned to the day tank. Alternatively, the heated oil is returned to the main tank where it is diluted with cool oil. The recommendations of the engine manufacturer should always be followed with respect to fuel piping and cooling.

## RULES OF THUMB

*As a rule of thumb for sizing generator fuel oil systems, each 100 kW of generator capacity will consume about 7 gallons per hour. Any oil that is pumped to the engine but is not returned to the day tank would add to the generator capacity based requirement.*

If all oil returned by the burner or engine is returned to the day tank, the fuel oil transfer system need only replace the fuel that is burned. The pumps will be sized based on the actual fuel consumption, the desired pump duty cycle, and some safety factor to allow for pump wear and unforeseen contingencies. For example, assume that a generator will consume 25 gallons per hour at full rated load and it is desired that the pumps run only 25 percent of the time. The transfer set should then be equipped with 120 gallon per hour pumps to provide a 20% safety factor on top of the 25% duty factor.

If oil returned by the burner or engine is returned to the main tank, the fuel oil transfer system must be sized to replace all of the oil directed to the engine (or burner) whether it is burned or not. The capacity of the day tank must be increased if the same period of operation must be maintained without depending on

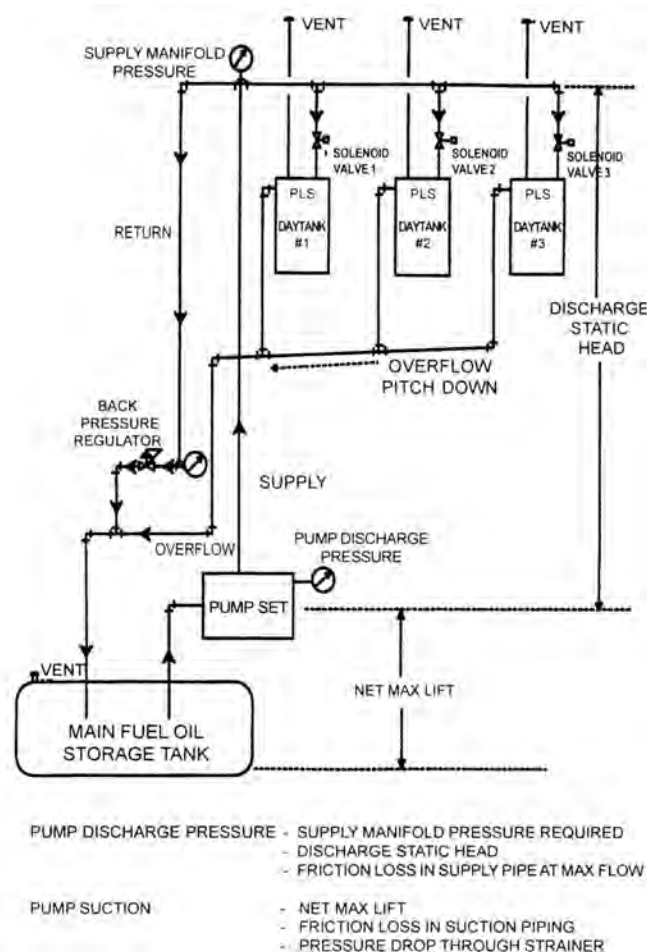


Figure 1  
Multiple Day Tanks



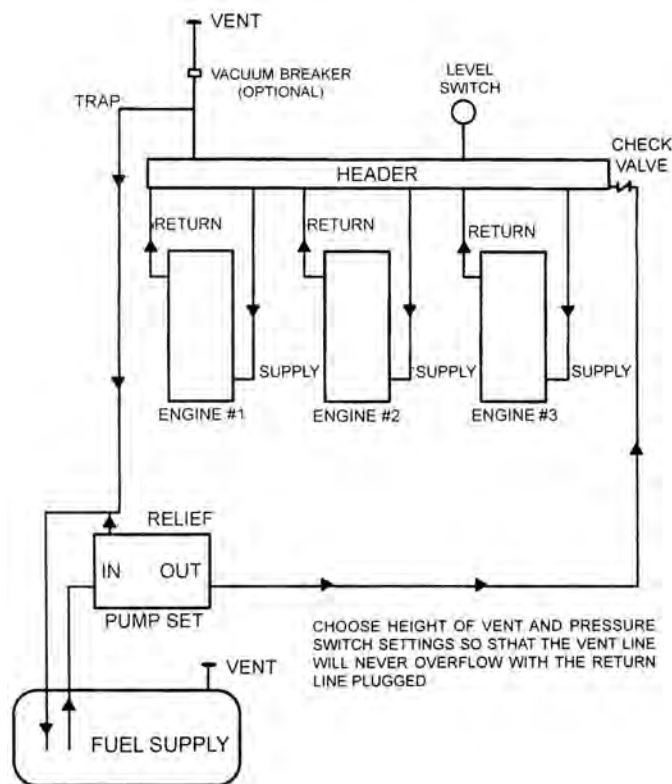
## FUEL OIL HANDLING SYSTEM DESIGN

the operation of the transfer set. If the amount of fuel returned to the main tank is considerable, the installation of an oil cooler in the engine return should be considered. The addition of a cooler will permit the return of oil to the day tank allowing the day tank volume and transfer set capacity to be smaller.

For multiple day tank systems piped (as shown in **Figure 1**), the transfer set would be sized to meet the total requirements of the individual generators as outlined above. The transfer set would only have to be capable of supplying those pieces of equipment that might operate together in a worst-case scenario. The level control system would assume the task of starting a pump and opening the appropriate solenoid valve when any day tank level dropped below the "pump start" setting of the level probe.

### Stand-By Generator "Loop" Systems

It is also possible to design the system shown in Figure 1 with pumps that operate continuously. The pump control portion of the control system would provide for the starting of a back-up pump in the event that flow in the loop was lost. It might also alternate the operation of the pumps on a time-clock basis.



#### Notes on Header Systems:

1. A back pressure regulating valve is added to keep the header full and to prevent oil syphoning out of the header.
2. The level switch is used for pump control. On pressurized header systems a pressure switch can replace the level switch.
3. A check valve prevents oil from flowing back down the fill line.

**Figure 2**  
**Emergency Generator "Loop System"**

A back pressure regulating valve in the loop would provide a constant inlet pressure at the solenoid valves. The tank level control portion of the control system would open and close the appropriate solenoid valves to keep the fuel levels in the individual tanks between the desired limits. It would be good practice to provide a back-up solenoid valve at each tank. This valve would shut off fuel flow into the tank in the event that high level in the day tank or leakage into the rupture basin was detected.

Sometimes it is desirable to allow for the operation of multiple emergency generators without the installation of the day tanks. One strategy that has been applied is to pump the fuel oil to an oversized pipe header above the generators as shown in **Figure 2**. A vent pipe extends to a height equivalent to the gravity head that would exist if the return line was shut off. This vent also serves to allow air to enter the header to compensate for the withdrawal of fuel without replacement by the transfer set. The generators are then able to operate without depending on the operation of the transfer set for some time. Optionally, a vacuum breaker is added to prevent oil from being siphoned out of the header.

The larger the pipe size used for the header, the longer the period the generators can operate without power to the transfer set. In effect, the header becomes the day tank. The pressure switch and vent ensure that the pressure in the header does not rise above the safe working pressure of the engine's fuel handling system.

### Multiple Pumps

When two pumps are used to form a duplex pump set, each pump is selected to provide 100% capacity so that there is complete redundancy. When three or more pumps are used, there are more possible options. Very large pump sets often have three 50% pumps so that any two pumps will provide 100% of the maximum required flow. If the load is reduced, say in a boiler plant in spring or fall, one pump may be adequate and the electrical demand of the system will be reduced. Another strategy for triplex pump sets is to use two 100% pumps and one smaller unit for periods of low flow requirements.

In extremely critical applications, pump sets have been constructed with up to four 100% pumps. In this application, the control system must reliably sequence through the available pumps if a loss of flow is detected. Microprocessor-based or programmable logic controller based operating systems may be used to provide the degree of control sophistication and reliability required by such pumping systems.

### Burner Loop Systems

Generally, the pump set runs continuously so that the entire piping system is continuously primed, and air is kept out of the burners. Any air entering the system is returned to the tank where it can settle out harmlessly.

## FUEL OIL HANDLING SYSTEM DESIGN

The pump set serves to pull oil from the main tank and supply oil to the burners when the burner pumps themselves may be inadequate. This would include cases where the burners are too high above the bottom of the tank or too far away to pull directly. In multiple burner installations, the use of a common fuel oil pump in conjunction with a burner loop system eliminates the need for each burner to be piped individually back to the main tank. To increase reliability, fuel oil pressure or flow switches may be incorporated into the system. Then, an impending loss of oil supply to the burners can be alarmed and corrected before a shutdown occurs. The use of a pump “lead/lag” control will fulfill the requirements if automatic back-up pump operation is specifically required.

In the case of a single oil burner, the selection of the required pumping rate is relatively simple. The pump set must be capable of supplying a greater oil flow into the loop than the maximum oil flow drawn out of the loop by the burner pump. **Figure 3** shows a simplified system with a pump set supplying oil to a single burner. Note that the burner draws from the loop and any excess oil flowing through the loop simply bypasses the burner on its way back to the tank.

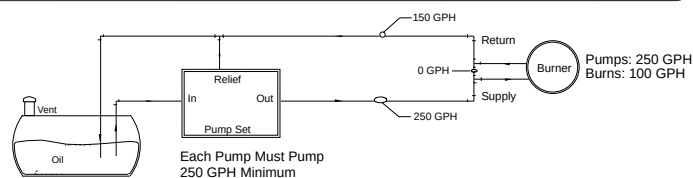
The important piece of information required for sizing the pumps is not the actual firing rate of the burner, but the pumping rate of the burner-mounted pump. It is relatively common for small burners (say 5 gallons per hour maximum firing rate) to have comparatively high pumping rates (up to 70 gallons per hour).

In this case, the pump set would be quite undersized if it was designed based on the traditional “rule of thumb” of twice the burner firing rate.

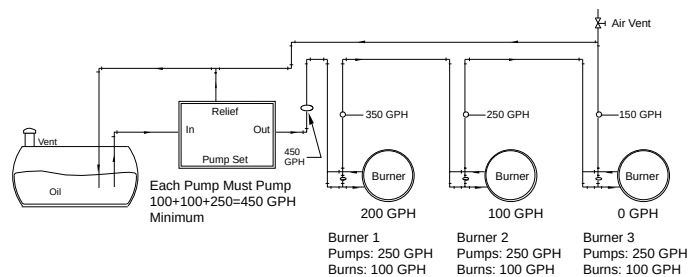
In the example presented in **Figure 3**, an undersized pump set would result in oil flowing backwards in the section of the loop between the supply and return connections on the burner. Any air leaking into the burner-mounted pump would be directed back to the burner supply rather than back to the tank where it would separate from the oil. Good practice dictates that the flow of oil in the loop should be continuous and one-directional from tank suction to tank return.

**Figure 4** shows three burners connected to one loop system. In this case, the absolute minimum flow rate leaving the pump set would be equal to the firing rate of the first and second burners plus the pumping rate of the third burner.

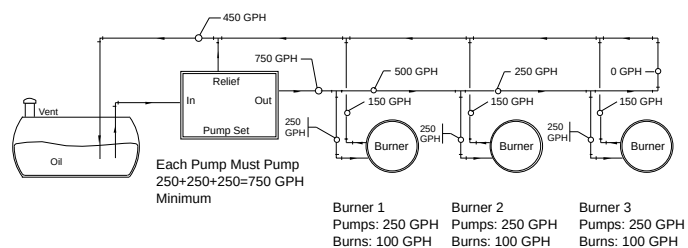
Assume that each burner has a maximum firing rate of 100 gallons per hour, and a pumping rate of 250 gallons per hour. The required minimum pump set capacity would be 100+100+250 gallons per hour. With all burners operating at maximum rate, the flow up to the supply line of the first burner would be 450 gallons per hour. The first burner would pull its pumping rate of 250 gallons per hour from the loop, leaving 200 gph of oil to flow to the second burner. The first burner



**Figure 3**  
**Single Burner**



**Figure 4**  
**Burners Piped in Series**



### Notes on Series vs. Parallel Piped Systems:

1. Traditional series loops have lower flow rates and operate at very low pressures.
2. If oil is heated, heaters are smaller in series loops.
3. Parallel loops may operate at high pressure.
4. Parallel loops are used for pressure atomizing applications without burner-mounted pumps.

**Figure 5**  
**Burners Piped in Parallel**

would burn 100 gph of the 250 gph drawn from the loop and return 150 gph to the loop. This would join with the 200 gph that had bypassed the burner. A total flow of 350 gph would be present just upstream of the supply connection for the second burner. Again, 250 gph would be drawn into the burner and 100 gph would flow past the burner. Of the 250 gph flowing into the burner, 100 gph would be burned and 150 gph would be returned to join the 100 gph that had by-passed the burner. A total of 250 gph would be available at the supply connection of the third burner. The entire 250 gph would enter the burner, there would be no flow bypassing the burner, and 150 gph would be returned to the tank from the third burner.

Of course the pump set, as designed, would have some reserve capacity because the pumps would be selected to have a design capacity exceeding the minimum requirement.



**Figure 5** shows three burners piped in parallel. In this case, the minimum pump set capacity would be equal to the total pumping rate of the three burners. For the burners described above, the pump set would have a minimum capacity of 750 gph. Note: The series system requires a substantially lower pump set capacity than the parallel arrangement.

### Actual Pump Capacity vs. Required Minimum Capacity

Once the theoretical minimum capacity of the pump set has been determined, the actual pump capacity must be chosen. An allowance should be made for pump wear especially with high discharge pressure and/or light fuel grade applications where slippage through a worn pump would pose a problem. A safety factor should also be applied to cover design approximations. The resultant number would then be compared to the available capacities of various pump and motor combinations. That combination with a capacity just greater than that determined above would be selected.

### DETERMINATION OF MAXIMUM INLET SUCTION

While quality fuel oil pumps are often capable of “pulling” 20-inch (mercury) suction, it is good practice to keep the suction at the inlet to the pumps below 15 in. Hg. At higher vacuums (lower absolute pressures) the pumps can cavitate as a result of fuel vaporization and/or the expansion of any air that has been entrained in the fuel. The problem of entrained air will be dealt with later on in this section.

The pressure available to the inlets of the pumps then must be kept above 15 in. Hg. in absolute terms. This pressure consists of the available atmospheric pressure (30 in. Hg. At sea level on an average day) minus the gravity head that must be overcome to get the oil to the pump inlet from the lowest point in the tank and minus the friction losses in the pipe, valves and fittings between the tank and the pump. It is important, of course, to keep all the pressure drop figures in the same units of measure. In this article, inches of mercury are used throughout. Others may have different preferences.

### Gravity Head

A multiplier may be developed to convert inches of oil to inches of mercury by dividing the specific gravity of the oil by the specific gravity of mercury (13.6). For fuel oil with a gravity of 0.85, a multiplier of 0.0625 would result. To lift this oil 12 feet, the available pump inlet pressure would be reduced by 9.0 inches of mercury ((12 feet) times (12 inches per foot) time (0.0625)).

In some cases, priming the system can require higher suctions (or present lower absolute inlet pressures) than normal operation. If the high point of the system is not at the pump inlet, it is imperative that provisions be made to fill the system at the high point. Check and foot valves should also be installed to keep the system primed.

For very large diameter tanks, or tanks buried deeply, it may not be possible to locate the pump set at grade without risking cavitation when the tank is nearly empty. In these instances, the pump set may be placed below grade in a pit. Precautions should be taken to prevent the pit from filling with oil or with ground water in the event of a leak. Drainage from the pit should be piped to a settling tank where oil and water can be separated and disposed of properly.

### Line Losses

Once the flow rate of the pump set has been determined, the suction line may be sized to keep the friction or line losses in the piping to an acceptable level. Bear in mind that pump sizes and motor speeds are not available in continuous spectrum. Usually, the next larger pump and motor combination above the minimum flow requirement will be used. Also, it is good practice in estimating friction losses to use the flow rate produced by the pump set with the minimum expected back pressure at the pump discharge. With thin fluids, the pumps will produce a higher flow at low discharge pressures because slippage diminishes. If a pump is rated 300 GPH at 100 PSIG discharge pressure when pumping #2 fuel oil, it may pump 350 GPH or more with little back pressure. Using the 100 PSIG flow rating when the actual pressure would be only 25 PSIG or so would result in underestimating the suction line friction losses.

Total line losses are comprised of frictional losses in the foot valve, the pipe itself, in fittings such as elbows and tees, in valves and in the suction strainer. These losses may be estimated using line loss tables, or by using computer programs such as the “Oil System Sizing Program,” available from your local PUMC sales representative.

To use any of these methods, it is necessary to know the specific gravity of the fuel as well as the viscosity. Since both the specific gravity and the viscosity of petroleum oils are a function of temperature, it is necessary to correct the values referenced to standard temperatures to those under actual expected flowing temperatures.

Once the flow rates, specific gravity and viscosity are known the pressure drop of the piping system may be determined using appropriate charts or the referenced program.

### Strainer Drop

The pressure drop through the suction strainer may be approximated by using the chart in this section, or using the Preferred “Oil System Sizing Program”. Note that the pressure drops that will be obtained will be for clean strainer baskets. As the strainer becomes clogged with foreign matter, the drop will increase. It is wise to use a 100% safety factor when estimating the strainer loss.

Often the main tank will be far enough away from the pump set such that the friction losses in the suction line are significantly

## FUEL OIL HANDLING SYSTEM DESIGN

larger than the loss through a strainer of the same pipe size. In these cases, it is common to use a suction strainer that is smaller than the suction piping.

### Summary of Suction Line Losses

The net positive pressure available to the inlet of the pump is determined by starting with atmospheric pressure, deducting the static lift from the bottom of the tank to the pump inlet, deducting the line losses at the actual flow rate and viscosity, and deducting the estimated loss through the suction strainer. The result should be comfortably less than 15 inches Hg.

With heated oil, it is important to use the worst case viscosity in any evaluations. This will be a function of the actual fuel purchased as well as the lowest temperature to which the piping will be exposed. For heavy oils and above ground piping, it may be necessary to provide heat tracing or impedance heating of the suction and return piping. In extreme cases, the piping can get so cool that the oil will not flow at all.

### PUMP DISCHARGE PRESSURE REQUIREMENTS

The pressure required at the discharge of the pump set will be the pressure required at the point of use plus the friction losses in the intervening piping, plus any additional gravity head that might need to be overcome. The same methods used for estimating the suction line friction losses and static head equivalents may be used.

In many cases, the gravity head to be overcome presents the largest single component of the pressure requirement. This is especially true when oil-consuming equipment is located near the top of a high-rise building while the pump set is in the basement.

The actual regulation of pressure is best accomplished at or near the point of use with the installation of a back pressure-regulating valve. **Figure 1** illustrates the application of a back pressure-regulating valve to a multiple day tank system. This valve serves to maintain header pressure independent of the amount of returning oil. Pressure, air, and steam atomizing burners may require that relatively high pressures be provided by the pump set if there is no pump on the burner itself. It is important that the proper pressure be provided in the loop and that this pressure be closely regulated with a back pressure regulating valve or pressure regulating valve at the burner. The valve should be sized so that the pressure buildup (in the case of a back pressure valve) or droop (in the case of a pressure regulator) is small.

Day tank systems require that the pressure at the inlet of the level control solenoid valve be sufficient to insure the necessary flow. As an example, assume that a system is to operate with a "valve open duty cycle" of 25%. The pressure and valve Cv combination should be chosen to provide a flow through the solenoid valve of 4 times the design flow rate of fuel from the tank.

### PIPING SYSTEM DESIGN CONSIDERATIONS

In laying out the entire fuel piping system, key issues deserve specific attention. Namely, the possibility of entraining air in the fuel should be eliminated; loss of system prime should be prevented; re-establishment of prime should be quick and easy; back-flows and over-flows should be prevented; and tanks should be properly vented.

### Entrained Air

This is a significant problem when dealing with distillate fuels. The best design approach is to insure that all the fuel piping stays full of fuel at all times. This will involve keeping all returns to tanks submerged, putting back pressure regulating valves at the bottom of vertical runs rather than at the top whenever feasible, and guarding against any suction leaks. Air that has become entrained in distillate fuel takes quite a long time to settle out and can stay in a poorly designed system on a permanent basis. This will cause noisy operation and poor performance of pumps and regulators, short equipment life, and poor performance of the equipment being supplied with the air-filled fuel.

### Provision for Tank Overflow and Tank Venting

These topics go hand in hand. Day tanks should always be equipped with overflow lines that will take excess fuel to a safe location in the event of a component failure. Remember that the vent line must be high enough so that the overflowing oil from the day tank does not just run out the vent. Conversely, an extremely high vent pipe could result in the development of a static pressure within the tank itself that exceeds the design rating. If the day tank is elevated sufficiently above the main tank, it may be necessary to provide an over flow holding tank. This tank would contain any oil spilling from an overfilled day tank or from the rupture basin of a leaking day tank. This fuel would be held until the situation was corrected, and a return to the main tank could be safely monitored.

### PUMP SET CONTROL SYSTEM STRATEGIES

One of the most difficult tasks in designing a completely integrated fuel oil handling system is selecting the control strategy. The control system must integrate the operation of the pump motors, any automatic valves, warning devices, and operator interfaces such as switches and lights.

The purpose of this section is to review the important considerations involved, not to present a complete design manual for control systems. The selection of the most appropriate control strategy for any given fuel oil pumping system involves answering the following questions:

1. Will the pumps be in operation continuously or intermittently?
2. If the pumps are started automatically, what signal will be used to direct this?
3. Is automatic alternation of pump operation desirable?
4. Should the back-up pump be brought on line automatically if needed?

## FUEL OIL HANDLING SYSTEM DESIGN

5. Are there automatic valves to be operated by the control system?
6. What conditions should result in the generation of an alarm signal?
7. What conditions should cause a shutdown of the pumping system?

Unless these questions are answered, it is impossible to design a control system to optimize the performance, safety, and reliability of the fuel handling system. A brief discussion of each of these major topics follows.

### Continuous vs. Intermittent Operation

If the pumps are to be run continuously, automatic start-stop signals are not required. In normal operation, one pump is manually started, and remains in operation until manually stopped. This does not eliminate the requirements for safety shutdown interlocks and automatic back-up pump operation.

Examples of such systems would include burner loop systems where the fuel oil is continuously circulated through the loop and past all the burners. The circulation is generally maintained regardless of burner operation. Similarly, some day tank level control systems rely on the opening and closing of multiple solenoid valves to keep the individual day tanks at the desired fuel levels. It might be desirable to keep oil circulating in a pressurized loop past all the day tanks to make certain that the suction piping cannot lose its prime during long idle periods.

Usually, it is desirable to have the pumps start and stop based on some automatic signal. This should be done only when there is no danger of the suction piping losing its prime during off periods. Many day tank level control systems are designed so that the pumps only operate when one of the tanks requires the addition of fuel. This intermittent operation will minimize wear and tear on the pumps and motors, as well as reduce the average electric energy usage for the facility.

### Automatic Start-Stop Signals

In some cases, the automatic pump start-stop signals are generated within the fuel handling system, and in other cases, they are generated externally. An example of an external start-stop signal is a set of contacts from an emergency generator management system. When a generator is required to operate, these contacts would close, and would be used to start the pump(s). This system could be used in a tankless loop system such as that depicted in **Figure 2**.

Day tank level control systems are examples of instances when pump start-stop signals are generated within the system. In most cases, level switches in the day tank are used to start and stop the pumps. By using separate switches for pump on and pump off, it is possible to minimize the on and off cycling of the pumps. When the level in the tank drops below the "pump on" setting, the pump will start. When the fuel level in the tank rises past the "pump on" switch, the pump continues

to run. It does not shut off until the level reaches the setting of the "pump off" switch. A four switch assembly can be used to provide a high alarm level above the "pump off" switch and a low alarm level below the "pump on" switch.

Multiple day tank level control systems may be designed with a constantly pressurized header feeding the individual solenoid-operated fill valves at each tank. The automatic signal to operate the pumps would come from a pressure switch (with dead band) at the top of the header. This system is similar to a domestic well water based system. An accumulator tank is used to provide an air cushion. Then the pumps will only have to start after a certain volume of fuel (the "draw-down") has been drawn out of the accumulator tank.

### Automatic Pump Alternation

When pumps are started and stopped remotely, it is desirable to alternate the operation of the pumps. This way, run time is spread equally between the available units. Also, if one unit should fail to operate, the pump that handled the "last call" for operation would be available as a back-up. If only one pump is run routinely, the back-up pump could freeze up, develop a leak, or be manually taken out of service and would not be available when required.

With duplex pump sets, a selector switch is used to select "Pump 1", "Pump 2" or automatic "Alternation". With more than two pumps, relay or microprocessor logic can be used to sequence the pumps whenever a start signal is received.

### Back-Up Pump Operation

The back-up pump(s) may be brought on line either manually or automatically as required. Generally it is desirable for this to happen automatically, and this function is often handled by the same logic that alternates the operation of the lead pump. This logic is referred to as "lead/lag" logic, and the pump that is normally in operation is referred to as the "lead" pump. The pump that would normally be the back-up pump is called the "lag" pump. When there are more than two pumps, the lag pumps are referred to as "first lag", "second lag", etc. The "first lag" pump is the back-up pump that will start first if the lead pump does not function properly.

The signal to start the back-up pump generally comes from within the fuel system since it must respond to a failure of the primary pump. It is important to select a device that will reliably discriminate between the proper operation and a failure of the lead pump. If the oil is being circulated in a loop without any back pressure device, there might not be sufficient pressure at the pump discharge to indicate whether or not a pump is operating properly. If the pumps are being used to circulate oil within a loop, a flow switch might be used to detect loss of flow in the system. When the level in a tank is being controlled, the low level switch in the tank would indicate whether or not the lead pump is performing properly. For a system maintaining a header pressurized, a pressure sensor could be used to

## FUEL OIL HANDLING SYSTEM DESIGN

control the operation of a back-up pump.

When required, additional logic can be provided so that only one pump at a time is allowed to operate. When a lead pump failure is detected, the lead pump is de-energized and the first lag pump is then energized, and so on.

When the pumps have to be operated from emergency power, this sort of sequencing can be useful for minimizing the instantaneous total connected motor horsepower on the emergency circuit.

### Automatic Valves

When one fuel oil pump set is used to maintain the level in multiple day tanks, automatic valves are required to isolate the tanks from one another. This assures that when the pumps operate, only those tanks that require fuel receive fuel. The control system is designed so that the level switch in the tank operates the fill valve. If the pumps were to run intermittently, the opening of any fill valve would trigger the starting of a pump. A second valve might be installed in the fill line to each tank, and controlled by the high level switch in the tank. If the main fill valve was to leak fuel into the tank, the back-up valve would then be closed preventing an overflow condition.

Another application of automatic valves in fuel oil handling systems is for main storage tank selection. Control logic can be provided to sense a nearly empty main tank, and to open the supply and return valves for the next tank in sequence. When these valves are proven open, the supply and return valves for the emptied tank close, isolating it from service.

### Alarm Signals

A properly designed control system will provide sufficient information to the operating personnel to make intelligent decisions regarding the operation and maintenance of the fuel oil handling system. Some of the more common malfunction alarms are discussed here.

The control system should alert the operator if the "lag" pump is needed. Usually, a memory circuit is required so that this alarm does not clear itself when the "lag" pump starts. For example, if the "lag" pump is started because the pump set flow was interrupted, this flow would be re-established once the lag pump was operating. The memory circuit would keep the alarm light on until it was manually cleared so that the operators were made aware that a problem had occurred. Similarly, high level in a tank would correct itself as the fuel was used. A manual reset memory circuit would be used to retain the information that a high level condition had existed.

Other alarm conditions might include high discharge pressure (indication of a restriction in the piping system, or a valve inadvertently closed) or low discharge pressure. Flow through an overflow pipe might indicate a failure of the pump "off" and high level alarm circuitry, or a manual bypass valve left

open or leaking. Build up of fuel in the day tank rupture basin would indicate a leak in the tank or connecting piping. By including a tank gauging system for the main storage tanks in the control system, the entire fuel system can be controlled from a central location and monitored for high and low levels, leaks and losses.

### Pump System Safety Shutdown

Some of the alarm conditions listed above might be reason to shut down the fuel system. The detection of leaking tanks or piping is generally used as an automatic safety shutdown signal. When tank overflow must be collected in an "overflow catch basin" or tank, the system should be shut down when that tank or basin nears capacity. Depending on the nature of the installation, the detection of high level in a day tank might be cause to shut the system down. This is especially true when a pump set serves only one tank. Each system is unique, and the control strategy will be different from one job to another. The need for reliability, safety, and automatic operation must be evaluated on a job by job basis.

### CONCLUSION

Many variables impact the design of a fuel pumping system and associated control logic. While the foregoing discussion is an attempt to highlight many of the major topics, it was not possible in this short article to touch on all of the unique problems and solutions that we have encountered in the past. Preferred Utilities Manufacturing Corp. has built thousands of custom designed fuel oil systems over the past half century and the variations continue. We stand ready to work with each customer to select the most appropriate fuel handling strategy for each job. If you have any questions, please do not hesitate to contact your nearest Preferred sales office or representative.

#### Unit Conversion

| Pressure          |        | Head            |  |
|-------------------|--------|-----------------|--|
| 1 PSI             | = 2.31 | ft of water     |  |
| 1 PSI             | = 2.60 | ft of No. 2 oil |  |
| Vacuum            |        | Head            |  |
| 1" Hg             | = 1.28 | ft of No. 2 oil |  |
| Head              |        | Vacuum          |  |
| 1 ft of No. 2 oil | = 0.78 | Inches Hg       |  |
| Head              |        | Pressure        |  |
| 1 ft of No. 2 oil | = 0.38 | PSI             |  |

#### RULES OF THUMB

| Head              |     | Vacuum    |  |
|-------------------|-----|-----------|--|
| 4 ft of No. 2 oil | ≈ 3 | Inches Hg |  |
| Head              |     | Pressure  |  |
| 5 ft of No. 2 oil | ≈ 2 | PSI       |  |
| 7 ft of Water     | ≈ 3 | PSI       |  |



## FUEL OIL HANDLING SYSTEM DATA

### Pressure Gauge Terminology

| "Pressure Gauge" Name: | "Compound" | "Gauge" | "Absolute" | "Gauge"   | "Absolute" | "Gauge"                 |
|------------------------|------------|---------|------------|-----------|------------|-------------------------|
| Units                  | PSI        | PSI     | PSIa       | Inches Hg | Inches Hg  | Inches H <sub>2</sub> O |
|                        | 20         | 20      | 34.7       | 40.72     | 70.649     | 554.2                   |
|                        | 19         | 19      | 33.7       | 38.684    | 68.613     | 526.49                  |
|                        | 18         | 18      | 32.7       | 36.648    | 66.577     | 498.78                  |
|                        | 17         | 17      | 31.7       | 34.612    | 64.541     | 471.07                  |
|                        | 16         | 16      | 30.7       | 32.576    | 62.505     | 443.36                  |
|                        | 15         | 15      | 29.7       | 30.54     | 60.469     | 415.65                  |
|                        | 14         | 14      | 28.7       | 28.504    | 58.433     | 387.94                  |
|                        | 13         | 13      | 27.7       | 26.468    | 56.397     | 360.23                  |
|                        | 12         | 12      | 26.7       | 24.432    | 54.361     | 332.52                  |
|                        | 11         | 11      | 25.7       | 22.396    | 52.325     | 304.81                  |
|                        | 10         | 10      | 24.7       | 20.36     | 50.289     | 277.1                   |
|                        | 9          | 9       | 23.7       | 18.324    | 48.253     | 249.39                  |
|                        | 8          | 8       | 22.7       | 16.288    | 46.217     | 221.68                  |
|                        | 7          | 7       | 21.7       | 14.252    | 44.181     | 193.97                  |
|                        | 6          | 6       | 20.7       | 12.216    | 42.145     | 166.26                  |
|                        | 5          | 5       | 19.7       | 10.18     | 40.109     | 138.55                  |
|                        | 4          | 4       | 18.7       | 8.144     | 38.073     | 110.84                  |
|                        | 3          | 3       | 17.7       | 6.108     | 36.037     | 83.13                   |
|                        | 2          | 2       | 16.7       | 4.072     | 34.001     | 55.42                   |
|                        | 1          | 1       | 15.7       | 2.036     | 31.965     | 27.71                   |
| Atmospheric            | 0          | 0       | 14.7       | 0         | 29.92      | 0                       |
|                        | 2          | -0.982  | 13.718     | -2        | 27.929     | -27.22                  |
|                        | 4          | -1.965  | 12.735     | -4        | 25.929     | -54.44                  |
|                        | 6          | -2.947  | 11.753     | -6        | 23.929     | -81.66                  |
|                        | 8          | -3.929  | 10.771     | -8        | 21.929     | -108.9                  |
|                        | 10         | -4.912  | 9.7884     | -10       | 19.929     | -136.1                  |
|                        | 12         | -5.894  | 8.8061     | -12       | 17.929     | -163.3                  |
|                        | 14         | -6.876  | 7.8238     | -14       | 15.929     | -190.5                  |
|                        | 16         | -7.859  | 6.8415     | -16       | 13.929     | -217.8                  |
|                        | 18         | -8.841  | 5.8591     | -18       | 11.929     | -245                    |
|                        | 20         | -9.823  | 4.8768     | -20       | 9.9292     | -272.2                  |
|                        | 22         | -10.81  | 3.8945     | -22       | 7.9292     | -299.4                  |
|                        | 24         | -11.79  | 2.9122     | -24       | 5.9292     | -326.6                  |
|                        | 26         | -12.77  | 1.9299     | -26       | 3.9292     | -353.9                  |
|                        | 28         | -13.75  | 0.9475     | -28       | 1.9292     | -381.1                  |
| Outer Space Vacuum     | 29.92      | -14.7   | 0          | -29.92    | 0          | -407.2                  |

**Traditional  
Compound  
Pressure  
Gauge**

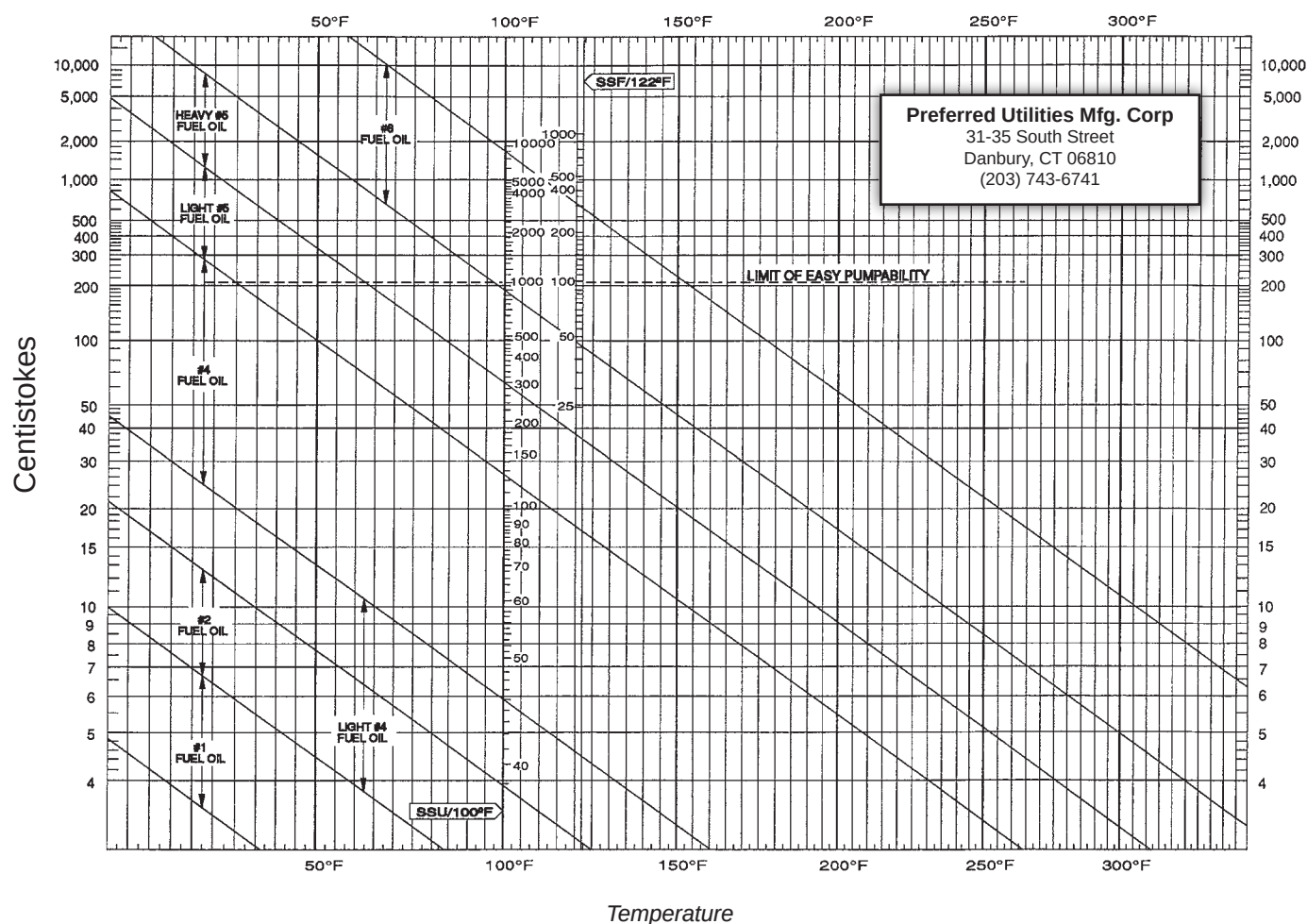
Reading is  
Relative to  
Local  
Atmosphere

Reading is  
Relative to  
Outer Space  
Vacuum



## FUEL OIL HANDLING SYSTEM DATA

### Typical Fuel Oil Temperature-Viscosity Curves



The above chart should be used as a guide to determine the proper or minimum temperature to be maintained in oil storage tanks and pipe lines to ensure reliable oil pumping. It can also be used for establishing the required fuel temperature to maintain fuel oil viscosity at the level prescribed by the burner manufacturer.

When using the chart for determining the proper oil temperature for atomization, the operator should obtain from his fuel oil supplier (or by an independent laboratory analysis) the viscosity of the fuel expressed in Centistokes, Saybolt Seconds Universal (SSU) or Saybolt Seconds Furol units. (NOTE: All are expressed referenced to a specific temperature) With this information, the application-specific fuel oil "viscosity vs. temperature" line can be drawn by

plotting the one point provided by the oil supplier and drawing a line through it which is parallel to the others on the graph. At the point where this diagonal line crosses the horizontal line marked with the burner manufacturer's recommended viscosity, read vertically down and note the proper temperature at which this oil should be burned.

When using the chart as a basis for the design of storage tank and piping layouts, a similar minimum temperature can be determined by reading vertically down from that point where the diagonal line crosses the horizontal line marked "Limit of Easy Pumpability." For example, a fuel oil having a viscosity of 30 Centistokes at 154° F should be kept in storage and in the pipe lines at a minimum temperature of 99.5° F to assure reliable pumping of the fuel.

## FUEL OIL HANDLING SYSTEM DATA

### Characteristics of Typical Fuel Oils

| Grade of Fuel Oil        | No. 1          | No. 2          | No. 4 Light    | No. 4 Heavy    | No. 5 Light    | No. 5 Heavy    | No. 6          |
|--------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Percent by Weight        |                |                |                |                |                |                |                |
| Sulphur                  | 0.01 to 0.5    | 0.05 to 1.0    | 0.2 to 2.0     | 0.2 to 2.0     | 0.5 to 3.0     | 0.5 to 3.0     | 0.7 to 3.5     |
| Hydrogen                 | 13.3 to 14.1   | 11.8 to 13.9   | 10.6 to 13.0   | 10.6 to 13.0   | 10.5 to 12.0   | 10.5 to 12.0   | 9.5 to 12      |
| Carbon                   | 85.9 to 86.7   | 86.1 to 88.2   | 86.5 to 89.2   | 86.5 to 89.2   | 86.5 to 89.2   | 86.5 to 89.2   | 86.5 to 90.2   |
| Nitrogen                 | 0.0 to 0.1     | 0.0 to 0.1     | ---            | ---            | ---            | ---            | 0.0 to 0.5     |
| Oxygen                   | ---            | ---            | ---            | ---            | ---            | ---            | 0.0 to 1.5     |
| Ash                      | ---            | ---            | 0.0 to 0.1     | 0.0 to 0.1     | 0.0 to 0.1     | 0.0 to 0.1     | 0.0 to 0.5     |
| Gravity                  |                |                |                |                |                |                |                |
| Degrees API              | 40 to 44       | 30 to 40       | 25 to 30       | 20 to 28       | 17 to 22       | 14 to 18       | 8 to 15        |
| Specific Gravity @ 60° F | 0.825 to 0.806 | 0.887 to 0.825 | .904 to .876   | .934 to .887   | .953 to .922   | .972 to .947   | 1.014 to .9659 |
| lb/gal at 60° F          | 6.87 to 6.71   | 7.39 to 6.87   | 7.529 to 7.296 | 7.778 to 7.387 | 7.935 to 7.676 | 8.099 to 7.882 | 8.448 to 8.043 |
| Pour Point, °F           | 0 to -50       | 0 to -40       | -10 to +30     | -10 to +50     | -10 to +50     | -10 to +80     | +15 to +85     |
| Viscosity                |                |                |                |                |                |                |                |
| Centistokes at 104° F    | 1.3 to 2.1     | 1.9 to 3.4     | 1.9 to 5.5     | 5.0 to 24.0    | 24.0 to 58.0   | 58.0 to 168.0  | 260 to 750     |
| SSU at 100° F            | ---            | 32.6 to 37.9   | 32.6 to 45.0   | 45 to 125      | 125 to 300     | 300 to 900     | 900 to 9000    |
| SSF at 122° F            | ---            | ---            | ---            | ---            | ---            | 23 to 40       | 45 to 300      |
| BS&W                     | ---            | 0.0 to 0.1     | 0.01 to 1.0    | 0.01 to 1.0    | 0.05 to 1.0    | 0.05 to 1.0    | 0.05 to 2.0    |
| (% by vol)               |                |                |                |                |                |                |                |
| HHV, Btu/gal, calculated |                |                |                |                |                |                |                |
| Max.                     | 137,000        | 141,800        | 145,000        | 148,100        | 150,000        | 152,000        | 155,900        |
| Min.                     | 132,900        | 135,800        | 143,100        | 145,000        | 146,800        | 149,400        | 151,300        |

**Grade of Fuel Oil:** The American Society for Testing and Materials (ASTM) has standardized on five basic grades, designated as Nos. 1, 2, 4, 5, and 6. Grades Nos. 4 and 5 are subdivided into light and heavy. The oil's viscosity determines into which subdivision it is classed.

**Percent by Weight:** The fuel's elements are expressed as a percentage of the fuel's total weight.

**Gravity:** The unit weight of a liquid in lbs. per gallon is the density of that liquid. The ratio of unit weight, or density of any liquid to the density of water is the Specific Gravity (SG) of that liquid. The density of water at 60° F is 8.328 lbs. The oil industry uses the API Gravity or "Gravity" scale. The relationship between API Gravity and specific gravity is as follows:

$$\text{Degrees API Gravity} = (141.5 \div \text{SG at } 60^\circ \text{ F}) - 131.5.$$

Thus, an oil with a specific gravity of 1.0 would have an API Gravity of  $(141.5 \div 1.0) - 131.5 = 10.0$  degrees API.

**Pour Point:** The Pour Point temperature is 5° F above the point where the oil congeals into a semi-fluid or a solid.

**Viscosity:** Viscosity is the measure of the oil's resistance to flow, or simply expressed as its "thickness" or "thinness." Kinematic Viscosity is usually given in terms of Centistokes, SSU (Saybolt Seconds Universal at 100° F) or SSF (Saybolt

Seconds Furol at 122° F). Absolute viscosity is given in terms of Centipoises and can be used to calculate Kinematic Viscosity as follows:

$$\text{Kinematic viscosity (centistokes)} = \text{Absolute viscosity (centipoises)} \div \text{specific gravity (SG)}$$

**AND**

$$\text{Kinematic viscosity (SSU)} = \text{Kinematic viscosity (centistokes)} \times 4.6347$$

**OR**

$$\text{Kinematic viscosity (SSF)} = \text{Kinematic viscosity (centistokes)} \times 0.4717$$

**BS&W or Bottom Sediments and Water:** BS&W are non-petroleum contaminates sometimes found in fuel oils. Some of the problems that can be associated with high levels of BS&W are erratic and unsteady combustion, sparking and spitting of the flame, flashback, plugging of burner tips and screens, loss of heat release and/or erosion of burner tips and mechanical parts.

**Higher Heating Value (HHV):** The HHV is the total heat content of a given measure of fuel including the latent heat of evaporation of the water vapor formed during combustion. The Lower Heating Value (LHV) assumes that the latent heat is not recovered because the water vapor is not condensed. When performing calculations for combustion or appliance sizing, always use the HHV.

## FUEL OIL HANDLING SYSTEM DATA

### Typical Fuel Oil Temperature-Viscosity Curves

Due to the thermal expansion and contraction of petroleum products, all are purchased and sold based on their volume at 60° F. Therefore, all petroleum products are corrected to this temperature by using a "correction factor". This factor converts quantities of oil at different temperatures to a comparable volume at a standard temperature.

When mechanical flow meters or differential pressure type flow elements are used for determining usage or for efficiency calculations, the reading must be temperature compensated to provide an accurate reading.

To convert gross gallons at the loading and unloading temperature to net gallons at 60° F, the temperature, the API Gravity of the oil and the coefficient of expansion factor must be known. A "rough approximation" of net gallons can be obtained from the equation provided. For a more precise conversion consult the factory or the "Manual of Petroleum Measurement Standards" jointly issued by the American Society for Testing and Materials, the American Petroleum Institute and the Institute of Petroleum. Included in these Standards are Table 5B (Correction of Observed API Gravity to API Gravity at 60° F) and Table 6B (Correction of Volume to 60° F against API Gravity at 60° F). Table 5B is used

to correct the observed gravity and temperature to the gravity at 60° F. Table 6B is used to obtain the coefficient of expansion factor from the observed gravity, temperature, and is used to convert gross to net gallons.

"Rough Approximation" Method:

$$\text{Correction Factor} = 1 - (\Delta T \times \text{Multiplier})$$

| Oil API          | Multiplier |
|------------------|------------|
| 0° to 14.9° API  | 0.00035    |
| 15° to 34.9° API | 0.0004     |
| 35° to 50.9° API | 0.0005     |

#### Example:

Oil having 17° API is clocked through a positive displacement meter at 565 GPH. The oil is 190° F at the meter. Find the corrected (i.e. 60° F) volumetric flow.

$$190 - 60 = 130^\circ \Delta T$$

$$\text{Correction Factor} = 1 - (130 \times 0.0004) = 0.9480$$

$$\text{Corrected Volumetric Flow} = 565 \times 0.9480$$

$$= 535.62 \text{ GPH}$$

### Energy Required To Heat No. 6 Oil

#### Electric

$$\text{Watts} = 1.25 \times \text{GPH} \times \Delta T (^\circ\text{F})$$

$$\text{Amps (single phase)} = \frac{\text{watts}}{\text{volts}}$$

$$\text{Amps (three phase)} = \frac{\text{watts}}{\text{volts} \times 1.73}$$

#### Example:

To heat 600 GPH of No. 6 oil from 90° F (32° C) to 150° F (65.5° C):

$$\Delta T = 60^\circ \text{ F (15.5}^\circ \text{ C)}$$

$$\text{Watts} = 1.25 \times 600 \times 60 = 45,000$$

$$\text{kW} = 45$$

$$\text{Amps at } 460/3/60 = 56.5$$

#### Steam

$$\text{lbs/hr steam} = \frac{\text{lbs/hr oil} \times \Delta T}{1920} \quad (\text{No. 6 oil \& 5 PSI steam})$$

$$= \frac{\text{GPH} \times \text{lb/gal} \times \Delta T}{1920}$$

#### Example:

To heat 600 GPH of No. 6 oil from 90° F (32° C) to 150° F (65.5° C):

$$\text{lbs/hr steam} = \frac{600 \times 8 \times 60}{1920} = 150$$

## FUEL OIL HANDLING SYSTEM DATA

Simplex Strainer Model No. 125

Approximate Strainer Pressure Drops in Inches of Mercury

(1" Hg = 0.49 PSI = 13.622" H<sub>2</sub>O)

No. 2 Fuel Oil  
(with clean 40 mesh baskets)

| FLOW<br>GPH | ½"   | ¾"    | 1"    | 1 ¼" | 1 ½"  | 2"    |
|-------------|------|-------|-------|------|-------|-------|
| 25          | ***  | ***   | ***   | ***  | ***   | ***   |
| 45          | ***  | ***   | ***   | ***  | ***   | ***   |
| 90          | 0.02 | ***   | ***   | ***  | ***   | ***   |
| 160         | 0.08 | 0.08  | 0.02  | ***  | ***   | ***   |
| 350         | 0.43 | 0.43  | 0.14  | 0.04 | 0.04  | ***   |
| 700         | 1.69 | 1.69  | 0.57  | 0.18 | 0.18  | 0.06  |
| 1100        | 4.17 | 4.19  | 1.43  | 0.45 | 0.45  | 0.16  |
| 1900        | xxx  | 12.50 | 4.26  | 1.32 | 1.32  | 0.51  |
| 3000        | xxx  | xxx   | 10.61 | 3.30 | 3.30  | 1.24  |
| 5000        | xxx  | xxx   | xxx   | 9.18 | 9.18  | 3.46  |
| 7500        | xxx  | xxx   | xxx   | xxx  | 20.65 | 7.80  |
| 10000       | xxx  | xxx   | xxx   | xxx  | xxx   | 13.84 |

No. 6 Fuel Oil at 5000 SSU  
(with clean 3/64" perforated baskets)

| FLOW<br>GPH | ½"   | ¾"    | 1"    | 1 ¼"  | 1 ½"  | 2"    |
|-------------|------|-------|-------|-------|-------|-------|
| 25          | ***  | ***   | ***   | ***   | ***   | ***   |
| 45          | ***  | ***   | ***   | ***   | ***   | ***   |
| 90          | 0.04 | ***   | ***   | ***   | ***   | ***   |
| 160         | 0.18 | 0.18  | 0.04  | ***   | ***   | ***   |
| 350         | 0.76 | 0.76  | 0.27  | 0.09  | ***   | ***   |
| 700         | 3.09 | 3.09  | 1.08  | 0.31  | 0.31  | ***   |
| 1100        | 7.66 | 7.66  | 2.60  | 0.81  | 0.81  | 0.31  |
| 1900        | xxx  | 22.93 | 7.79  | 2.42  | 2.42  | 0.90  |
| 3000        | xxx  | xxx   | 19.44 | 6.05  | 6.05  | 2.28  |
| 5000        | xxx  | xxx   | xxx   | 16.84 | 16.84 | 6.36  |
| 7500        | xxx  | xxx   | xxx   | xxx   | xxx   | 14.29 |
| 10000       | xxx  | xxx   | xxx   | xxx   | xxx   | xxx   |

\*\*\* Indicates insignificant pressure loss

xxx Indicates excessive pressure loss

## FUEL OIL HANDLING SYSTEM DATA

Duplex Strainer Model No. 72

Approximate Strainer Pressure Drops in Inches of Mercury

(1" Hg = 0.49 PSI = 13.622" H<sub>2</sub>O)

No. 2 Fuel Oil  
(with clean 40 mesh baskets)

| FLOW<br>GPH | ¾"  | 1"  | 1 ¼" | 1 ½" | 2"   | 2 ½" | 3"  | 4"  | 5"  | 6"  |
|-------------|-----|-----|------|------|------|------|-----|-----|-----|-----|
| 25          | *** | *** | ***  | ***  | ***  | ***  | *** | *** | *** | *** |
| 45          | *** | *** | ***  | ***  | ***  | ***  | *** | *** | *** | *** |
| 90          | *** | *** | ***  | ***  | ***  | ***  | *** | *** | *** | *** |
| 160         | 0.1 | 0.1 | ***  | ***  | ***  | ***  | *** | *** | *** | *** |
| 350         | 0.4 | 0.3 | 0.2  | 0.1  | ***  | ***  | *** | *** | *** | *** |
| 700         | 2   | 1.8 | 0.8  | 0.5  | 0.15 | ***  | *** | *** | *** | *** |
| 1100        | 4.2 | 4   | 1.8  | 1.2  | 0.4  | 0.2  | *** | *** | *** | *** |
| 1900        | xxx | 12  | 5    | 3.2  | 1.6  | 0.4  | 0.2 | *** | *** | *** |
| 3000        | xxx | xxx | 12   | 7.6  | 2.5  | 1.1  | 0.5 | 0.2 | *** | *** |
| 5000        | xxx | xxx | xxx  | xxx  | 7.2  | 3    | 1.5 | 0.4 | 0.2 | *** |
| 7500        | xxx | xxx | xxx  | xxx  | xxx  | 6    | 3   | 0.9 | 0.4 | 0.2 |
| 10000       | xxx | xxx | xxx  | xxx  | xxx  | 10.4 | 5   | 1.5 | 0.7 | 0.3 |

No. 6 Fuel Oil at 5,000 SSU  
(with clean 3/64" perforated baskets)

| FLOW<br>GPH | ¾"  | 1"  | 1 ¼" | 1 ½" | 2"   | 2 ½" | 3"   | 4"  | 5"  | 6"  |
|-------------|-----|-----|------|------|------|------|------|-----|-----|-----|
| 25          | *** | *** | ***  | ***  | ***  | ***  | ***  | *** | *** | *** |
| 45          | *** | *** | ***  | ***  | ***  | ***  | ***  | *** | *** | *** |
| 90          | 0.1 | 0.1 | ***  | ***  | ***  | ***  | ***  | *** | *** | *** |
| 160         | 0.4 | 0.3 | 0.1  | ***  | ***  | ***  | ***  | *** | *** | *** |
| 350         | 1.3 | 1.2 | 0.5  | 0.3  | 0.1  | ***  | ***  | *** | *** | *** |
| 700         | 4.2 | 4   | 1.7  | 1.1  | 0.4  | ***  | ***  | *** | *** | *** |
| 1100        | xxx | 9.5 | 4    | 2.5  | 0.8  | 0.4  | 0.2  | *** | *** | *** |
| 1900        | xxx | xxx | 11.4 | 7.1  | 2.4  | 1.1  | 0.5  | 0.2 | *** | *** |
| 3000        | xxx | xxx | xxx  | 16.3 | 5.5  | 2.4  | 1.1  | 0.4 | *** | *** |
| 5000        | xxx | xxx | xxx  | xxx  | 15.3 | 6.6  | 3.3  | 1   | 0.4 | 0.2 |
| 7500        | xxx | xxx | xxx  | xxx  | xxx  | 13.9 | 6.5  | 2   | 0.9 | 0.4 |
| 10000       | xxx | xxx | xxx  | xxx  | xxx  | xxx  | 11.2 | 3.5 | 1.5 | 0.8 |

\*\*\* Indicates insignificant pressure loss

xxx Indicates excessive pressure loss



## FUEL OIL HANDLING SYSTEM DATA

Contents of Horizontal Cylindrical Tanks

Percent of Total Volume Filled vs. Percent of Liquid Depth

| Depth % | Gallons % | Depth % | Gallons % | Depth % | Gallons % | Depth % | Gallons % |
|---------|-----------|---------|-----------|---------|-----------|---------|-----------|
| 0       | 0.00      | 25      | 19.6      | 50      | 50.0      | 76      | 81.5      |
| 1       | 0.2       | 26      | 20.7      | 51      | 51.3      | 77      | 82.6      |
| 2       | 0.5       | 27      | 21.8      | 52      | 52.5      | 78      | 83.7      |
| 3       | 0.9       | 28      | 22.9      | 53      | 53.8      | 79      | 84.7      |
| 4       | 1.3       | 29      | 24.1      | 54      | 55.1      | 80      | 85.8      |
| 5       | 1.9       | 30      | 25.2      | 55      | 56.4      | 81      | 86.8      |
| 6       | 2.4       | 31      | 26.4      | 56      | 57.6      | 82      | 87.8      |
| 7       | 3.1       | 32      | 27.6      | 57      | 58.9      | 83      | 88.8      |
| 8       | 3.7       | 33      | 28.8      | 58      | 60.1      | 84      | 89.7      |
| 9       | 4.5       | 34      | 30.0      | 59      | 61.4      | 85      | 90.6      |
| 10      | 5.2       | 35      | 31.2      | 60      | 62.6      | 86      | 91.5      |
| 11      | 6.0       | 36      | 32.4      | 61      | 63.9      | 87      | 92.4      |
| 12      | 6.8       | 37      | 33.6      | 62      | 65.1      | 88      | 93.2      |
| 13      | 7.6       | 38      | 34.9      | 63      | 66.4      | 89      | 94.0      |
| 14      | 8.5       | 39      | 36.1      | 64      | 67.6      | 90      | 94.8      |
| 15      | 9.4       | 40      | 37.4      | 65      | 68.8      | 91      | 95.5      |
| 16      | 10.3      | 41      | 38.6      | 66      | 70.0      | 92      | 96.3      |
| 17      | 11.3      | 42      | 39.9      | 68      | 72.4      | 93      | 96.9      |
| 18      | 12.2      | 43      | 41.1      | 69      | 73.6      | 94      | 97.6      |
| 19      | 13.2      | 44      | 42.4      | 70      | 74.8      | 95      | 98.1      |
| 20      | 14.2      | 45      | 43.6      | 71      | 75.9      | 96      | 98.7      |
| 21      | 15.3      | 46      | 44.9      | 72      | 77.1      | 97      | 99.1      |
| 22      | 16.3      | 47      | 46.2      | 73      | 78.2      | 98      | 99.5      |
| 23      | 17.4      | 48      | 47.5      | 74      | 79.3      | 99      | 99.8      |
| 24      | 18.5      | 49      | 48.7      | 75      | 80.4      | 100     | 100.0     |

**Note:** These figures apply only to tanks with flat ends, *not* to tanks with *dished ends*. For greater accuracy, consult the stick chart prepared by the tank manufacturer.

### Example:

A 12 foot (144") diameter tank has 98.5 inches of oil as measured by the stick. Dividing the depth (98.5") by the tank inside diameter (144"), yields 68% tank depth. From the table, the volume is 72.4% of capacity. For a 20,000 gallon tank the contents would be approximately 14,480 gallons.



*Tank With Flat Ends*

# GENERAL ENGINEERING DATA

## Unit Conversion Tables

### Pressure or Force Per Unit Area

| Knowing             | To Obtain   |        |                     |                   |              |                   |              |
|---------------------|-------------|--------|---------------------|-------------------|--------------|-------------------|--------------|
|                     | Atmospheres | PSI    | lbs/ft <sup>2</sup> | Kg/M <sup>2</sup> | Inches of Hg | Centimeters of Hg | Inches Water |
|                     | Multiply By |        |                     |                   |              |                   |              |
| Atmospheres 32° F   |             | 14.696 | 2116.22             | 10332.3           | 29.92        | 76                | 406.79       |
| PSI                 | .068046     |        | 144                 | 703.07            | 2.036        | 5.1715            | 27.681       |
| lbs/ft <sup>2</sup> | .000473     | .00694 |                     | 4.882             | .01414       | .03591            | .1922        |
| Kg/M <sup>2</sup>   | .0000968    | .00142 | .20481              |                   | .00290       | .00736            | .03937       |
| Inches Hg-32° F     | .03342      | .4912  | 70.726              | 345.32            |              | 2.540             | 13.596       |
| Cent. of Hg-32° F   | .01316      | .19337 | 27.845              | 135.95            | .3937        |                   | 5.355        |
| Inches Water-39° F  | .002458     | .03613 | 5.202               | 25.40             | .07355       | .1868             |              |

### Power or Rate of Doing Work

| Knowing            | To Obtain    |                            |                  |                   |                  |           |       |
|--------------------|--------------|----------------------------|------------------|-------------------|------------------|-----------|-------|
|                    | BTU per min. | Kilogram Calories per min. | Foot Lbs. per hr | Foot Lbs. per min | Mech. Horsepower | KiloWatts | Watts |
|                    | Multiply By  |                            |                  |                   |                  |           |       |
| BTU per min.       |              | .2520                      | 778.03           | 12.97             | .02357           | .01758    | 17.58 |
| Kil. Cal. per min. | 3.969        |                            | 3087.0           | 51.44             | .09355           | .06977    | 69.77 |
| Foot Lbs. per min  | .001285      | .00032                     |                  | .01667            | .000030          | .000023   | .0226 |
| Foot Lbs. per min  | .07712       | .01943                     | 60.              |                   | .001818          | .001356   | 1.356 |
| Mech. Horsepower   | 42.415       | 10.688                     | 33000.           | 550.              |                  | .7457     | 745.7 |
| KiloWatts          | 56.88        | 14.333                     | 44253.6          | 737.56            | 1.3410           |           | 1000. |
| Watts              | .05688       | .0143                      | 44.25            | .7376             | .001341          | .001      |       |

### Boiler Horsepower and Quantity of Fuel Oil Burned

| Knowing                           | To Obtain                              |                |                         |                                       |                                 |                           |                       |                        |                                 |
|-----------------------------------|----------------------------------------|----------------|-------------------------|---------------------------------------|---------------------------------|---------------------------|-----------------------|------------------------|---------------------------------|
|                                   | Boiler Horse Power (BHP)               | BTU/Hr. Output | Sq. Ft. Steam Radiation | Sq. Ft. Hot Installed Water Radiation | Gallons (U.S.) Oil/ Hour Burned |                           |                       |                        | 10,000 BTU/Hr. Input 70% Effic. |
|                                   |                                        |                |                         |                                       | No. 6 Fuel Oil 70% Effic.       | No. 6 Fuel Oil 80% Effic. | #2 Fuel Oil 70% Effic | #2 Fuel Oil 80% Effic. |                                 |
| Boiler Horse Power (BHP)          | 1                                      | 33472          | 139.5                   | 223.1                                 | .321                            | .281                      | .342                  | .299                   | 4.782                           |
| 10,000 Btu/Hr. Output             | .307                                   | 10,000         | 42.1                    | 67.3                                  | .0968                           | .0848                     | .1032                 | .0902                  | .1468                           |
| Sq. Ft. Installed Steam Radiation | .00717                                 | 240            | 1                       | 1.6                                   | .0023                           | .0020                     | .0025                 | .0021                  | .0343                           |
| Sq. Ft. Hot Water Radiation       | .00448                                 | 150            | .625                    | 1                                     | .0014                           | .0013                     | .0015                 | .0013                  | .0214                           |
| Gal (U.S.) Oil/Hour Burned        | No. 6 Fuel Oil-150,000 Btu. 70% Effic. | 3.136          | 105,000                 | 437.5                                 | 699.7                           | ---                       | ---                   | ---                    | ---                             |
|                                   | No. 6 Fuel Oil-150,000 Btu. 80% Effic. | 3.583          | 120,000                 | 499.7                                 | 799.3                           | ---                       | ---                   | ---                    | ---                             |
|                                   | No. 2 Fuel Oil-140,000 Btu. 70% Effic. | 2.924          | 97,871                  | 407.9                                 | 652.3                           | ---                       | ---                   | ---                    | ---                             |
|                                   | No. 2 Fuel Oil-140,000 Btu. 80% Effic. | 3.344          | 111,946                 | 466.6                                 | 746.2                           | ---                       | ---                   | ---                    | ---                             |
| 10000 Btu/Hr. Input 70% Effic.    | .209                                   | 7,000          | 29.2                    | 46.7                                  | ---                             | ---                       | ---                   | ---                    | 1                               |

# GENERAL ENGINEERING DATA

## Flow Of Water Through Schedule 40 Steel Pipe

| Discharge                |                            | Pressure Drop per 100 feet and Velocity in Schedule 40 Pipe for Water at 60 F. |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |
|--------------------------|----------------------------|--------------------------------------------------------------------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|------------------------|
|                          |                            | Veloc-<br>ity                                                                  | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         | Veloc-<br>ity         | Press.<br>Drop         |
| Gallons<br>per<br>Minute | Cubic Ft.<br>per<br>Second | Feet<br>per<br>Second                                                          | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. | Feet<br>per<br>Second | Lbs.<br>per<br>Sq. In. |
|                          |                            | 1/8"                                                                           |                        | 1/4"                  |                        | 3/8"                  |                        | 1/2"                  |                        | 3/4"                  |                        | 1"                    |                        | 1 1/4"                |                        | 1 1/2"                |                        |
| .2                       | 0.000446                   | 1.13                                                                           | 1.86                   | 0.616                 | 0.359                  |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |
| .3                       | 0.000668                   | 1.69                                                                           | 4.22                   | 0.924                 | 0.903                  | 0.504                 | 0.159                  | 0.317                 | 0.061                  |                       |                        |                       |                        |                       |                        |                       |                        |
| .4                       | 0.000891                   | 2.26                                                                           | 6.98                   | 1.23                  | 1.61                   | 0.672                 | 0.345                  | 0.422                 | 0.086                  |                       |                        |                       |                        |                       |                        |                       |                        |
| .5                       | 0.00111                    | 2.82                                                                           | 10.5                   | 1.54                  | 2.39                   | 0.840                 | 0.539                  | 0.528                 | 0.167                  | 0.301                 | 0.033                  |                       |                        |                       |                        |                       |                        |
| .6                       | 0.00134                    | 3.39                                                                           | 14.7                   | 1.85                  | 3.29                   | 1.01                  | 0.751                  | 0.633                 | 0.240                  | 0.361                 | 0.041                  |                       |                        |                       |                        |                       |                        |
| .8                       | 0.00178                    | 4.52                                                                           | 25.0                   | 2.46                  | 5.44                   | 1.34                  | 1.25                   | 0.844                 | 0.408                  | 0.481                 | 0.102                  |                       |                        |                       |                        |                       |                        |
| 1                        | 0.00223                    | 5.65                                                                           | 37.2                   | 3.08                  | 8.28                   | 1.68                  | 1.85                   | 1.06                  | 0.600                  | 0.602                 | 0.155                  | 0.371                 | 0.048                  |                       |                        |                       |                        |
| 2                        | 0.00446                    | 11.29                                                                          | 134.4                  | 6.16                  | 30.1                   | 3.36                  | 6.58                   | 2.11                  | 2.10                   | 1.20                  | 0.526                  | 0.743                 | 0.164                  | 0.429                 | 0.044                  |                       |                        |
| 3                        | 0.00668                    |                                                                                |                        | 9.25                  | 64.1                   | 5.04                  | 13.9                   | 3.17                  | 4.33                   | 1.81                  | 1.09                   | 1.114                 | 0.336                  | 0.644                 | 0.090                  | 0.473                 | 0.043                  |
| 4                        | 0.00891                    |                                                                                |                        | 12.33                 | 111.2                  | 6.72                  | 23.9                   | 4.22                  | 7.42                   | 2.41                  | 1.83                   | 1.49                  | 0.565                  | 0.858                 | 0.150                  | 0.630                 | 0.071                  |
| 5                        | 0.01114                    | 2"                                                                             |                        |                       |                        | 8.40                  | 36.7                   | 5.28                  | 11.2                   | 3.01                  | 2.75                   | 1.86                  | 0.835                  | 1.073                 | 0.223                  | 0.788                 | 0.104                  |
| 6                        | 0.01337                    | 0.574                                                                          | 0.044                  | 2 1/2"                |                        | 10.08                 | 51.9                   | 6.33                  | 15.8                   | 3.61                  | 3.84                   | 2.23                  | 1.17                   | 1.29                  | 0.309                  | 0.946                 | 0.145                  |
| 8                        | 0.01782                    | 0.765                                                                          | 0.073                  |                       |                        | 13.44                 | 91.1                   | 8.45                  | 27.7                   | 4.81                  | 6.60                   | 2.97                  | 1.99                   | 1.72                  | 0.518                  | 1.26                  | 0.241                  |
| 10                       | 0.02228                    | 0.956                                                                          | 0.108                  | 0.670                 | 0.046                  |                       |                        | 10.56                 | 42.4                   | 6.02                  | 9.99                   | 3.71                  | 2.99                   | 2.15                  | 0.774                  | 1.58                  | 0.361                  |
| 15                       | 0.03342                    | 1.43                                                                           | 0.224                  | 1.01                  | 0.094                  | 3"                    |                        |                       |                        | 9.03                  | 21.6                   | 5.57                  | 6.36                   | 3.22                  | 1.63                   | 2.37                  | 0.755                  |
| 20                       | 0.04456                    | 1.91                                                                           | 0.375                  | 1.34                  | 0.158                  | 0.868                 | 0.056                  | 3 1/2"                |                        | 12.03                 | 37.8                   | 7.43                  | 10.9                   | 4.29                  | 2.78                   | 3.16                  | 1.28                   |
| 25                       | 0.05570                    | 2.39                                                                           | 0.561                  | 1.68                  | 0.234                  | 1.09                  | 0.083                  | 0.812                 | 0.041                  |                       |                        | 9.28                  | 16.7                   | 5.37                  | 4.22                   | 3.94                  | 1.93                   |
| 30                       | 0.06684                    | 2.87                                                                           | 0.786                  | 2.01                  | 0.327                  | 1.30                  | 0.114                  | 0.974                 | 0.056                  |                       |                        | 11.14                 | 23.8                   | 6.44                  | 5.92                   | 4.73                  | 2.72                   |
| 35                       | 0.07798                    | 3.35                                                                           | 1.05                   | 2.35                  | 0.436                  | 1.52                  | 0.151                  | 1.14                  | 0.071                  | 0.882                 | 0.041                  | 12.99                 | 32.2                   | 7.51                  | 7.90                   | 5.52                  | 3.64                   |
| 40                       | 0.08912                    | 3.83                                                                           | 1.35                   | 2.68                  | 0.556                  | 1.74                  | 0.192                  | 1.30                  | 0.095                  | 1.01                  | 0.052                  | 14.85                 | 41.5                   | 8.59                  | 10.24                  | 6.30                  | 4.65                   |
| 45                       | 0.1003                     | 4.30                                                                           | 1.67                   | 3.02                  | 0.668                  | 1.95                  | 0.239                  | 1.46                  | 0.117                  | 1.13                  | 0.064                  |                       |                        | 9.67                  | 12.80                  | 7.09                  | 5.85                   |
| 50                       | 0.1114                     | 4.78                                                                           | 2.03                   | 3.35                  | 0.839                  | 2.17                  | 0.288                  | 1.62                  | 0.142                  | 1.26                  | 0.076                  | 5"                    |                        | 10.74                 | 15.66                  | 7.88                  | 7.15                   |
| 60                       | 0.1337                     | 5.74                                                                           | 2.87                   | 4.02                  | 1.18                   | 2.60                  | 0.406                  | 1.95                  | 0.204                  | 1.51                  | 0.107                  |                       |                        | 12.89                 | 22.2                   | 9.47                  | 10.21                  |
| 70                       | 0.1560                     | 6.70                                                                           | 3.84                   | 4.69                  | 1.59                   | 3.04                  | 0.540                  | 2.27                  | 0.261                  | 1.76                  | 0.143                  | 1.12                  | 0.047                  |                       |                        | 11.05                 | 13.71                  |
| 80                       | 0.1782                     | 7.65                                                                           | 4.97                   | 5.36                  | 2.03                   | 3.47                  | 0.687                  | 2.60                  | 0.334                  | 2.02                  | 0.180                  | 1.28                  | 0.060                  |                       |                        | 12.62                 | 17.59                  |
| 90                       | 0.2005                     | 8.60                                                                           | 6.20                   | 6.03                  | 2.53                   | 3.91                  | 0.861                  | 2.92                  | 0.416                  | 2.27                  | 0.224                  | 1.44                  | 0.074                  | 6"                    |                        | 14.20                 | 22.0                   |
| 100                      | 0.2228                     | 9.56                                                                           | 7.59                   | 6.70                  | 3.09                   | 4.34                  | 1.05                   | 3.25                  | 0.509                  | 2.52                  | 0.272                  | 1.60                  | 0.090                  | 1.11                  | 0.036                  | 15.78                 | 26.9                   |
| 125                      | 0.2785                     | 11.97                                                                          | 11.76                  | 8.38                  | 4.71                   | 5.43                  | 1.61                   | 4.06                  | 0.769                  | 3.15                  | 0.415                  | 2.01                  | 0.135                  | 1.39                  | 0.055                  | 19.72                 | 41.4                   |
| 150                      | 0.3342                     | 14.36                                                                          | 16.70                  | 10.05                 | 6.69                   | 6.51                  | 2.24                   | 4.87                  | 1.08                   | 3.78                  | 0.580                  | 2.41                  | 0.190                  | 1.67                  | 0.077                  |                       |                        |
| 175                      | 0.3899                     | 16.75                                                                          | 22.3                   | 11.73                 | 8.97                   | 7.60                  | 3.00                   | 5.68                  | 1.44                   | 4.41                  | 0.774                  | 2.81                  | 0.253                  | 1.94                  | 0.102                  |                       |                        |
| 200                      | 0.4456                     | 19.14                                                                          | 28.8                   | 13.42                 | 11.68                  | 8.68                  | 3.87                   | 6.49                  | 1.85                   | 5.04                  | 0.985                  | 3.21                  | 0.323                  | 2.22                  | 0.130                  | 8"                    |                        |
| 225                      | 0.5013                     | ...                                                                            | ...                    | 15.09                 | 14.63                  | 9.77                  | 4.83                   | 7.30                  | 2.32                   | 5.67                  | 1.23                   | 3.61                  | 0.401                  | 2.50                  | 0.162                  | 1.44                  | 0.043                  |
| 250                      | 0.557                      | ...                                                                            | ...                    | ...                   | ...                    | 10.85                 | 5.93                   | 8.12                  | 2.84                   | 6.30                  | 1.46                   | 4.01                  | 0.495                  | 2.78                  | 0.195                  | 1.60                  | 0.051                  |
| 275                      | 0.6127                     | ...                                                                            | ...                    | ...                   | ...                    | 11.94                 | 7.14                   | 8.93                  | 3.40                   | 6.93                  | 1.79                   | 4.41                  | 0.583                  | 3.05                  | 0.234                  | 1.76                  | 0.061                  |
| 300                      | 0.6684                     | ...                                                                            | ...                    | ...                   | ...                    | 13.00                 | 8.36                   | 9.74                  | 4.02                   | 7.56                  | 2.11                   | 4.81                  | 0.683                  | 3.33                  | 0.275                  | 1.92                  | 0.072                  |
| 325                      | 0.7241                     | ...                                                                            | ...                    | ...                   | ...                    | 14.12                 | 9.89                   | 10.53                 | 4.09                   | 8.19                  | 2.47                   | 5.21                  | 0.797                  | 3.61                  | 0.320                  | 2.08                  | 0.083                  |
| 350                      | 0.7798                     | ...                                                                            | ...                    | ...                   | ...                    | ...                   | ...                    | 11.36                 | 5.41                   | 8.82                  | 2.84                   | 5.62                  | 0.919                  | 3.89                  | 0.367                  | 2.24                  | 0.095                  |
| 375                      | 0.8355                     | ...                                                                            | ...                    | ...                   | ...                    | ...                   | ...                    | 12.17                 | 6.18                   | 9.45                  | 3.25                   | 6.02                  | 1.05                   | 4.16                  | 0.416                  | 2.40                  | 0.108                  |
| 400                      | 0.8912                     | ...                                                                            | ...                    | ...                   | ...                    | ...                   | ...                    | 12.98                 | 7.03                   | 10.08                 | 3.68                   | 6.42                  | 1.19                   | 4.44                  | 0.471                  | 2.56                  | 0.121                  |
| 425                      | 0.9469                     | ...                                                                            | ...                    | ...                   | ...                    | ...                   | ...                    | 13.80                 | 7.89                   | 10.71                 | 4.12                   | 6.82                  | 1.33                   | 4.72                  | 0.529                  | 2.73                  | 0.136                  |
| 450                      | 1.003                      | 10"                                                                            |                        | ...                   | ...                    | ...                   | ...                    | 14.61                 | 8.80                   | 11.34                 | 4.60                   | 7.22                  | 1.48                   | 5.00                  | 0.590                  | 2.89                  | 0.151                  |
| 475                      | 1.059                      | 1.93                                                                           | 0.054                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 11.97                 | 5.12                   | 7.62                  | 1.64                   | 5.27                  | 0.653                  | 3.04                  | 0.166                  |
| 500                      | 1.114                      | 2.03                                                                           | 0.059                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 12.60                 | 5.65                   | 8.02                  | 1.81                   | 5.55                  | 0.720                  | 3.21                  | 0.182                  |
| 550                      | 1.225                      | 2.24                                                                           | 0.071                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 13.85                 | 6.79                   | 8.82                  | 2.17                   | 6.11                  | 0.861                  | 3.53                  | 0.219                  |
| 600                      | 1.337                      | 2.44                                                                           | 0.083                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 15.12                 | 8.04                   | 9.63                  | 2.55                   | 6.66                  | 1.02                   | 3.85                  | 0.258                  |
| 650                      | 1.448                      | 2.64                                                                           | 0.097                  | 12"                   |                        | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 10.43                 | 2.98                   | 7.22                  | 1.18                   | 4.17                  | 0.301                  |
| 700                      | 1.560                      | 2.85                                                                           | 0.112                  | 2.01                  | 0.047                  | 14"                   |                        | ...                   | ...                    | ...                   | ...                    | 11.23                 | 3.43                   | 7.78                  | 1.35                   | 4.49                  | 0.343                  |
| 750                      | 1.671                      | 3.05                                                                           | 0.127                  | 2.15                  | 0.054                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 12.03                 | 3.92                   | 8.33                  | 1.55                   | 4.81                  | 0.392                  |
| 800                      | 1.782                      | 3.25                                                                           | 0.143                  | 2.29                  | 0.061                  | ...                   | ...                    | ...                   | ...                    | ...                   | ...                    | 12.83                 | 4.43                   | 8.88                  | 1.75                   | 5.13                  | 0.443                  |
| 850                      | 1.894                      | 3.46                                                                           | 0.160                  | 2.44                  | 0.068                  | 2.02                  | 0.042                  | ...                   | ...                    | ...                   | ...                    | 13.64                 | 5.00                   | 9.44                  | 1.96                   | 5.45                  | 0.497                  |
| 900                      | 2.005                      | 3.66                                                                           | 0.179                  | 2.58                  | 0.075                  | 2.13                  | 0.047                  | ...                   | ...                    | ...                   | ...                    | 14.44                 | 5.58                   | 9.99                  | 2.18                   | 5.77                  | 0.554                  |
| 950                      | 2.117                      | 3.86                                                                           | 0.198                  | 2.72                  | 0.083                  | 2.25                  | 0.052                  | 16"                   |                        | ...                   | ...                    | 15.24                 | 6.21                   | 10.55                 | 2.42                   | 6.09                  | 0.613                  |
| 1000                     | 2.228                      | 4.07                                                                           | 0.218                  | 2.87                  | 0.091                  | 2.37                  | 0.057                  | ...                   | ...                    | ...                   | ...                    | 16.04                 | 6.84                   | 11.10                 | 2.68                   | 6.41                  | 0.675                  |
| 1100                     | 2.451                      | 4.48                                                                           | 0.260                  | 3.15                  | 0.110                  | 2.61                  | 0.068                  | ...                   | ...                    | ...                   | ...                    | 17.65                 | 8.23                   | 12.22                 | 3.22                   | 7.05                  | 0.807                  |
| 1200                     | 2.674                      | 4.88                                                                           | 0.306                  | 3.44                  | 0.128                  | 2.85                  | 0.080                  | 2.18                  | 0.042                  | ...                   | ...                    | ...                   | ...                    | 13.33                 | 3.81                   | 7.70                  | 0.948                  |
| 1300                     | 2.896                      | 5.29                                                                           | 0.355                  | 3.73                  | 0.150                  | 3.08                  | 0.093                  | 2.36                  | 0.048                  | ...                   | ...                    | ...                   | ...                    | 14.43                 | 4.45                   | 8.33                  | 1.11                   |
| 1400                     | 3.119                      | 5.70                                                                           | 0.409                  | 4.01                  | 0.171                  | 3.32                  | 0.107                  | 2.54                  | 0.055                  | 18"                   |                        | ...                   | ...                    | 15.55                 | 5.13                   | 8.98                  | 1.28                   |
| 1500                     | 3.342                      | 6.10                                                                           | 0.466                  | 4.30                  | 0.195                  | 3.56                  | 0.122                  | 2.72                  | 0.063                  | ...                   | ...                    | ...                   | ...                    | 16.66                 | 5.85                   | 9.62                  | 1.46                   |
| 1600                     | 3.565                      | 6.51                                                                           | 0.527                  | 4.59                  | 0.219                  | 3.79                  | 0.138                  | 2.90                  | 0.071                  | ...                   | ...                    | ...                   | ...                    | 17.77                 | 6.61                   | 10.26                 | 1.65                   |
| 1800                     | 4.010                      | 7.32                                                                           | 0.663                  | 5.16                  | 0.276                  | 4.27                  | 0.172                  | 3.27                  | 0.088                  | 2.58                  | 0.050                  | ...                   | ...                    | 19.99                 | 8.37                   | 11.54                 | 2.08                   |
| 2000                     | 4.456                      | 8.14                                                                           | 0.808                  | 5.73                  | 0.339                  | 4.74                  | 0.209                  | 3.63                  | 0.107                  | 2.87                  | 0.060                  | 20"                   |                        | 22.21                 | 10.3                   | 12.82                 | 2.55                   |
| 2500                     | 5.570                      | 10.17                                                                          | 1.24                   | 7.17                  | 0.515                  | 5.93                  | 0.321                  | 4.54                  | 0.163                  | 3.59                  | 0.091                  | 24"                   |                        | ...                   | ...                    | 16.03                 | 3.94                   |
| 3000                     | 6.684                      | 12.20                                                                          | 1.76                   | 8.60                  | 0.731                  | 7.11                  | 0.451                  | 5.45                  | 0.232                  | 4.30                  | 0.129                  | 3.46                  | 0.075                  | ...                   | ...                    | 19.24                 | 5.59                   |
| 3500                     | 7.798                      | 14.24                                                                          | 2.38                   | 10.03                 | 0.982                  | 8.30                  | 0.607                  | 6.35                  | 0.312                  | 5.02                  | 0.173                  | 4.04                  | 0.101                  | ...                   | ...                    | 22.44                 | 7.56                   |
| 400                      |                            |                                                                                |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |                       |                        |



# GENERAL ENGINEERING DATA

## Flow Of Water Through Schedule 40 Steel Pipe

For lengths of pipe other than 100 feet, the pressure drop is proportional to the length. Thus, for 50 feet of pipe, the pressure drop is approximately one-half the value given in the table . . . for 300 feet, three times the given value, etc.

The pressure drop is also inversely proportional to the absolute pressure and directly proportional to the absolute temperature.

Therefore, to determine the pressure drop for inlet or average pressures other than 100 psi and at temperatures other than 60 F, multiply the values given in the table by the ratio:

$$\left( \frac{100 + 14.7}{P + 14.7} \right) \left( \frac{460 + t}{520} \right)$$

where:

"P" is the inlet or average gauge pressure in pounds per square inch, and,

"t" is the temperature in degrees Fahrenheit under consideration.

The cubic feet per minute of compressed air at any pressure is inversely proportional to the absolute pressure and directly proportional to the absolute temperature.

To determine the cubic feet per minute of compressed air at any temperature and pressure other than standard conditions, multiply the value of cubic feet per minute of free air by the ratio:

$$\left( \frac{14.7}{14.7 + P} \right) \left( \frac{460 + t}{520} \right)$$

### Calculations for Pipe Other than Schedule 40

To determine the velocity of water, or the pressure drop of water or air, through pipe other than Schedule 40, use the following formulas:

$$v_a = v_{40} \left( \frac{d_{40}}{d_a} \right)^2$$

$$\Delta P_a = \Delta P_{40} \left( \frac{d_{40}}{d_a} \right)^5$$

Subscript "a" refers to the Schedule of pipe through which velocity or pressure drop is desired.

Subscript "40" refers to the velocity or pressure drop through Schedule 40 pipe, as given in the tables on these facing pages.

| Free Air<br>$q'_m$                                   | Com-<br>pressed Air                                 | Pressure Drop of Air<br>In Pounds per Square Inch<br>Per 100 Feet of Schedule 40 Pipe<br>For Air at 100 Pounds per Square Inch<br>Gauge Pressure and 60 F Temperature |       |        |       |       |       |        |        |       |  |
|------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------|-------|-------|-------|--------|--------|-------|--|
| Cubic Feet<br>Per Minute<br>at 60 F and<br>14.7 psia | Cubic Feet<br>Per Minute<br>at 60 F and<br>100 psig |                                                                                                                                                                       | 1/8"  | 1/4"   | 3/8"  | 1/2"  |       |        |        |       |  |
| 1                                                    | 0.128                                               | 0.361                                                                                                                                                                 | 0.083 | 0.018  |       |       |       |        |        |       |  |
| 2                                                    | 0.256                                               | 1.31                                                                                                                                                                  | 0.285 | 0.064  | 0.020 |       |       |        |        |       |  |
| 3                                                    | 0.384                                               | 3.06                                                                                                                                                                  | 0.605 | 0.133  | 0.042 | 3/4"  |       |        |        |       |  |
| 4                                                    | 0.513                                               | 4.83                                                                                                                                                                  | 1.04  | 0.226  | 0.071 |       |       |        |        |       |  |
| 5                                                    | 0.641                                               | 7.45                                                                                                                                                                  | 1.58  | 0.343  | 0.106 | 0.027 | 1"    |        |        |       |  |
| 6                                                    | 0.769                                               | 10.6                                                                                                                                                                  | 2.23  | 0.408  | 0.148 | 0.037 |       |        |        |       |  |
| 8                                                    | 1.025                                               | 18.6                                                                                                                                                                  | 3.89  | 0.848  | 0.255 | 0.062 | 0.019 |        |        |       |  |
| 10                                                   | 1.282                                               | 28.7                                                                                                                                                                  | 5.96  | 1.26   | 0.356 | 0.094 | 0.029 | 1 1/4" | 1 1/2" |       |  |
| 15                                                   | 1.922                                               | ...                                                                                                                                                                   | 13.0  | 2.73   | 0.834 | 0.201 | 0.062 |        |        |       |  |
| 20                                                   | 2.563                                               | ...                                                                                                                                                                   | 22.8  | 4.76   | 1.43  | 0.345 | 0.102 | 0.026  |        |       |  |
| 25                                                   | 3.204                                               | ...                                                                                                                                                                   | 35.6  | 7.34   | 2.21  | 0.526 | 0.156 | 0.039  | 0.019  |       |  |
| 30                                                   | 3.845                                               | ...                                                                                                                                                                   | ...   | 10.5   | 3.15  | 0.748 | 0.219 | 0.055  | 0.026  |       |  |
| 35                                                   | 4.486                                               | ...                                                                                                                                                                   | ...   | 14.2   | 4.24  | 1.00  | 0.293 | 0.073  | 0.035  |       |  |
| 40                                                   | 5.126                                               | ...                                                                                                                                                                   | ...   | 18.4   | 5.49  | 1.30  | 0.379 | 0.095  | 0.044  |       |  |
| 45                                                   | 5.767                                               | ...                                                                                                                                                                   | ...   | 23.1   | 6.90  | 1.62  | 0.474 | 0.116  | 0.055  | 2"    |  |
| 50                                                   | 6.408                                               |                                                                                                                                                                       |       | 28.5   | 8.49  | 1.99  | 0.578 | 0.149  | 0.067  | 0.019 |  |
| 60                                                   | 7.690                                               | 2 1/2"                                                                                                                                                                |       | 40.7   | 12.2  | 2.85  | 0.819 | 0.200  | 0.094  | 0.027 |  |
| 70                                                   | 8.971                                               |                                                                                                                                                                       |       |        | 16.5  | 3.83  | 1.10  | 0.270  | 0.126  | 0.036 |  |
| 80                                                   | 10.25                                               | 0.019                                                                                                                                                                 |       |        | 21.4  | 4.96  | 1.43  | 0.350  | 0.162  | 0.046 |  |
| 90                                                   | 11.53                                               | 0.023                                                                                                                                                                 |       |        | 27.0  | 6.25  | 1.80  | 0.437  | 0.203  | 0.058 |  |
| 100                                                  | 12.82                                               | 0.029                                                                                                                                                                 | 3"    |        | 33.2  | 7.69  | 2.21  | 0.534  | 0.247  | 0.070 |  |
| 125                                                  | 16.02                                               | 0.044                                                                                                                                                                 |       |        |       | 11.9  | 3.39  | 0.825  | 0.380  | 0.107 |  |
| 150                                                  | 19.22                                               | 0.062                                                                                                                                                                 | 0.021 |        |       | 17.0  | 4.87  | 1.17   | 0.537  | 0.151 |  |
| 175                                                  | 22.43                                               | 0.083                                                                                                                                                                 | 0.028 |        |       | 23.1  | 6.60  | 1.58   | 0.727  | 0.205 |  |
| 200                                                  | 25.63                                               | 0.107                                                                                                                                                                 | 0.036 | 3 1/2" |       | 30.0  | 8.54  | 2.05   | 0.937  | 0.264 |  |
| 225                                                  | 28.84                                               | 0.134                                                                                                                                                                 | 0.045 | 0.022  |       | 37.9  | 10.8  | 2.59   | 1.19   | 0.331 |  |
| 250                                                  | 32.04                                               | 0.164                                                                                                                                                                 | 0.055 | 0.027  |       |       | 13.3  | 3.18   | 1.45   | 0.404 |  |
| 275                                                  | 35.24                                               | 0.191                                                                                                                                                                 | 0.066 | 0.032  |       |       | 16.0  | 3.83   | 1.75   | 0.484 |  |
| 300                                                  | 38.45                                               | 0.232                                                                                                                                                                 | 0.078 | 0.037  |       |       | 19.0  | 4.56   | 2.07   | 0.573 |  |
| 325                                                  | 41.65                                               | 0.270                                                                                                                                                                 | 0.090 | 0.043  |       |       | 22.3  | 5.32   | 2.42   | 0.673 |  |
| 350                                                  | 44.87                                               | 0.313                                                                                                                                                                 | 0.104 | 0.050  | 4"    |       |       |        |        |       |  |
| 375                                                  | 48.06                                               | 0.356                                                                                                                                                                 | 0.119 | 0.057  | 0.030 |       | 25.8  | 6.17   | 2.80   | 0.776 |  |
| 400                                                  | 51.26                                               | 0.402                                                                                                                                                                 | 0.134 | 0.064  | 0.034 |       | 29.6  | 7.05   | 3.20   | 0.887 |  |
| 425                                                  | 54.47                                               | 0.452                                                                                                                                                                 | 0.151 | 0.072  | 0.038 |       | 33.6  | 8.02   | 3.64   | 1.00  |  |
| 450                                                  | 57.67                                               | 0.507                                                                                                                                                                 | 0.168 | 0.081  | 0.042 |       | 37.9  | 9.01   | 4.09   | 1.13  |  |
|                                                      |                                                     |                                                                                                                                                                       |       |        |       |       |       | 10.2   | 4.59   | 1.26  |  |
| 475                                                  | 60.88                                               | 0.562                                                                                                                                                                 | 0.187 | 0.089  | 0.047 |       |       | 11.3   | 5.09   | 1.40  |  |
| 500                                                  | 64.08                                               | 0.623                                                                                                                                                                 | 0.206 | 0.099  | 0.052 |       |       | 12.5   | 5.61   | 1.55  |  |
| 550                                                  | 70.49                                               | 0.749                                                                                                                                                                 | 0.248 | 0.118  | 0.062 |       |       | 15.1   | 6.79   | 1.87  |  |
| 600                                                  | 76.90                                               | 0.887                                                                                                                                                                 | 0.293 | 0.139  | 0.073 |       |       | 18.0   | 8.04   | 2.21  |  |
| 650                                                  | 83.30                                               | 1.04                                                                                                                                                                  | 0.342 | 0.163  | 0.086 | 5"    |       | 21.1   | 9.43   | 2.60  |  |
| 700                                                  | 89.71                                               | 1.19                                                                                                                                                                  | 0.395 | 0.188  | 0.099 | 0.032 |       | 24.3   | 10.9   | 3.00  |  |
| 750                                                  | 96.12                                               | 1.36                                                                                                                                                                  | 0.451 | 0.214  | 0.113 | 0.036 |       | 27.9   | 12.6   | 3.44  |  |
| 800                                                  | 102.5                                               | 1.55                                                                                                                                                                  | 0.513 | 0.244  | 0.127 | 0.041 |       | 31.8   | 14.2   | 3.90  |  |
| 850                                                  | 108.9                                               | 1.74                                                                                                                                                                  | 0.576 | 0.274  | 0.144 | 0.046 |       | 35.9   | 16.0   | 4.40  |  |
| 900                                                  | 115.3                                               | 1.95                                                                                                                                                                  | 0.642 | 0.305  | 0.160 | 0.051 | 6"    | 40.2   | 18.0   | 4.91  |  |
| 950                                                  | 121.8                                               | 2.18                                                                                                                                                                  | 0.715 | 0.340  | 0.178 | 0.057 | 0.023 |        | 20.0   | 5.47  |  |
| 1000                                                 | 128.2                                               | 2.40                                                                                                                                                                  | 0.788 | 0.375  | 0.197 | 0.063 | 0.025 |        | 22.1   | 6.06  |  |
| 1100                                                 | 141.0                                               | 2.89                                                                                                                                                                  | 0.948 | 0.451  | 0.236 | 0.075 | 0.030 |        | 26.7   | 7.29  |  |
| 1200                                                 | 153.8                                               | 3.44                                                                                                                                                                  | 1.13  | 0.533  | 0.279 | 0.089 | 0.035 |        | 31.8   | 8.63  |  |
| 1300                                                 | 166.6                                               | 4.01                                                                                                                                                                  | 1.32  | 0.626  | 0.327 | 0.103 | 0.041 |        | 37.3   | 10.1  |  |
| 1400                                                 | 179.4                                               | 4.65                                                                                                                                                                  | 1.52  | 0.718  | 0.377 | 0.119 | 0.047 |        |        | 11.8  |  |
| 1500                                                 | 192.2                                               | 5.31                                                                                                                                                                  | 1.74  | 0.824  | 0.431 | 0.136 | 0.054 | 8"     |        | 13.5  |  |
| 1600                                                 | 205.1                                               | 6.04                                                                                                                                                                  | 1.97  | 0.932  | 0.490 | 0.154 | 0.061 |        |        | 15.3  |  |
| 1800                                                 | 230.7                                               | 7.65                                                                                                                                                                  | 2.50  | 1.18   | 0.616 | 0.193 | 0.075 |        |        | 19.3  |  |
| 2000                                                 | 256.3                                               | 9.44                                                                                                                                                                  | 3.06  | 1.45   | 0.757 | 0.237 | 0.094 | 0.023  | 10"    | 23.9  |  |
| 2500                                                 | 320.4                                               | 14.7                                                                                                                                                                  | 4.76  | 2.25   | 1.17  | 0.366 | 0.143 | 0.035  |        | 37.3  |  |
| 3000                                                 | 384.5                                               | 21.1                                                                                                                                                                  | 6.82  | 3.20   | 1.67  | 0.524 | 0.204 | 0.051  | 0.016  |       |  |
| 3500                                                 | 448.6                                               | 28.8                                                                                                                                                                  | 9.23  | 4.33   | 2.26  | 0.709 | 0.276 | 0.068  | 0.022  |       |  |
| 4000                                                 | 512.6                                               | 37.6                                                                                                                                                                  | 12.1  | 5.66   | 2.94  | 0.919 | 0.358 | 0.088  | 0.028  |       |  |
| 4500                                                 | 576.7                                               | 47.6                                                                                                                                                                  | 15.3  | 7.16   | 3.69  | 1.16  | 0.450 | 0.111  | 0.035  | 12"   |  |
| 5000                                                 | 640.8                                               |                                                                                                                                                                       | 18.8  | 8.85   | 4.56  | 1.42  | 0.552 | 0.136  | 0.043  | 0.018 |  |
| 6000                                                 | 769.0                                               |                                                                                                                                                                       | 27.1  | 12.7   | 6.57  | 2.03  | 0.794 | 0.195  | 0.061  | 0.025 |  |
| 7000                                                 | 897.1                                               |                                                                                                                                                                       | 36.9  | 17.2   | 8.94  | 2.76  | 1.07  | 0.262  | 0.082  | 0.034 |  |
| 8000                                                 | 1025                                                |                                                                                                                                                                       |       | 22.5   | 11.7  | 3.59  | 1.39  | 0.339  | 0.107  | 0.044 |  |
| 9000                                                 | 1153                                                |                                                                                                                                                                       |       | 28.5   | 14.9  | 4.54  | 1.76  | 0.427  | 0.134  | 0.055 |  |
| 10000                                                | 1282                                                |                                                                                                                                                                       |       | 35.2   | 18.4  | 5.60  | 2.16  | 0.526  | 0.164  | 0.067 |  |
| 11000                                                | 1410                                                |                                                                                                                                                                       |       |        | 22.2  | 6.78  | 2.62  | 0.633  | 0.197  | 0.081 |  |
| 12000                                                | 1538                                                |                                                                                                                                                                       |       |        | 26.4  | 8.07  | 3.09  | 0.753  | 0.234  | 0.096 |  |
| 13000                                                | 1666                                                |                                                                                                                                                                       |       |        | 31.0  | 9.47  | 3.63  | 0.884  | 0.273  | 0.112 |  |
| 14000                                                | 1794                                                |                                                                                                                                                                       |       |        | 36.0  | 11.0  | 4.21  | 1.02   | 0.316  | 0.129 |  |
| 15000                                                | 1922                                                |                                                                                                                                                                       |       |        |       | 12.6  | 4.84  | 1.17   | 0.364  | 0.148 |  |
| 16000                                                | 2051                                                |                                                                                                                                                                       |       |        |       | 14.3  | 5.50  | 1.33   | 0.411  | 0.167 |  |
| 18000                                                | 2307                                                |                                                                                                                                                                       |       |        |       | 18.2  | 6.96  | 1.68   | 0.520  | 0.213 |  |
| 20000                                                | 2563                                                |                                                                                                                                                                       |       |        |       | 22.4  | 8.60  | 2.01   | 0.642  | 0.260 |  |
| 22000                                                | 2820                                                |                                                                                                                                                                       |       |        |       | 27.1  | 10.4  | 2.50   | 0.771  | 0.314 |  |
| 24000                                                | 3076                                                |                                                                                                                                                                       |       |        |       | 32.3  | 12.4  | 2.97   | 0.918  | 0.371 |  |
| 26000                                                | 3332                                                |                                                                                                                                                                       |       |        |       | 37.9  | 14.5  | 3.49   | 1.12   | 0.435 |  |
| 28000                                                | 3588                                                |                                                                                                                                                                       |       |        |       |       | 16.9  | 4.04   | 1.25   | 0.505 |  |
| 30000                                                | 3845                                                |                                                                                                                                                                       |       |        |       |       | 19.3  | 4.64   | 1.42   | 0.520 |  |

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# GENERAL ENGINEERING DATA

## Pipe Data

### Carbon and Alloy Steel - Stainless Steel

(also see next three pages)

| Nom-<br>inal<br>Pipe<br>Size<br><br>Inches | Outside<br>Diam.<br><br>Inches | Identification       |               |                                          | Wall<br>Thick-<br>ness<br>(t)<br><br>Inches | Inside<br>Diam-<br>eter<br>(d)<br><br>Inches | Area<br>of<br>Metal<br><br>Square<br>Inches | Transverse                  |                           | Moment<br>of<br>Inertia<br>(I)<br><br>Inches <sup>4</sup> | Weight<br>Pipe<br><br>Pounds<br>per<br>foot | Weight<br>Water<br><br>Pounds<br>per foot<br>of pipe | External<br>Surface<br><br>Sq. Ft.<br>per foot<br>of pipe | Section<br>Modulus<br><br>$\left(2\frac{I}{O.D.}\right)$ |
|--------------------------------------------|--------------------------------|----------------------|---------------|------------------------------------------|---------------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------|---------------------------|-----------------------------------------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|
|                                            |                                | Steel                |               | Stain-<br>less<br>Steel<br>Sched.<br>No. |                                             |                                              |                                             | Internal Area               |                           |                                                           |                                             |                                                      |                                                           |                                                          |
|                                            |                                | Iron<br>Pipe<br>Size | Sched.<br>No. |                                          |                                             |                                              |                                             | (a)<br><br>Square<br>Inches | (A)<br><br>Square<br>Feet |                                                           |                                             |                                                      |                                                           |                                                          |
| 1/8                                        | 0.405                          | ...                  | ...           | 10S                                      | .049                                        | .307                                         | .0548                                       | .0740                       | .00051                    | .00088                                                    | .19                                         | .032                                                 | .106                                                      | .00437                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .068                                        | .269                                         | .0720                                       | .0568                       | .00040                    | .00106                                                    | .24                                         | .025                                                 | .106                                                      | .00523                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .095                                        | .215                                         | .0925                                       | .0364                       | .00025                    | .00122                                                    | .31                                         | .016                                                 | .106                                                      | .00602                                                   |
| 1/4                                        | 0.540                          | ...                  | ...           | 10S                                      | .065                                        | .410                                         | .0970                                       | .1320                       | .00091                    | .00279                                                    | .33                                         | .057                                                 | .141                                                      | .01032                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .088                                        | .364                                         | .1250                                       | .1041                       | .00072                    | .00331                                                    | .42                                         | .045                                                 | .141                                                      | .01227                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .119                                        | .302                                         | .1574                                       | .0716                       | .00050                    | .00377                                                    | .54                                         | .031                                                 | .141                                                      | .01395                                                   |
| 3/8                                        | 0.675                          | ...                  | ...           | 10S                                      | .065                                        | .545                                         | .1246                                       | .2333                       | .00162                    | .00586                                                    | .42                                         | .101                                                 | .178                                                      | .01736                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .091                                        | .493                                         | .1670                                       | .1910                       | .00133                    | .00729                                                    | .57                                         | .083                                                 | .178                                                      | .02160                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .126                                        | .423                                         | .2173                                       | .1405                       | .00098                    | .00862                                                    | .74                                         | .061                                                 | .178                                                      | .02554                                                   |
| 1/2                                        | 0.840                          | ...                  | ...           | 5S                                       | .065                                        | .710                                         | .1583                                       | .3959                       | .00275                    | .01197                                                    | .54                                         | .172                                                 | .220                                                      | .02849                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .083                                        | .674                                         | .1974                                       | .3568                       | .00248                    | .01431                                                    | .67                                         | .155                                                 | .220                                                      | .03407                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .109                                        | .622                                         | .2503                                       | .3040                       | .00211                    | .01709                                                    | .85                                         | .132                                                 | .220                                                      | .04069                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .147                                        | .546                                         | .3200                                       | .2340                       | .00163                    | .02008                                                    | 1.09                                        | .102                                                 | .220                                                      | .04780                                                   |
|                                            |                                | ...                  | 160           | ...                                      | .187                                        | .466                                         | .3836                                       | .1706                       | .00118                    | .02212                                                    | 1.31                                        | .074                                                 | .220                                                      | .05267                                                   |
|                                            |                                | XXS                  | ...           | ...                                      | .294                                        | .252                                         | .5043                                       | .050                        | .00035                    | .02424                                                    | 1.71                                        | .022                                                 | .220                                                      | .05772                                                   |
| 3/4                                        | 1.050                          | ...                  | ...           | 5S                                       | .065                                        | .920                                         | .2011                                       | .6648                       | .00462                    | .02450                                                    | .69                                         | .288                                                 | .275                                                      | .04667                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .083                                        | .884                                         | .2521                                       | .6138                       | .00426                    | .02969                                                    | .86                                         | .266                                                 | .275                                                      | .05655                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .113                                        | .824                                         | .3326                                       | .5330                       | .00371                    | .03704                                                    | 1.13                                        | .231                                                 | .275                                                      | .07055                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .154                                        | .742                                         | .4335                                       | .4330                       | .00300                    | .04479                                                    | 1.47                                        | .188                                                 | .275                                                      | .08531                                                   |
|                                            |                                | ...                  | 160           | ...                                      | .219                                        | .612                                         | .5698                                       | .2961                       | .00206                    | .05269                                                    | 1.94                                        | .128                                                 | .275                                                      | .10036                                                   |
|                                            |                                | XXS                  | ...           | ...                                      | .308                                        | .434                                         | .7180                                       | .148                        | .00103                    | .05792                                                    | 2.44                                        | .064                                                 | .275                                                      | .11032                                                   |
| 1                                          | 1.315                          | ...                  | ...           | 5S                                       | .065                                        | 1.185                                        | .2553                                       | 1.1029                      | .00766                    | .04999                                                    | .87                                         | .478                                                 | .344                                                      | .07603                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .109                                        | 1.097                                        | .4130                                       | .9452                       | .00656                    | .07569                                                    | 1.40                                        | .409                                                 | .344                                                      | .11512                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .133                                        | 1.049                                        | .4939                                       | .8640                       | .00600                    | .08734                                                    | 1.68                                        | .375                                                 | .344                                                      | .1328                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .179                                        | .957                                         | .6388                                       | .7190                       | .00499                    | .1056                                                     | 2.17                                        | .312                                                 | .344                                                      | .1606                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .250                                        | .815                                         | .8365                                       | .5217                       | .00362                    | .1251                                                     | 2.84                                        | .230                                                 | .344                                                      | .1903                                                    |
|                                            |                                | XXS                  | ...           | ...                                      | .358                                        | .599                                         | 1.0760                                      | .282                        | .00196                    | .1405                                                     | 3.66                                        | .122                                                 | .344                                                      | .2136                                                    |
| 1¼                                         | 1.660                          | ...                  | ...           | 5S                                       | .065                                        | 1.530                                        | .3257                                       | 1.839                       | .01277                    | .1038                                                     | 1.11                                        | .797                                                 | .435                                                      | .1250                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .109                                        | 1.442                                        | .4717                                       | 1.633                       | .01134                    | .1605                                                     | 1.81                                        | .708                                                 | .435                                                      | .1934                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .140                                        | 1.380                                        | .6685                                       | 1.495                       | .01040                    | .1947                                                     | 2.27                                        | .649                                                 | .435                                                      | .2346                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .191                                        | 1.278                                        | .8815                                       | 1.283                       | .00891                    | .2418                                                     | 3.00                                        | .555                                                 | .435                                                      | .2913                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .250                                        | 1.160                                        | 1.1070                                      | 1.057                       | .00734                    | .2839                                                     | 3.76                                        | .458                                                 | .435                                                      | .3421                                                    |
|                                            |                                | XXS                  | ...           | ...                                      | .382                                        | .896                                         | 1.534                                       | .630                        | .00438                    | .3411                                                     | 5.21                                        | .273                                                 | .435                                                      | .4110                                                    |
| 1½                                         | 1.900                          | ...                  | ...           | 5S                                       | .065                                        | 1.770                                        | .3747                                       | 2.461                       | .01709                    | .1579                                                     | 1.28                                        | 1.066                                                | .497                                                      | .1662                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .109                                        | 1.682                                        | .6133                                       | 2.222                       | .01543                    | .2468                                                     | 2.09                                        | .963                                                 | .497                                                      | .2598                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .145                                        | 1.610                                        | .7995                                       | 2.036                       | .01414                    | .3099                                                     | 2.72                                        | .882                                                 | .497                                                      | .3262                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .200                                        | 1.500                                        | 1.068                                       | 1.767                       | .01225                    | .3912                                                     | 3.63                                        | .765                                                 | .497                                                      | .4118                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .281                                        | 1.338                                        | 1.429                                       | 1.406                       | .00976                    | .4824                                                     | 4.86                                        | .608                                                 | .497                                                      | .5078                                                    |
|                                            |                                | XXS                  | ...           | ...                                      | .400                                        | 1.100                                        | 1.885                                       | .950                        | .00660                    | .5678                                                     | 6.41                                        | .42                                                  | .497                                                      | .5977                                                    |
| 2                                          | 2.375                          | ...                  | ...           | 5S                                       | .065                                        | 2.245                                        | .4717                                       | 3.958                       | .02749                    | .3149                                                     | 1.61                                        | 1.72                                                 | .622                                                      | .2652                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .109                                        | 2.157                                        | .7760                                       | 3.654                       | .02538                    | .4992                                                     | 2.64                                        | 1.58                                                 | .622                                                      | .4204                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .154                                        | 2.067                                        | 1.075                                       | 3.355                       | .02330                    | .6657                                                     | 3.65                                        | 1.45                                                 | .622                                                      | .5606                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .218                                        | 1.939                                        | 1.477                                       | 2.953                       | .02050                    | .8679                                                     | 5.02                                        | 1.28                                                 | .622                                                      | .7309                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .344                                        | 1.687                                        | 2.190                                       | 2.241                       | .01556                    | 1.162                                                     | 7.46                                        | .97                                                  | .622                                                      | .979                                                     |
|                                            |                                | XXS                  | ...           | ...                                      | .436                                        | 1.503                                        | 2.656                                       | 1.774                       | .01232                    | 1.311                                                     | 9.03                                        | .77                                                  | .622                                                      | 1.104                                                    |
| 2½                                         | 2.875                          | ...                  | ...           | 5S                                       | .083                                        | 2.709                                        | .7280                                       | 5.764                       | .04002                    | .7100                                                     | 2.48                                        | 2.50                                                 | .753                                                      | .4939                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .120                                        | 2.635                                        | 1.039                                       | 5.453                       | .03787                    | .9873                                                     | 3.53                                        | 2.36                                                 | .753                                                      | .6868                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .203                                        | 2.469                                        | 1.704                                       | 4.788                       | .03322                    | 1.530                                                     | 5.79                                        | 2.07                                                 | .753                                                      | 1.064                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .276                                        | 2.323                                        | 2.254                                       | 4.238                       | .02942                    | 1.924                                                     | 7.66                                        | 1.87                                                 | .753                                                      | 1.339                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .375                                        | 2.125                                        | 2.945                                       | 3.546                       | .02463                    | 2.353                                                     | 10.01                                       | 1.54                                                 | .753                                                      | 1.638                                                    |
|                                            |                                | XXS                  | ...           | ...                                      | .552                                        | 1.771                                        | 4.028                                       | 2.464                       | .01710                    | 2.871                                                     | 13.69                                       | 1.07                                                 | .753                                                      | 1.997                                                    |
| 3                                          | 3.500                          | ...                  | ...           | 5S                                       | .083                                        | 3.334                                        | .8910                                       | 8.730                       | .06063                    | 1.301                                                     | 3.03                                        | 3.78                                                 | .916                                                      | .7435                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .120                                        | 3.260                                        | 1.274                                       | 8.347                       | .05796                    | 1.822                                                     | 4.33                                        | 3.62                                                 | .916                                                      | 1.041                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .216                                        | 3.068                                        | 2.228                                       | 7.393                       | .05130                    | 3.017                                                     | 7.58                                        | 3.20                                                 | .916                                                      | 1.724                                                    |
|                                            |                                | XS                   | 80            | 80S                                      | .300                                        | 2.900                                        | 3.016                                       | 6.605                       | .04587                    | 3.894                                                     | 10.25                                       | 2.86                                                 | .916                                                      | 2.225                                                    |
|                                            |                                | ...                  | 160           | ...                                      | .438                                        | 2.624                                        | 4.205                                       | 5.408                       | .03755                    | 5.032                                                     | 14.32                                       | 2.35                                                 | .916                                                      | 2.876                                                    |
|                                            |                                | XXS                  | ...           | ...                                      | .600                                        | 2.300                                        | 5.466                                       | 4.155                       | .02885                    | 5.993                                                     | 18.58                                       | 1.80                                                 | .916                                                      | 3.424                                                    |

Identification, wall thickness and weights are extracted from ANSI B36.10 and B36.19. The notations STD, XS, and XXS indicate Standard, Extra Strong, and Double Extra Strong pipe respectively.

Transverse internal area values listed in "square feet" also represent volume in cubic feet per foot of pipe length.

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# GENERAL ENGINEERING DATA

## Pipe Data

### Carbon and Alloy Steel - Stainless Steel

| Nom-<br>inal<br>Pipe<br>Size<br><br>Inches | Outside<br>Diam.<br><br>Inches | Identification       |               |                                          | Wall<br>Thick-<br>ness<br>(t)<br><br>Inches | Inside<br>Diam-<br>eter<br>(d)<br><br>Inches | Area<br>of<br>Metal<br><br>Square<br>Inches | Transverse<br>Internal Area |                           | Moment<br>of<br>Inertia<br>(I)<br><br>Inches <sup>4</sup> | Weight<br>Pipe<br><br>Pounds<br>per<br>foot | Weight<br>Water<br><br>Pounds<br>per foot<br>of pipe | External<br>Surface<br><br>Sq. Ft.<br>per foot<br>of pipe | Section<br>Modulus<br><br>$\left(\frac{I}{O.D.}\right)$ |
|--------------------------------------------|--------------------------------|----------------------|---------------|------------------------------------------|---------------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------|---------------------------|-----------------------------------------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------|
|                                            |                                | Steel                |               | Stain-<br>less<br>Steel<br>Sched.<br>No. |                                             |                                              |                                             | (a)<br><br>Square<br>Inches | (I)<br><br>Square<br>Feet |                                                           |                                             |                                                      |                                                           |                                                         |
|                                            |                                | Iron<br>Pipe<br>Size | Sched.<br>No. |                                          |                                             |                                              |                                             |                             |                           |                                                           |                                             |                                                      |                                                           |                                                         |
| 3/2                                        | 4.000                          | ...                  | ...           | 5S                                       | .083                                        | 3.834                                        | 1.021                                       | 11.545                      | .08017                    | 1.960                                                     | 3.48                                        | 5.00                                                 | 1.047                                                     | .9799                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .120                                        | 3.760                                        | 1.463                                       | 11.104                      | .07711                    | 2.755                                                     | 4.97                                        | 4.81                                                 | 1.047                                                     | 1.378                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .226                                        | 3.548                                        | 2.680                                       | 9.886                       | .06870                    | 4.788                                                     | 9.11                                        | 4.29                                                 | 1.047                                                     | 2.394                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .318                                        | 3.364                                        | 3.678                                       | 8.888                       | .06170                    | 6.280                                                     | 12.50                                       | 3.84                                                 | 1.047                                                     | 3.140                                                   |
| 4                                          | 4.500                          | ...                  | ...           | 5S                                       | .083                                        | 4.334                                        | 1.152                                       | 14.75                       | .10245                    | 2.810                                                     | 3.92                                        | 6.39                                                 | 1.178                                                     | 1.249                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .120                                        | 4.260                                        | 1.651                                       | 14.25                       | .09898                    | 3.963                                                     | 5.61                                        | 6.18                                                 | 1.178                                                     | 1.761                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .237                                        | 4.026                                        | 3.174                                       | 12.73                       | .08840                    | 7.233                                                     | 10.79                                       | 5.50                                                 | 1.178                                                     | 3.214                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .337                                        | 3.826                                        | 4.407                                       | 11.50                       | .07986                    | 9.610                                                     | 14.98                                       | 4.98                                                 | 1.178                                                     | 4.271                                                   |
|                                            |                                | ...                  | 120           | ...                                      | .438                                        | 3.624                                        | 5.595                                       | 10.31                       | .0716                     | 11.65                                                     | 19.00                                       | 4.47                                                 | 1.178                                                     | 5.178                                                   |
|                                            |                                | ...                  | 160           | ...                                      | .531                                        | 3.438                                        | 6.621                                       | 9.28                        | .0645                     | 13.27                                                     | 22.51                                       | 4.02                                                 | 1.178                                                     | 5.898                                                   |
| 5                                          | 5.563                          | ...                  | ...           | 5S                                       | .109                                        | 5.345                                        | 1.868                                       | 22.44                       | .1558                     | 6.947                                                     | 6.36                                        | 9.72                                                 | 1.456                                                     | 2.498                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .134                                        | 5.295                                        | 2.285                                       | 22.02                       | .1529                     | 8.425                                                     | 7.77                                        | 9.54                                                 | 1.456                                                     | 3.029                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .258                                        | 5.047                                        | 4.300                                       | 20.01                       | .1390                     | 15.16                                                     | 14.62                                       | 8.67                                                 | 1.456                                                     | 5.451                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .375                                        | 4.813                                        | 6.112                                       | 18.19                       | .1263                     | 20.67                                                     | 20.78                                       | 7.88                                                 | 1.456                                                     | 7.431                                                   |
|                                            |                                | ...                  | 120           | ...                                      | .500                                        | 4.563                                        | 7.953                                       | 16.35                       | .1136                     | 25.73                                                     | 27.04                                       | 7.09                                                 | 1.456                                                     | 9.250                                                   |
|                                            |                                | ...                  | 160           | ...                                      | .625                                        | 4.313                                        | 9.696                                       | 14.61                       | .1015                     | 30.03                                                     | 32.96                                       | 6.33                                                 | 1.456                                                     | 10.796                                                  |
| 6                                          | 6.625                          | ...                  | ...           | 5S                                       | .109                                        | 6.407                                        | 2.231                                       | 32.24                       | .2239                     | 11.85                                                     | 7.60                                        | 13.97                                                | 1.734                                                     | 3.576                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .134                                        | 6.357                                        | 2.733                                       | 31.74                       | .2204                     | 14.40                                                     | 9.29                                        | 13.75                                                | 1.734                                                     | 4.346                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .280                                        | 6.065                                        | 5.581                                       | 28.89                       | .2006                     | 28.14                                                     | 18.97                                       | 12.51                                                | 1.734                                                     | 8.496                                                   |
|                                            |                                | XS                   | 80            | 80S                                      | .432                                        | 5.761                                        | 8.405                                       | 26.07                       | .1810                     | 40.49                                                     | 28.57                                       | 11.29                                                | 1.734                                                     | 12.22                                                   |
|                                            |                                | ...                  | 120           | ...                                      | .562                                        | 5.501                                        | 10.70                                       | 23.77                       | .1650                     | 49.61                                                     | 36.39                                       | 10.30                                                | 1.734                                                     | 14.98                                                   |
|                                            |                                | ...                  | 160           | ...                                      | .719                                        | 5.187                                        | 13.32                                       | 21.15                       | .1469                     | 58.97                                                     | 45.35                                       | 9.16                                                 | 1.734                                                     | 17.81                                                   |
| 8                                          | 8.625                          | ...                  | ...           | 5S                                       | .109                                        | 8.407                                        | 2.916                                       | 55.51                       | .3855                     | 26.44                                                     | 9.93                                        | 24.06                                                | 2.258                                                     | 6.131                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .148                                        | 8.329                                        | 3.941                                       | 54.48                       | .3784                     | 35.41                                                     | 13.40                                       | 23.61                                                | 2.258                                                     | 8.212                                                   |
|                                            |                                | ...                  | 20            | ...                                      | .250                                        | 8.125                                        | 6.57                                        | 51.85                       | .3601                     | 57.72                                                     | 22.36                                       | 22.47                                                | 2.258                                                     | 13.39                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .277                                        | 8.071                                        | 7.26                                        | 51.16                       | .3553                     | 63.35                                                     | 24.70                                       | 22.17                                                | 2.258                                                     | 14.69                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .322                                        | 7.981                                        | 8.40                                        | 50.03                       | .3474                     | 72.49                                                     | 28.55                                       | 21.70                                                | 2.258                                                     | 16.81                                                   |
|                                            |                                | ...                  | 60            | ...                                      | .406                                        | 7.813                                        | 10.48                                       | 47.94                       | .3329                     | 88.73                                                     | 35.64                                       | 20.77                                                | 2.258                                                     | 20.58                                                   |
| 10                                         | 10.750                         | ...                  | ...           | 5S                                       | .109                                        | 10.482                                       | 4.36                                        | 86.29                       | .5992                     | 63.0                                                      | 15.19                                       | 37.39                                                | 2.814                                                     | 11.71                                                   |
|                                            |                                | ...                  | ...           | 10S                                      | .165                                        | 10.420                                       | 5.49                                        | 85.28                       | .5922                     | 76.9                                                      | 18.65                                       | 36.95                                                | 2.814                                                     | 14.30                                                   |
|                                            |                                | ...                  | 20            | ...                                      | .250                                        | 10.250                                       | 8.24                                        | 82.52                       | .5731                     | 113.7                                                     | 28.04                                       | 35.76                                                | 2.814                                                     | 21.15                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .307                                        | 10.136                                       | 10.07                                       | 80.69                       | .5603                     | 137.4                                                     | 34.24                                       | 34.96                                                | 2.814                                                     | 25.57                                                   |
|                                            |                                | STD                  | 40            | 40S                                      | .365                                        | 10.020                                       | 11.90                                       | 78.86                       | .5475                     | 160.7                                                     | 40.48                                       | 34.20                                                | 2.814                                                     | 29.90                                                   |
|                                            |                                | XS                   | 60            | 80S                                      | .500                                        | 9.750                                        | 16.10                                       | 74.66                       | .5185                     | 212.0                                                     | 54.74                                       | 32.35                                                | 2.814                                                     | 39.43                                                   |
| 12                                         | 12.75                          | ...                  | ...           | 5S                                       | .156                                        | 12.438                                       | 6.17                                        | 121.50                      | .8438                     | 122.4                                                     | 20.98                                       | 52.65                                                | 3.338                                                     | 19.2                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .180                                        | 12.390                                       | 7.11                                        | 120.57                      | .8373                     | 140.4                                                     | 24.17                                       | 52.25                                                | 3.338                                                     | 22.0                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .250                                        | 12.250                                       | 9.82                                        | 117.86                      | .8185                     | 191.8                                                     | 33.38                                       | 51.07                                                | 3.338                                                     | 30.2                                                    |
|                                            |                                | ...                  | 30            | ...                                      | .330                                        | 12.090                                       | 12.87                                       | 114.80                      | .7972                     | 248.4                                                     | 43.77                                       | 49.74                                                | 3.338                                                     | 39.0                                                    |
|                                            |                                | STD                  | 40            | 40S                                      | .375                                        | 12.000                                       | 14.58                                       | 113.10                      | .7854                     | 279.3                                                     | 49.56                                       | 49.00                                                | 3.338                                                     | 43.8                                                    |
|                                            |                                | XS                   | 60            | 80S                                      | .500                                        | 11.938                                       | 15.77                                       | 111.93                      | .7773                     | 300.3                                                     | 53.52                                       | 48.50                                                | 3.338                                                     | 47.1                                                    |



# GENERAL ENGINEERING DATA

## Pipe Data

### Carbon and Alloy Steel - Stainless Steel

| Nom-<br>inal<br>Pipe<br>Size<br><br>Inches | Outside<br>Diam.<br><br>Inches | Identification       |               |                                          | Wall<br>Thick-<br>ness<br>(t)<br><br>Inches | Inside<br>Diam-<br>eter<br>(d)<br><br>Inches | Area<br>of<br>Metal<br><br>Square<br>Inches | Transverse                  |                           | Moment<br>of<br>Inertia<br>(I)<br><br>Inches <sup>4</sup> | Weight<br>Pipe<br><br>Pounds<br>per<br>foot | Weight<br>Water<br><br>Pounds<br>per foot<br>of pipe | External<br>Surface<br><br>Sq. Ft.<br>per foot<br>of pipe | Section<br>Modulus<br><br>$\left(\frac{I}{O.D.}\right)$ |
|--------------------------------------------|--------------------------------|----------------------|---------------|------------------------------------------|---------------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------|---------------------------|-----------------------------------------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------|
|                                            |                                | Steel                |               | Stain-<br>less<br>Steel<br>Sched.<br>No. |                                             |                                              |                                             | Internal Area               |                           |                                                           |                                             |                                                      |                                                           |                                                         |
|                                            |                                | Iron<br>Pipe<br>Size | Sched.<br>No. |                                          |                                             |                                              |                                             | (a)<br><br>Square<br>Inches | (A)<br><br>Square<br>Feet |                                                           |                                             |                                                      |                                                           |                                                         |
| 14                                         | 14.00                          | ...                  | ...           | 5S                                       | .156                                        | 13.688                                       | 6.78                                        | 147.15                      | 1.0219                    | 162.6                                                     | 23.07                                       | 63.77                                                | 3.665                                                     | 23.2                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .188                                        | 13.624                                       | 8.16                                        | 145.78                      | 1.0124                    | 194.6                                                     | 27.73                                       | 63.17                                                | 3.665                                                     | 27.8                                                    |
|                                            |                                | ...                  | 10            | ...                                      | .250                                        | 13.500                                       | 10.80                                       | 143.14                      | .9940                     | 255.3                                                     | 36.71                                       | 62.03                                                | 3.665                                                     | 36.6                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .312                                        | 13.376                                       | 13.42                                       | 140.52                      | .9758                     | 314.4                                                     | 45.61                                       | 60.89                                                | 3.665                                                     | 45.0                                                    |
|                                            |                                | STD                  | 30            | ...                                      | .375                                        | 13.250                                       | 16.05                                       | 137.88                      | .9575                     | 372.8                                                     | 54.57                                       | 59.75                                                | 3.665                                                     | 53.2                                                    |
|                                            |                                | ...                  | 40            | ...                                      | .438                                        | 13.124                                       | 18.66                                       | 135.28                      | .9394                     | 429.1                                                     | 63.44                                       | 58.64                                                | 3.665                                                     | 61.3                                                    |
|                                            |                                | XS                   | ...           | ...                                      | .500                                        | 13.000                                       | 21.21                                       | 132.73                      | .9217                     | 483.8                                                     | 72.09                                       | 57.46                                                | 3.665                                                     | 69.1                                                    |
|                                            |                                | ...                  | 60            | ...                                      | .594                                        | 12.812                                       | 24.98                                       | 128.96                      | .8956                     | 562.3                                                     | 85.05                                       | 55.86                                                | 3.665                                                     | 80.3                                                    |
|                                            |                                | ...                  | 80            | ...                                      | .750                                        | 12.500                                       | 31.22                                       | 122.72                      | .8522                     | 678.3                                                     | 106.13                                      | 53.18                                                | 3.665                                                     | 98.2                                                    |
|                                            |                                | ...                  | 100           | ...                                      | .938                                        | 12.124                                       | 38.45                                       | 115.49                      | .8020                     | 824.4                                                     | 130.85                                      | 50.04                                                | 3.665                                                     | 117.8                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 1.094                                       | 11.812                                       | 44.32                                       | 109.62                      | .7612                     | 929.6                                                     | 150.79                                      | 47.45                                                | 3.665                                                     | 132.8                                                   |
|                                            |                                | ...                  | 140           | ...                                      | 1.250                                       | 11.500                                       | 50.07                                       | 103.87                      | .7213                     | 1027.0                                                    | 170.28                                      | 45.01                                                | 3.665                                                     | 146.8                                                   |
| ...                                        | 160                            | ...                  | 1.406         | 11.188                                   | 55.63                                       | 98.31                                        | .6827                                       | 1117.0                      | 189.11                    | 42.60                                                     | 3.665                                       | 159.6                                                |                                                           |                                                         |
| 16                                         | 16.00                          | ...                  | ...           | 5S                                       | .165                                        | 15.670                                       | 8.21                                        | 192.85                      | 1.3393                    | 257.3                                                     | 27.90                                       | 83.57                                                | 4.189                                                     | 32.2                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .188                                        | 15.624                                       | 9.34                                        | 191.72                      | 1.3314                    | 291.9                                                     | 31.75                                       | 83.08                                                | 4.189                                                     | 36.5                                                    |
|                                            |                                | ...                  | 10            | ...                                      | .250                                        | 15.500                                       | 12.37                                       | 188.69                      | 1.3103                    | 383.7                                                     | 42.05                                       | 81.74                                                | 4.189                                                     | 48.0                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .312                                        | 15.376                                       | 15.38                                       | 185.69                      | 1.2895                    | 473.2                                                     | 52.27                                       | 80.50                                                | 4.189                                                     | 59.2                                                    |
|                                            |                                | STD                  | 30            | ...                                      | .375                                        | 15.250                                       | 18.41                                       | 182.65                      | 1.2684                    | 562.1                                                     | 62.58                                       | 79.12                                                | 4.189                                                     | 70.3                                                    |
|                                            |                                | ...                  | 40            | ...                                      | .500                                        | 15.000                                       | 24.35                                       | 176.72                      | 1.2272                    | 731.9                                                     | 82.77                                       | 76.58                                                | 4.189                                                     | 91.5                                                    |
|                                            |                                | ...                  | 60            | ...                                      | .656                                        | 14.688                                       | 31.62                                       | 169.44                      | 1.1766                    | 932.4                                                     | 107.50                                      | 73.42                                                | 4.189                                                     | 116.6                                                   |
|                                            |                                | ...                  | 80            | ...                                      | .844                                        | 14.312                                       | 40.14                                       | 160.92                      | 1.1175                    | 1155.8                                                    | 136.61                                      | 69.73                                                | 4.189                                                     | 144.5                                                   |
|                                            |                                | ...                  | 100           | ...                                      | 1.031                                       | 13.938                                       | 48.48                                       | 152.58                      | 1.0596                    | 1364.5                                                    | 164.82                                      | 66.12                                                | 4.189                                                     | 170.5                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 1.219                                       | 13.562                                       | 56.56                                       | 144.50                      | 1.0035                    | 1555.8                                                    | 192.43                                      | 62.62                                                | 4.189                                                     | 194.5                                                   |
|                                            |                                | ...                  | 140           | ...                                      | 1.438                                       | 13.124                                       | 65.78                                       | 135.28                      | .9394                     | 1760.3                                                    | 223.64                                      | 58.64                                                | 4.189                                                     | 220.0                                                   |
|                                            |                                | ...                  | 160           | ...                                      | 1.594                                       | 12.812                                       | 72.10                                       | 128.96                      | .8956                     | 1893.5                                                    | 245.25                                      | 55.83                                                | 4.189                                                     | 236.7                                                   |
| 18                                         | 18.00                          | ...                  | ...           | 5S                                       | .165                                        | 17.670                                       | 9.25                                        | 245.22                      | 1.7029                    | 367.6                                                     | 31.43                                       | 106.26                                               | 4.712                                                     | 40.8                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .188                                        | 17.624                                       | 10.52                                       | 243.95                      | 1.6941                    | 417.3                                                     | 35.76                                       | 105.71                                               | 4.712                                                     | 46.4                                                    |
|                                            |                                | ...                  | 10            | ...                                      | .250                                        | 17.500                                       | 13.94                                       | 240.53                      | 1.6703                    | 549.1                                                     | 47.39                                       | 104.21                                               | 4.712                                                     | 61.1                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .312                                        | 17.376                                       | 17.34                                       | 237.13                      | 1.6467                    | 678.2                                                     | 58.94                                       | 102.77                                               | 4.712                                                     | 75.5                                                    |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 17.250                                       | 20.76                                       | 233.71                      | 1.6230                    | 806.7                                                     | 70.59                                       | 101.18                                               | 4.712                                                     | 89.6                                                    |
|                                            |                                | ...                  | 30            | ...                                      | .438                                        | 17.124                                       | 24.17                                       | 230.30                      | 1.5990                    | 930.3                                                     | 82.15                                       | 99.84                                                | 4.712                                                     | 103.4                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .500                                        | 17.000                                       | 27.49                                       | 226.98                      | 1.5763                    | 1053.2                                                    | 93.45                                       | 98.27                                                | 4.712                                                     | 117.0                                                   |
|                                            |                                | XS                   | ...           | ...                                      | .562                                        | 16.876                                       | 30.79                                       | 223.68                      | 1.5533                    | 1171.5                                                    | 104.67                                      | 96.93                                                | 4.712                                                     | 130.1                                                   |
|                                            |                                | ...                  | 60            | ...                                      | .750                                        | 16.500                                       | 40.64                                       | 213.83                      | 1.4849                    | 1514.7                                                    | 138.17                                      | 92.57                                                | 4.712                                                     | 168.3                                                   |
|                                            |                                | ...                  | 80            | ...                                      | .938                                        | 16.124                                       | 50.23                                       | 204.24                      | 1.4183                    | 1833.0                                                    | 170.92                                      | 88.50                                                | 4.712                                                     | 203.8                                                   |
|                                            |                                | ...                  | 100           | ...                                      | 1.156                                       | 15.688                                       | 61.17                                       | 193.30                      | 1.3423                    | 2180.0                                                    | 207.96                                      | 83.76                                                | 4.712                                                     | 242.3                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 1.375                                       | 15.250                                       | 71.81                                       | 182.66                      | 1.2684                    | 2498.1                                                    | 244.14                                      | 79.07                                                | 4.712                                                     | 277.6                                                   |
| ...                                        | 140                            | ...                  | 1.562         | 14.876                                   | 80.66                                       | 173.80                                       | 1.2070                                      | 2749.0                      | 274.22                    | 75.32                                                     | 4.712                                       | 305.5                                                |                                                           |                                                         |
| ...                                        | 160                            | ...                  | 1.781         | 14.438                                   | 90.75                                       | 163.72                                       | 1.1369                                      | 3020.0                      | 308.50                    | 70.88                                                     | 4.712                                       | 335.6                                                |                                                           |                                                         |
| 20                                         | 20.00                          | ...                  | ...           | 5S                                       | .188                                        | 19.624                                       | 11.70                                       | 302.46                      | 2.1004                    | 574.2                                                     | 39.78                                       | 131.06                                               | 5.236                                                     | 57.4                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .218                                        | 19.564                                       | 13.55                                       | 300.61                      | 2.0876                    | 662.8                                                     | 46.06                                       | 130.27                                               | 5.236                                                     | 66.3                                                    |
|                                            |                                | ...                  | 10            | ...                                      | .250                                        | 19.500                                       | 15.51                                       | 298.65                      | 2.0740                    | 765.4                                                     | 52.73                                       | 129.42                                               | 5.236                                                     | 75.6                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .375                                        | 19.250                                       | 23.12                                       | 290.04                      | 2.0142                    | 1113.0                                                    | 78.60                                       | 125.67                                               | 5.236                                                     | 111.3                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .500                                        | 19.000                                       | 30.63                                       | 283.53                      | 1.9690                    | 1457.0                                                    | 104.13                                      | 122.87                                               | 5.236                                                     | 145.7                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .594                                        | 18.812                                       | 36.15                                       | 278.00                      | 1.9305                    | 1703.0                                                    | 123.11                                      | 120.46                                               | 5.236                                                     | 170.4                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .812                                        | 18.376                                       | 48.95                                       | 265.21                      | 1.8417                    | 2257.0                                                    | 166.40                                      | 114.92                                               | 5.236                                                     | 225.7                                                   |
|                                            |                                | ...                  | 60            | ...                                      | 1.031                                       | 17.938                                       | 61.44                                       | 252.72                      | 1.7550                    | 2772.0                                                    | 208.87                                      | 109.51                                               | 5.236                                                     | 277.1                                                   |
|                                            |                                | ...                  | 80            | ...                                      | 1.281                                       | 17.438                                       | 75.33                                       | 238.83                      | 1.6585                    | 3315.2                                                    | 256.10                                      | 103.39                                               | 5.236                                                     | 331.5                                                   |
|                                            |                                | ...                  | 100           | ...                                      | 1.500                                       | 17.000                                       | 87.18                                       | 226.98                      | 1.5762                    | 3754.0                                                    | 296.37                                      | 98.35                                                | 5.236                                                     | 375.5                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 1.750                                       | 16.500                                       | 100.33                                      | 213.82                      | 1.4849                    | 4216.0                                                    | 341.09                                      | 92.66                                                | 5.236                                                     | 421.7                                                   |
|                                            |                                | ...                  | 140           | ...                                      | 1.969                                       | 16.062                                       | 111.49                                      | 202.67                      | 1.4074                    | 4585.5                                                    | 379.17                                      | 87.74                                                | 5.236                                                     | 458.5                                                   |
| 22                                         | 22.00                          | ...                  | ...           | 5S                                       | .188                                        | 21.624                                       | 12.88                                       | 367.25                      | 2.5503                    | 766.2                                                     | 43.80                                       | 159.14                                               | 5.760                                                     | 69.7                                                    |
|                                            |                                | ...                  | ...           | 10S                                      | .218                                        | 21.564                                       | 14.92                                       | 365.21                      | 2.5362                    | 884.8                                                     | 50.71                                       | 158.26                                               | 5.760                                                     | 80.4                                                    |
|                                            |                                | ...                  | 10            | ...                                      | .250                                        | 21.500                                       | 17.08                                       | 363.05                      | 2.5212                    | 1010.3                                                    | 58.07                                       | 157.32                                               | 5.760                                                     | 91.8                                                    |
|                                            |                                | ...                  | 20            | ...                                      | .375                                        | 21.250                                       | 25.48                                       | 354.66                      | 2.4629                    | 1489.7                                                    | 86.61                                       | 153.68                                               | 5.760                                                     | 135.4                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .500                                        | 21.000                                       | 33.77                                       | 346.36                      | 2.4053                    | 1952.5                                                    | 114.81                                      | 150.09                                               | 5.760                                                     | 171.5                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .875                                        | 20.250                                       | 58.07                                       | 322.06                      | 2.2365                    | 3244.9                                                    | 197.41                                      | 139.56                                               | 5.760                                                     | 295.0                                                   |
|                                            |                                | ...                  | 40            | ...                                      | 1.125                                       | 19.75                                        | 73.78                                       | 306.35                      | 2.1275                    | 4030.4                                                    | 250.81                                      | 132.76                                               | 5.760                                                     | 366.4                                                   |
|                                            |                                | ...                  | 60            | ...                                      | 1.375                                       | 19.25                                        | 89.09                                       | 291.04                      | 2.0211                    | 4758.5                                                    | 302.88                                      | 126.12                                               | 5.760                                                     | 432.6                                                   |
|                                            |                                | ...                  | 80            | ...                                      | 1.625                                       | 18.75                                        | 104.02                                      | 276.12                      | 1.9175                    | 5432.0                                                    | 353.61                                      | 119.65                                               | 5.760                                                     | 493.8                                                   |
|                                            |                                | ...                  | 100           | ...                                      | 1.875                                       | 18.25                                        | 118.55                                      | 261.59                      | 1.8166                    | 6053.7                                                    | 403.00                                      | 113.36                                               | 5.760                                                     | 550.3                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 2.125                                       | 17.75                                        | 132.68                                      | 247.45                      | 1.7184                    | 6626.4                                                    | 451.06                                      | 107.23                                               | 5.760                                                     | 602.4                                                   |
|                                            |                                | ...                  | 140           | ...                                      | 2.375                                       | 17.25                                        | 148.88                                      | 232.88                      | 1.6271                    | 7288.8                                                    | 507.91                                      | 102.88                                               | 5.760                                                     | 660.8                                                   |
| ...                                        | 160                            | ...                  | 2.625         | 16.75                                    | 165.31                                      | 218.31                                       | 1.5358                                      | 7951.2                      | 564.82                    | 100.00                                                    | 5.760                                       | 720.2                                                |                                                           |                                                         |

Identification, wall thickness and weights are extracted from ANSI B36.10 and B36.19. The notations STD, XS, and XXS indicate Standard, Extra Strong, and Double Extra Strong pipe respectively.

Transverse internal area values listed in "square feet" also represent volume in cubic feet per foot of pipe length.

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# GENERAL ENGINEERING DATA

## Pipe Data

### Carbon and Alloy Steel - Stainless Steel

| Nom-<br>inal<br>Pipe<br>Size<br><br>Inches | Outside<br>Diam.<br><br>Inches | Identification       |               |                                          | Wall<br>Thick-<br>ness<br>(t)<br><br>Inches | Inside<br>Diam-<br>eter<br>(d)<br><br>Inches | Area<br>of<br>Metal<br><br>Square<br>Inches | Transverse<br>Internal Area |                           | Moment<br>of<br>Inertia<br>(I)<br><br>Inches <sup>4</sup> | Weight<br>Pipe<br><br>Pounds<br>per<br>foot | Weight<br>Water<br><br>Pounds<br>per foot<br>of pipe | External<br>Surface<br><br>Sq. Ft.<br>per foot<br>of pipe | Section<br>Modulus<br><br>$\left(\frac{I}{O.D.}\right)$ |
|--------------------------------------------|--------------------------------|----------------------|---------------|------------------------------------------|---------------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------|---------------------------|-----------------------------------------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------|
|                                            |                                | Steel                |               | Stain-<br>less<br>Steel<br>Sched.<br>No. |                                             |                                              |                                             | (a)<br><br>Square<br>Inches | (A)<br><br>Square<br>Feet |                                                           |                                             |                                                      |                                                           |                                                         |
|                                            |                                | Iron<br>Pipe<br>Size | Sched.<br>No. |                                          |                                             |                                              |                                             |                             |                           |                                                           |                                             |                                                      |                                                           |                                                         |
| 24                                         | 24.00                          | ...                  | ...           | 5S                                       | .218                                        | 23.564                                       | 16.29                                       | 436.10                      | 3.0285                    | 1151.6                                                    | 55.37                                       | 188.98                                               | 6.283                                                     | 96.0                                                    |
|                                            |                                | ...                  | 10            | 10S                                      | .250                                        | 23.500                                       | 18.65                                       | 433.74                      | 3.0121                    | 1315.4                                                    | 63.41                                       | 187.95                                               | 6.283                                                     | 109.6                                                   |
|                                            |                                | STD                  | 20            | ...                                      | .375                                        | 23.250                                       | 27.83                                       | 424.56                      | 2.9483                    | 1942.0                                                    | 94.62                                       | 183.95                                               | 6.283                                                     | 161.9                                                   |
|                                            |                                | XS                   | ...           | ...                                      | .500                                        | 23.000                                       | 36.91                                       | 415.48                      | 2.8853                    | 2549.5                                                    | 125.49                                      | 179.87                                               | 6.283                                                     | 212.5                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .562                                        | 22.876                                       | 41.39                                       | 411.00                      | 2.8542                    | 2843.0                                                    | 140.68                                      | 178.09                                               | 6.283                                                     | 237.0                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .688                                        | 22.624                                       | 50.31                                       | 402.07                      | 2.7921                    | 3421.3                                                    | 171.29                                      | 174.23                                               | 6.283                                                     | 285.1                                                   |
|                                            |                                | ...                  | 60            | ...                                      | .969                                        | 22.062                                       | 70.04                                       | 382.35                      | 2.6552                    | 4652.8                                                    | 238.35                                      | 165.52                                               | 6.283                                                     | 387.7                                                   |
|                                            |                                | ...                  | 80            | ...                                      | 1.219                                       | 21.562                                       | 87.17                                       | 365.22                      | 2.5362                    | 5672.0                                                    | 296.58                                      | 158.26                                               | 6.283                                                     | 472.8                                                   |
|                                            |                                | ...                  | 100           | ...                                      | 1.531                                       | 20.938                                       | 108.07                                      | 344.32                      | 2.3911                    | 6849.9                                                    | 367.39                                      | 149.06                                               | 6.283                                                     | 570.8                                                   |
|                                            |                                | ...                  | 120           | ...                                      | 1.812                                       | 20.376                                       | 126.31                                      | 326.08                      | 2.2645                    | 7825.0                                                    | 429.39                                      | 141.17                                               | 6.283                                                     | 652.1                                                   |
|                                            |                                | ...                  | 140           | ...                                      | 2.062                                       | 19.876                                       | 142.11                                      | 310.28                      | 2.1547                    | 8625.0                                                    | 483.12                                      | 134.45                                               | 6.283                                                     | 718.9                                                   |
|                                            |                                | ...                  | 160           | ...                                      | 2.344                                       | 19.312                                       | 159.41                                      | 292.98                      | 2.0346                    | 9455.9                                                    | 542.13                                      | 126.84                                               | 6.283                                                     | 787.9                                                   |
| 26                                         | 26.00                          | ...                  | 10            | ...                                      | .312                                        | 25.376                                       | 25.18                                       | 505.75                      | 3.5122                    | 2077.2                                                    | 85.60                                       | 219.16                                               | 6.806                                                     | 159.8                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 25.250                                       | 30.19                                       | 500.74                      | 3.4774                    | 2478.4                                                    | 102.63                                      | 216.99                                               | 6.806                                                     | 190.6                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 25.000                                       | 40.06                                       | 490.87                      | 3.4088                    | 3257.0                                                    | 136.17                                      | 212.71                                               | 6.806                                                     | 250.5                                                   |
| 28                                         | 28.00                          | ...                  | 10            | ...                                      | .312                                        | 27.376                                       | 27.14                                       | 588.61                      | 4.0876                    | 2601.0                                                    | 92.26                                       | 255.07                                               | 7.330                                                     | 185.8                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 27.250                                       | 32.54                                       | 583.21                      | 4.0501                    | 3105.1                                                    | 110.64                                      | 252.73                                               | 7.330                                                     | 221.8                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 27.000                                       | 43.20                                       | 572.56                      | 3.9761                    | 4084.8                                                    | 146.85                                      | 248.11                                               | 7.330                                                     | 291.8                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .625                                        | 26.750                                       | 53.75                                       | 562.00                      | 3.9028                    | 5037.7                                                    | 182.73                                      | 243.53                                               | 7.330                                                     | 359.8                                                   |
| 30                                         | 30.00                          | ...                  | ...           | 5S                                       | .250                                        | 29.500                                       | 23.37                                       | 683.49                      | 4.7465                    | 2585.2                                                    | 79.43                                       | 296.18                                               | 7.854                                                     | 172.3                                                   |
|                                            |                                | ...                  | 10            | 10S                                      | .312                                        | 29.376                                       | 29.10                                       | 677.76                      | 4.7067                    | 3206.3                                                    | 98.93                                       | 293.70                                               | 7.854                                                     | 213.8                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 29.250                                       | 34.90                                       | 671.96                      | 4.6664                    | 3829.4                                                    | 118.65                                      | 291.18                                               | 7.854                                                     | 255.3                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 29.000                                       | 46.34                                       | 660.52                      | 4.5869                    | 5042.2                                                    | 157.53                                      | 286.22                                               | 7.854                                                     | 336.1                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .625                                        | 28.750                                       | 57.68                                       | 649.18                      | 4.5082                    | 6224.0                                                    | 196.08                                      | 281.31                                               | 7.854                                                     | 414.9                                                   |
| 32                                         | 32.00                          | ...                  | 10            | ...                                      | .312                                        | 31.376                                       | 31.06                                       | 773.19                      | 5.3694                    | 3898.9                                                    | 105.59                                      | 335.05                                               | 8.378                                                     | 243.7                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 31.250                                       | 37.26                                       | 766.99                      | 5.3263                    | 4658.5                                                    | 126.66                                      | 332.36                                               | 8.378                                                     | 291.2                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 31.000                                       | 49.48                                       | 754.77                      | 5.2414                    | 6138.6                                                    | 168.21                                      | 327.06                                               | 8.378                                                     | 383.7                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .625                                        | 30.750                                       | 61.60                                       | 742.64                      | 5.1572                    | 7583.4                                                    | 209.43                                      | 321.81                                               | 8.378                                                     | 474.0                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .688                                        | 30.624                                       | 67.68                                       | 736.57                      | 5.1151                    | 8298.3                                                    | 230.08                                      | 319.18                                               | 8.378                                                     | 518.6                                                   |
| 34                                         | 34.00                          | ...                  | 10            | ...                                      | .344                                        | 33.312                                       | 36.37                                       | 871.55                      | 6.0524                    | 5150.5                                                    | 123.65                                      | 377.67                                               | 8.901                                                     | 303.0                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 33.250                                       | 39.61                                       | 868.31                      | 6.0299                    | 5599.3                                                    | 134.67                                      | 376.27                                               | 8.901                                                     | 329.4                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 33.000                                       | 52.62                                       | 855.30                      | 5.9396                    | 7383.5                                                    | 178.89                                      | 370.63                                               | 8.901                                                     | 434.3                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .625                                        | 32.750                                       | 65.53                                       | 842.39                      | 5.8499                    | 9127.6                                                    | 222.78                                      | 365.03                                               | 8.901                                                     | 536.9                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .688                                        | 32.624                                       | 72.00                                       | 835.92                      | 5.8050                    | 9991.6                                                    | 244.77                                      | 362.23                                               | 8.901                                                     | 587.7                                                   |
| 36                                         | 36.00                          | ...                  | 10            | ...                                      | .312                                        | 35.376                                       | 34.98                                       | 982.90                      | 6.8257                    | 5569.5                                                    | 118.92                                      | 425.92                                               | 9.425                                                     | 309.4                                                   |
|                                            |                                | STD                  | ...           | ...                                      | .375                                        | 35.250                                       | 41.97                                       | 975.91                      | 6.7771                    | 6658.9                                                    | 142.68                                      | 422.89                                               | 9.425                                                     | 369.9                                                   |
|                                            |                                | XS                   | 20            | ...                                      | .500                                        | 35.000                                       | 55.76                                       | 962.11                      | 6.6813                    | 8786.2                                                    | 189.57                                      | 416.91                                               | 9.425                                                     | 488.1                                                   |
|                                            |                                | ...                  | 30            | ...                                      | .625                                        | 34.750                                       | 69.46                                       | 948.42                      | 6.5862                    | 10868.4                                                   | 236.13                                      | 417.22                                               | 9.425                                                     | 603.8                                                   |
|                                            |                                | ...                  | 40            | ...                                      | .750                                        | 34.500                                       | 83.06                                       | 934.82                      | 6.4918                    | 12906.1                                                   | 282.35                                      | 405.09                                               | 9.425                                                     | 717.0                                                   |

Identification, wall thickness and weights are extracted from ANSI B36.10 and B36.19. The notations STD, XS, and XXS indicate Standard, Extra Strong, and Double Extra Strong pipe respectively.

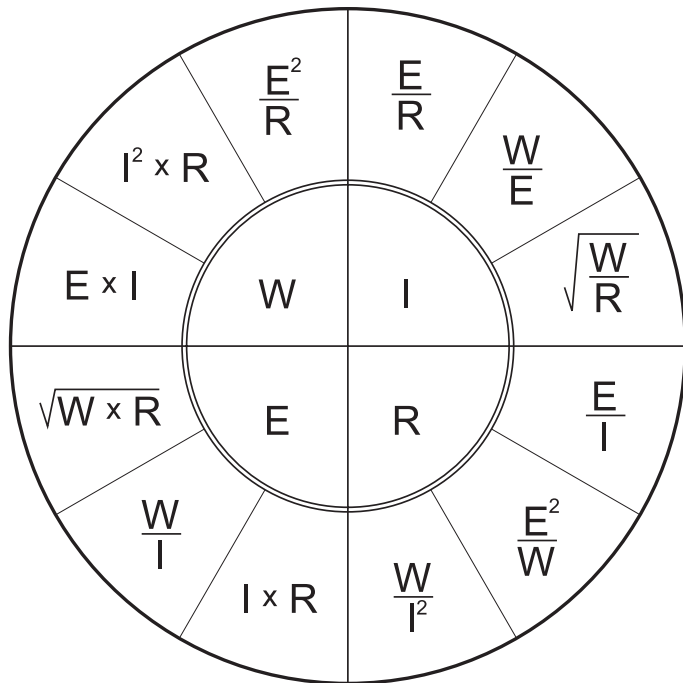
Transverse internal area values listed in "square feet" also represent volume in cubic feet per foot of pipe length.

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## GENERAL ENGINEERING DATA

### Electrical Formulas



**W** = Power (Watts)  
**E** = Voltage (Volts)  
**I** = Current (Amperes)  
**R** = Resistance (Ohms)

### Electrical Units:

**Volts:** The units of electrical motive force. Force required to move one ampere of current through one ohm of resistance.

**Ohms:** The units of resistance. The resistance offered to the passage of one ampere, when moved by one volt of force.

**Amps:** The units of current. The current which one volt can move through a resistance of one ohm.

**Watts:** The unit of electrical energy or power, and is the product of one ampere and one volt. That is, one ampere of current flowing under a force of one volt gives one watt of energy.

#### Volt

**Amps:** The product of the volts and amperes as shown by a voltmeter and ammeter. In direct current systems, this is the same as watts (energy delivered). In alternating current systems, the volts and amperes may or may not lie in step. When in step, the volt amperes equal the watts shown directly on a wattmeter. When out of step, volt amperes exceed watts.

#### Kilovolt

**Amp:** One kilovolt ampere (KVA) is equal to 1,000 volt amperes.

#### Power

**Factor:** The ratio of watts to volt amperes.

**Farad:** The unit of capacity of a condenser charged to the potential of one volt by one ampere of electricity per second.

#### Micro-

**Farad:** Equal to 1/1,000,000 part of a Farad.

### Electric Consumption:

The cost to run electric auxiliaries should not be overlooked when considering the total cost to run a facility. The cost of electric auxiliaries can be found by determining the Kilowatt hours used and your cost per kilowatt - hour. The following are some "rule of thumb" relationships:

One Horsepower of Electricity is equal to 0.746 kilowatts.

A 1 HP. motor running at full load for 24 hours would use 17.90 Kilowatt-hours of electricity.

# GENERAL ENGINEERING DATA

## Properties of Saturated Steam and Saturated Water

| Absolute Pressure                |                 | Vacuum<br>Inches<br>of Hg | Temper-<br>ature<br><i>t</i><br>Degrees F. | Heat of<br>the<br>Liquid<br>Btu/lb. | Latent Heat<br>of<br>Evaporation<br>Btu/lb. | Total Heat<br>of Steam<br><i>h<sub>g</sub></i><br>Btu/lb. | Specific Volume<br><i>V</i> |                          |
|----------------------------------|-----------------|---------------------------|--------------------------------------------|-------------------------------------|---------------------------------------------|-----------------------------------------------------------|-----------------------------|--------------------------|
| Lbs. per<br>Sq. In.<br><i>P'</i> | Inches<br>of Hg |                           |                                            |                                     |                                             |                                                           | Water<br>Cu. ft. per lb.    | Steam<br>Cu. ft. per lb. |
| 0.08859                          | 0.02            | 29.90                     | 32.018                                     | 0.0003                              | 1075.5                                      | 1075.5                                                    | 0.016022                    | 3302.4                   |
| 0.10                             | 0.20            | 29.72                     | 35.023                                     | 3.026                               | 1073.8                                      | 1076.8                                                    | 0.016020                    | 2945.5                   |
| 0.15                             | 0.31            | 29.61                     | 45.453                                     | 13.498                              | 1067.9                                      | 1081.4                                                    | 0.016020                    | 2004.7                   |
| 0.20                             | 0.41            | 29.51                     | 53.160                                     | 21.217                              | 1053.5                                      | 1084.7                                                    | 0.016025                    | 1526.3                   |
| 0.25                             | 0.51            | 29.41                     | 59.323                                     | 27.382                              | 1060.1                                      | 1087.4                                                    | 0.016032                    | 1235.5                   |
| 0.30                             | 0.61            | 29.31                     | 64.484                                     | 32.541                              | 1057.1                                      | 1089.7                                                    | 0.016040                    | 1039.7                   |
| 0.35                             | 0.71            | 29.21                     | 68.939                                     | 36.992                              | 1054.6                                      | 1091.6                                                    | 0.016048                    | 898.6                    |
| 0.40                             | 0.81            | 29.11                     | 72.869                                     | 40.917                              | 1052.4                                      | 1093.3                                                    | 0.016056                    | 792.1                    |
| 0.45                             | 0.92            | 29.00                     | 76.387                                     | 44.430                              | 1050.5                                      | 1094.9                                                    | 0.016063                    | 708.8                    |
| 0.50                             | 1.02            | 28.90                     | 79.586                                     | 47.623                              | 1048.6                                      | 1096.3                                                    | 0.016071                    | 641.5                    |
| 0.60                             | 1.22            | 28.70                     | 85.218                                     | 53.245                              | 1045.5                                      | 1098.7                                                    | 0.016085                    | 540.1                    |
| 0.70                             | 1.43            | 28.49                     | 90.09                                      | 58.10                               | 1042.7                                      | 1100.8                                                    | 0.016099                    | 466.94                   |
| 0.80                             | 1.63            | 28.29                     | 94.38                                      | 62.39                               | 1040.3                                      | 1102.6                                                    | 0.016112                    | 411.69                   |
| 0.90                             | 1.83            | 28.09                     | 98.24                                      | 66.24                               | 1038.1                                      | 1104.3                                                    | 0.016124                    | 368.43                   |
| 1.0                              | 2.04            | 27.88                     | 101.74                                     | 69.73                               | 1036.1                                      | 1105.8                                                    | 0.016136                    | 333.60                   |
| 1.2                              | 2.44            | 27.48                     | 107.91                                     | 75.90                               | 1032.6                                      | 1108.5                                                    | 0.016158                    | 280.96                   |
| 1.4                              | 2.85            | 27.07                     | 113.26                                     | 81.23                               | 1029.5                                      | 1110.7                                                    | 0.016178                    | 243.02                   |
| 1.6                              | 3.26            | 26.66                     | 117.98                                     | 85.95                               | 1026.8                                      | 1112.7                                                    | 0.016196                    | 214.33                   |
| 1.8                              | 3.66            | 26.26                     | 122.22                                     | 90.18                               | 1024.3                                      | 1114.5                                                    | 0.016213                    | 191.85                   |
| 2.0                              | 4.07            | 25.85                     | 126.07                                     | 94.03                               | 1022.1                                      | 1116.2                                                    | 0.016230                    | 173.76                   |
| 2.2                              | 4.48            | 25.44                     | 129.61                                     | 97.57                               | 1020.1                                      | 1117.6                                                    | 0.016245                    | 158.87                   |
| 2.4                              | 4.89            | 25.03                     | 132.88                                     | 100.84                              | 1018.2                                      | 1119.0                                                    | 0.016260                    | 146.40                   |
| 2.6                              | 5.29            | 24.63                     | 135.93                                     | 103.88                              | 1016.4                                      | 1120.3                                                    | 0.016274                    | 135.80                   |
| 2.8                              | 5.70            | 24.22                     | 138.78                                     | 106.73                              | 1014.7                                      | 1121.5                                                    | 0.016287                    | 126.67                   |
| 3.0                              | 6.11            | 23.81                     | 141.47                                     | 109.42                              | 1013.2                                      | 1122.6                                                    | 0.016300                    | 118.73                   |
| 3.5                              | 7.13            | 22.79                     | 147.56                                     | 115.51                              | 1009.6                                      | 1125.1                                                    | 0.016331                    | 102.74                   |
| 4.0                              | 8.14            | 21.78                     | 152.96                                     | 120.92                              | 1006.4                                      | 1127.3                                                    | 0.016358                    | 90.64                    |
| 4.5                              | 9.16            | 20.76                     | 157.82                                     | 125.77                              | 1003.5                                      | 1129.3                                                    | 0.016384                    | 83.03                    |
| 5.0                              | 10.18           | 19.74                     | 162.24                                     | 130.20                              | 1000.9                                      | 1131.1                                                    | 0.016407                    | 73.532                   |
| 5.5                              | 11.20           | 18.72                     | 166.29                                     | 134.26                              | 998.5                                       | 1132.7                                                    | 0.016430                    | 67.249                   |
| 6.0                              | 12.22           | 17.70                     | 170.05                                     | 138.03                              | 996.2                                       | 1134.2                                                    | 0.016451                    | 61.984                   |
| 6.5                              | 13.23           | 16.69                     | 173.56                                     | 141.54                              | 994.1                                       | 1135.6                                                    | 0.016472                    | 57.506                   |
| 7.0                              | 14.25           | 15.67                     | 176.84                                     | 144.83                              | 992.1                                       | 1136.9                                                    | 0.016491                    | 53.650                   |
| 7.5                              | 15.27           | 14.65                     | 179.93                                     | 147.93                              | 990.2                                       | 1138.2                                                    | 0.016510                    | 50.294                   |
| 8.0                              | 16.29           | 13.63                     | 182.86                                     | 150.87                              | 988.5                                       | 1139.3                                                    | 0.016527                    | 47.345                   |
| 8.5                              | 17.31           | 12.61                     | 185.63                                     | 153.65                              | 986.8                                       | 1140.4                                                    | 0.016545                    | 44.733                   |
| 9.0                              | 18.32           | 11.60                     | 188.27                                     | 156.30                              | 985.1                                       | 1141.4                                                    | 0.016561                    | 42.402                   |
| 9.5                              | 19.34           | 10.58                     | 190.80                                     | 158.84                              | 983.6                                       | 1142.4                                                    | 0.016577                    | 40.310                   |
| 10.0                             | 20.36           | 9.56                      | 193.21                                     | 161.26                              | 982.1                                       | 1143.3                                                    | 0.016592                    | 38.420                   |
| 11.0                             | 22.40           | 7.52                      | 197.75                                     | 165.82                              | 979.3                                       | 1145.1                                                    | 0.016622                    | 35.142                   |
| 12.0                             | 24.43           | 5.49                      | 201.96                                     | 170.05                              | 976.6                                       | 1146.7                                                    | 0.016650                    | 32.394                   |
| 13.0                             | 26.47           | 3.45                      | 205.88                                     | 174.00                              | 974.2                                       | 1148.2                                                    | 0.016676                    | 30.057                   |
| 14.0                             | 28.50           | 1.42                      | 209.56                                     | 177.71                              | 971.9                                       | 1149.6                                                    | 0.016702                    | 28.043                   |

| Pressure<br>Lbs. per Sq. In. |                  | Temper-<br>ature<br><i>t</i><br>Degrees F. | Heat of<br>the<br>Liquid<br>Btu/lb. | Latent Heat<br>of<br>Evaporation<br>Btu/lb. | Total Heat<br>of Steam<br><i>h<sub>g</sub></i><br>Btu/lb. | Specific Volume<br><i>V</i> |                          |
|------------------------------|------------------|--------------------------------------------|-------------------------------------|---------------------------------------------|-----------------------------------------------------------|-----------------------------|--------------------------|
| Absolute<br><i>P'</i>        | Gage<br><i>P</i> |                                            |                                     |                                             |                                                           | Water<br>Cu. ft. per lb.    | Steam<br>Cu. ft. per lb. |
| 14.696                       | 0.0              | 212.00                                     | 180.17                              | 970.3                                       | 1150.5                                                    | 0.016719                    | 26.799                   |
| 15.0                         | 0.3              | 213.03                                     | 181.21                              | 969.7                                       | 1150.9                                                    | 0.016726                    | 26.290                   |
| 16.0                         | 1.3              | 216.32                                     | 184.52                              | 967.6                                       | 1152.1                                                    | 0.016749                    | 24.750                   |
| 17.0                         | 2.3              | 219.44                                     | 187.66                              | 965.6                                       | 1153.2                                                    | 0.016771                    | 23.385                   |
| 18.0                         | 3.3              | 222.41                                     | 190.66                              | 963.7                                       | 1154.3                                                    | 0.016793                    | 22.168                   |
| 19.0                         | 4.3              | 225.24                                     | 193.52                              | 961.8                                       | 1155.3                                                    | 0.016814                    | 21.074                   |
| 20.0                         | 5.3              | 227.96                                     | 196.27                              | 960.1                                       | 1156.3                                                    | 0.016834                    | 20.087                   |
| 21.0                         | 6.3              | 230.57                                     | 198.90                              | 958.4                                       | 1157.3                                                    | 0.016854                    | 19.190                   |
| 22.0                         | 7.3              | 233.07                                     | 201.44                              | 956.7                                       | 1158.1                                                    | 0.016873                    | 18.373                   |
| 23.0                         | 8.3              | 235.49                                     | 203.88                              | 955.1                                       | 1159.0                                                    | 0.016891                    | 17.624                   |
| 24.0                         | 9.3              | 237.82                                     | 206.24                              | 953.6                                       | 1159.8                                                    | 0.016909                    | 16.936                   |
| 25.0                         | 10.3             | 240.07                                     | 208.52                              | 952.1                                       | 1160.6                                                    | 0.016927                    | 16.301                   |
| 26.0                         | 11.3             | 242.25                                     | 210.7                               | 950.6                                       | 1161.4                                                    | 0.016944                    | 15.7138                  |
| 27.0                         | 12.3             | 244.36                                     | 212.9                               | 949.2                                       | 1162.1                                                    | 0.016961                    | 15.1684                  |
| 28.0                         | 13.3             | 246.41                                     | 214.9                               | 947.9                                       | 1162.8                                                    | 0.016977                    | 14.6607                  |
| 29.0                         | 14.3             | 248.40                                     | 217.0                               | 946.5                                       | 1163.5                                                    | 0.016993                    | 14.1869                  |
| 30.0                         | 15.3             | 250.34                                     | 218.9                               | 945.2                                       | 1164.1                                                    | 0.017009                    | 13.7436                  |
| 31.0                         | 16.3             | 252.22                                     | 220.8                               | 943.9                                       | 1164.8                                                    | 0.017024                    | 13.3280                  |
| 32.0                         | 17.3             | 254.05                                     | 222.7                               | 942.7                                       | 1165.4                                                    | 0.017039                    | 12.9376                  |
| 33.0                         | 18.3             | 255.84                                     | 224.5                               | 941.5                                       | 1166.0                                                    | 0.017054                    | 12.5700                  |
| 34.0                         | 19.3             | 257.58                                     | 226.3                               | 940.3                                       | 1166.6                                                    | 0.017069                    | 12.2234                  |

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# GENERAL ENGINEERING DATA

## Properties of Saturated Steam and Saturated Water

| Pressure<br>Lbs. per Sq. In. |                  | Temperature<br><i>t</i><br>Degrees F. | Heat of the<br>Liquid<br>Btu/lb. | Latent Heat of<br>Evaporation<br>Btu/lb. | Total Heat of<br>Steam<br><i>h<sub>g</sub></i><br>Btu/lb. | Specific Volume<br><i>V</i> |                          |
|------------------------------|------------------|---------------------------------------|----------------------------------|------------------------------------------|-----------------------------------------------------------|-----------------------------|--------------------------|
| Absolute<br><i>P'</i>        | Gage<br><i>P</i> |                                       |                                  |                                          |                                                           | Water<br>Cu. ft. per lb.    | Steam<br>Cu. ft. per lb. |
| 35.0                         | 20.3             | 259.29                                | 228.0                            | 939.1                                    | 1167.1                                                    | 0.017083                    | 11.8959                  |
| 36.0                         | 21.3             | 260.95                                | 229.7                            | 938.0                                    | 1167.7                                                    | 0.017097                    | 11.5860                  |
| 37.0                         | 22.3             | 262.58                                | 231.4                            | 936.9                                    | 1168.2                                                    | 0.017111                    | 11.2923                  |
| 38.0                         | 23.3             | 264.17                                | 233.0                            | 935.8                                    | 1168.8                                                    | 0.017124                    | 11.0136                  |
| 39.0                         | 24.3             | 265.72                                | 234.6                            | 934.7                                    | 1169.3                                                    | 0.017138                    | 10.7487                  |
| 40.0                         | 25.3             | 267.25                                | 236.1                            | 933.6                                    | 1169.8                                                    | 0.017151                    | 10.4965                  |
| 41.0                         | 26.3             | 268.74                                | 237.7                            | 932.6                                    | 1170.2                                                    | 0.017164                    | 10.2563                  |
| 42.0                         | 27.3             | 270.21                                | 239.2                            | 931.5                                    | 1170.7                                                    | 0.017177                    | 10.0272                  |
| 43.0                         | 28.3             | 271.65                                | 240.6                            | 930.5                                    | 1171.2                                                    | 0.017189                    | 9.8083                   |
| 44.0                         | 29.3             | 273.06                                | 242.1                            | 929.5                                    | 1171.6                                                    | 0.017202                    | 9.5991                   |
| 45.0                         | 30.3             | 274.44                                | 243.5                            | 928.6                                    | 1172.0                                                    | 0.017214                    | 9.3988                   |
| 46.0                         | 31.3             | 275.80                                | 244.9                            | 927.6                                    | 1172.5                                                    | 0.017226                    | 9.2070                   |
| 47.0                         | 32.3             | 277.14                                | 246.2                            | 926.6                                    | 1172.9                                                    | 0.017238                    | 9.0231                   |
| 48.0                         | 33.3             | 278.45                                | 247.6                            | 925.7                                    | 1173.3                                                    | 0.017250                    | 8.8465                   |
| 49.0                         | 34.3             | 279.74                                | 248.9                            | 924.8                                    | 1173.7                                                    | 0.017262                    | 8.6770                   |
| 50.0                         | 35.3             | 281.02                                | 250.2                            | 923.9                                    | 1174.1                                                    | 0.017274                    | 8.5140                   |
| 51.0                         | 36.3             | 282.27                                | 251.5                            | 923.0                                    | 1174.5                                                    | 0.017285                    | 8.3571                   |
| 52.0                         | 37.3             | 283.50                                | 252.8                            | 922.1                                    | 1174.9                                                    | 0.017296                    | 8.2061                   |
| 53.0                         | 38.3             | 284.71                                | 254.0                            | 921.2                                    | 1175.2                                                    | 0.017307                    | 8.0606                   |
| 54.0                         | 39.3             | 285.90                                | 255.2                            | 920.4                                    | 1175.6                                                    | 0.017319                    | 7.9203                   |
| 55.0                         | 40.3             | 287.08                                | 256.4                            | 919.5                                    | 1175.9                                                    | 0.017329                    | 7.7850                   |
| 56.0                         | 41.3             | 288.24                                | 257.6                            | 918.7                                    | 1176.3                                                    | 0.017340                    | 7.6543                   |
| 57.0                         | 42.3             | 289.38                                | 258.8                            | 917.8                                    | 1176.6                                                    | 0.017351                    | 7.5280                   |
| 58.0                         | 43.3             | 290.50                                | 259.9                            | 917.0                                    | 1177.0                                                    | 0.017362                    | 7.4059                   |
| 59.0                         | 44.3             | 291.62                                | 261.1                            | 916.2                                    | 1177.3                                                    | 0.017372                    | 7.2879                   |
| 60.0                         | 45.3             | 292.71                                | 262.2                            | 915.4                                    | 1177.6                                                    | 0.017383                    | 7.1736                   |
| 61.0                         | 46.3             | 293.79                                | 263.3                            | 914.6                                    | 1177.9                                                    | 0.017393                    | 7.0630                   |
| 62.0                         | 47.3             | 294.86                                | 264.4                            | 913.8                                    | 1178.2                                                    | 0.017403                    | 6.9558                   |
| 63.0                         | 48.3             | 295.91                                | 265.5                            | 913.0                                    | 1178.6                                                    | 0.017413                    | 6.8519                   |
| 64.0                         | 49.3             | 296.95                                | 266.6                            | 912.3                                    | 1178.9                                                    | 0.017423                    | 6.7511                   |
| 65.0                         | 50.3             | 297.98                                | 267.6                            | 911.5                                    | 1179.1                                                    | 0.017433                    | 6.6533                   |
| 66.0                         | 51.3             | 298.99                                | 268.7                            | 910.8                                    | 1179.4                                                    | 0.017443                    | 6.5584                   |
| 67.0                         | 52.3             | 299.99                                | 269.7                            | 910.0                                    | 1179.7                                                    | 0.017453                    | 6.4662                   |
| 68.0                         | 53.3             | 300.99                                | 270.7                            | 909.3                                    | 1180.0                                                    | 0.017463                    | 6.3767                   |
| 69.0                         | 54.3             | 301.96                                | 271.7                            | 908.5                                    | 1180.3                                                    | 0.017472                    | 6.2896                   |
| 70.0                         | 55.3             | 302.93                                | 272.7                            | 907.8                                    | 1180.6                                                    | 0.017482                    | 6.2050                   |
| 71.0                         | 56.3             | 303.89                                | 273.7                            | 907.1                                    | 1180.8                                                    | 0.017491                    | 6.1226                   |
| 72.0                         | 57.3             | 304.83                                | 274.7                            | 906.4                                    | 1181.1                                                    | 0.017501                    | 6.0425                   |
| 73.0                         | 58.3             | 305.77                                | 275.7                            | 905.7                                    | 1181.4                                                    | 0.017510                    | 5.9645                   |
| 74.0                         | 59.3             | 306.69                                | 276.6                            | 905.0                                    | 1181.6                                                    | 0.017519                    | 5.8885                   |
| 75.0                         | 60.3             | 307.61                                | 277.6                            | 904.3                                    | 1181.9                                                    | 0.017529                    | 5.8144                   |
| 76.0                         | 61.3             | 308.51                                | 278.5                            | 903.6                                    | 1182.1                                                    | 0.017538                    | 5.7423                   |
| 77.0                         | 62.3             | 309.41                                | 279.4                            | 902.9                                    | 1182.4                                                    | 0.017547                    | 5.6720                   |
| 78.0                         | 63.3             | 310.29                                | 280.3                            | 902.3                                    | 1182.6                                                    | 0.017556                    | 5.6034                   |
| 79.0                         | 64.3             | 311.17                                | 281.3                            | 901.6                                    | 1182.8                                                    | 0.017565                    | 5.5364                   |
| 80.0                         | 65.3             | 312.04                                | 282.1                            | 900.9                                    | 1183.1                                                    | 0.017573                    | 5.4711                   |
| 81.0                         | 66.3             | 312.90                                | 283.0                            | 900.3                                    | 1183.3                                                    | 0.017582                    | 5.4074                   |
| 82.0                         | 67.3             | 313.75                                | 283.9                            | 899.6                                    | 1183.5                                                    | 0.017591                    | 5.3451                   |
| 83.0                         | 68.3             | 314.60                                | 284.8                            | 899.0                                    | 1183.8                                                    | 0.017600                    | 5.2843                   |
| 84.0                         | 69.3             | 315.43                                | 285.7                            | 898.3                                    | 1184.0                                                    | 0.017608                    | 5.2249                   |
| 85.0                         | 70.3             | 316.26                                | 286.5                            | 897.7                                    | 1184.2                                                    | 0.017617                    | 5.1669                   |
| 86.0                         | 71.3             | 317.08                                | 287.4                            | 897.0                                    | 1184.4                                                    | 0.017625                    | 5.1101                   |
| 87.0                         | 72.3             | 317.89                                | 288.2                            | 896.4                                    | 1184.6                                                    | 0.017634                    | 5.0546                   |
| 88.0                         | 73.3             | 318.69                                | 289.0                            | 895.8                                    | 1184.8                                                    | 0.017642                    | 5.0004                   |
| 89.0                         | 74.3             | 319.49                                | 289.9                            | 895.2                                    | 1185.0                                                    | 0.017651                    | 4.9473                   |
| 90.0                         | 75.3             | 320.28                                | 290.7                            | 894.6                                    | 1185.3                                                    | 0.017659                    | 4.8953                   |
| 91.0                         | 76.3             | 321.06                                | 291.5                            | 893.9                                    | 1185.5                                                    | 0.017667                    | 4.8445                   |
| 92.0                         | 77.3             | 321.84                                | 292.3                            | 893.3                                    | 1185.7                                                    | 0.017675                    | 4.7947                   |
| 93.0                         | 78.3             | 322.61                                | 293.1                            | 892.7                                    | 1185.9                                                    | 0.017684                    | 4.7459                   |
| 94.0                         | 79.3             | 323.37                                | 293.9                            | 892.1                                    | 1186.0                                                    | 0.017692                    | 4.6982                   |
| 95.0                         | 80.3             | 324.13                                | 294.7                            | 891.5                                    | 1186.2                                                    | 0.017700                    | 4.6514                   |
| 96.0                         | 81.3             | 324.88                                | 295.5                            | 891.0                                    | 1186.4                                                    | 0.017708                    | 4.6055                   |
| 97.0                         | 82.3             | 325.63                                | 296.3                            | 890.4                                    | 1186.6                                                    | 0.017716                    | 4.5606                   |
| 98.0                         | 83.3             | 326.36                                | 297.0                            | 889.8                                    | 1186.8                                                    | 0.017724                    | 4.5166                   |
| 99.0                         | 84.3             | 327.10                                | 297.8                            | 889.2                                    | 1187.0                                                    | 0.017732                    | 4.4734                   |
| 100.0                        | 85.3             | 327.82                                | 298.5                            | 888.6                                    | 1187.2                                                    | 0.017740                    | 4.4310                   |
| 101.0                        | 86.3             | 328.54                                | 299.3                            | 888.1                                    | 1187.3                                                    | 0.01775                     | 4.3895                   |
| 102.0                        | 87.3             | 329.26                                | 300.0                            | 887.5                                    | 1187.5                                                    | 0.01776                     | 4.3487                   |
| 103.0                        | 88.3             | 329.97                                | 300.8                            | 886.9                                    | 1187.7                                                    | 0.01776                     | 4.3087                   |
| 104.0                        | 89.3             | 330.67                                | 301.5                            | 886.4                                    | 1187.9                                                    | 0.01777                     | 4.2695                   |
| 105.0                        | 90.3             | 331.37                                | 302.2                            | 885.8                                    | 1188.0                                                    | 0.01778                     | 4.2309                   |
| 106.0                        | 91.3             | 332.06                                | 303.0                            | 885.2                                    | 1188.2                                                    | 0.01779                     | 4.1931                   |
| 107.0                        | 92.3             | 332.75                                | 303.7                            | 884.7                                    | 1188.4                                                    | 0.01779                     | 4.1560                   |
| 108.0                        | 93.3             | 333.44                                | 304.4                            | 884.1                                    | 1188.5                                                    | 0.01780                     | 4.1195                   |
| 109.0                        | 94.3             | 334.11                                | 305.1                            | 883.6                                    | 1188.7                                                    | 0.01781                     | 4.0837                   |

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# GENERAL ENGINEERING DATA

## Properties of Saturated Steam and Saturated Water

| Pressure<br>Lbs. per Sq. In. |             | Temperature       | Heat of the Liquid | Latent Heat of Evaporation | Total Heat of Steam | Specific Volume<br>$\bar{V}$ |                          |
|------------------------------|-------------|-------------------|--------------------|----------------------------|---------------------|------------------------------|--------------------------|
| Absolute<br>$P'$             | Gage<br>$P$ | $t$<br>Degrees F. | Btu/lb.            | Btu/lb.                    | $h_g$<br>Btu/lb.    | Water<br>Cu. ft. per lb.     | Steam<br>Cu. ft. per lb. |
| 110.0                        | 95.3        | 334.79            | 305.8              | 883.1                      | 1188.9              | 0.01782                      | 4.0484                   |
| 111.0                        | 96.3        | 335.46            | 306.5              | 882.5                      | 1189.0              | 0.01782                      | 4.0138                   |
| 112.0                        | 97.3        | 336.12            | 307.2              | 882.0                      | 1189.2              | 0.01783                      | 3.9798                   |
| 113.0                        | 98.3        | 336.78            | 307.9              | 881.4                      | 1189.3              | 0.01784                      | 3.9464                   |
| 114.0                        | 99.3        | 337.43            | 308.6              | 880.9                      | 1189.5              | 0.01785                      | 3.9136                   |
| 115.0                        | 100.3       | 338.08            | 309.3              | 880.4                      | 1189.6              | 0.01785                      | 3.8813                   |
| 116.0                        | 101.3       | 338.73            | 309.9              | 879.9                      | 1189.8              | 0.01786                      | 3.8495                   |
| 117.0                        | 102.3       | 339.37            | 310.6              | 879.3                      | 1189.9              | 0.01787                      | 3.8183                   |
| 118.0                        | 103.3       | 340.01            | 311.3              | 878.8                      | 1190.1              | 0.01787                      | 3.7875                   |
| 119.0                        | 104.3       | 340.64            | 311.9              | 878.3                      | 1190.2              | 0.01788                      | 3.7573                   |
| 120.0                        | 105.3       | 341.27            | 312.6              | 877.8                      | 1190.4              | 0.01789                      | 3.7275                   |
| 121.0                        | 106.3       | 341.89            | 313.2              | 877.3                      | 1190.5              | 0.01790                      | 3.6983                   |
| 122.0                        | 107.3       | 342.51            | 313.9              | 876.8                      | 1190.7              | 0.01790                      | 3.6695                   |
| 123.0                        | 108.3       | 343.13            | 314.5              | 876.3                      | 1190.8              | 0.01791                      | 3.6411                   |
| 124.0                        | 109.3       | 343.74            | 315.2              | 875.8                      | 1190.9              | 0.01792                      | 3.6132                   |
| 125.0                        | 110.3       | 344.35            | 315.8              | 875.3                      | 1191.1              | 0.01792                      | 3.5857                   |
| 126.0                        | 111.3       | 344.95            | 316.4              | 874.8                      | 1191.2              | 0.01793                      | 3.5586                   |
| 127.0                        | 112.3       | 345.55            | 317.1              | 874.3                      | 1191.3              | 0.01794                      | 3.5320                   |
| 128.0                        | 113.3       | 346.15            | 317.7              | 873.8                      | 1191.5              | 0.01794                      | 3.5057                   |
| 129.0                        | 114.3       | 346.74            | 318.3              | 873.3                      | 1191.6              | 0.01795                      | 3.4799                   |
| 130.0                        | 115.3       | 347.33            | 319.0              | 872.8                      | 1191.7              | 0.01796                      | 3.4544                   |
| 131.0                        | 116.3       | 347.92            | 319.6              | 872.3                      | 1191.9              | 0.01797                      | 3.4293                   |
| 132.0                        | 117.3       | 348.50            | 320.2              | 871.8                      | 1192.0              | 0.01797                      | 3.4046                   |
| 133.0                        | 118.3       | 349.08            | 320.8              | 871.3                      | 1192.1              | 0.01798                      | 3.3802                   |
| 134.0                        | 119.3       | 349.65            | 321.4              | 870.8                      | 1192.2              | 0.01799                      | 3.3562                   |
| 135.0                        | 120.3       | 350.23            | 322.0              | 870.4                      | 1192.4              | 0.01799                      | 3.3325                   |
| 136.0                        | 121.3       | 350.79            | 322.6              | 869.9                      | 1192.5              | 0.01800                      | 3.3091                   |
| 137.0                        | 122.3       | 351.36            | 323.2              | 869.4                      | 1192.6              | 0.01801                      | 3.2861                   |
| 138.0                        | 123.3       | 351.92            | 323.8              | 868.9                      | 1192.7              | 0.01801                      | 3.2634                   |
| 139.0                        | 124.3       | 352.48            | 324.4              | 868.5                      | 1192.8              | 0.01802                      | 3.2411                   |
| 140.0                        | 125.3       | 353.04            | 325.0              | 868.0                      | 1193.0              | 0.01803                      | 3.2190                   |
| 141.0                        | 126.3       | 353.59            | 325.5              | 867.5                      | 1193.1              | 0.01803                      | 3.1972                   |
| 142.0                        | 127.3       | 354.14            | 326.1              | 867.1                      | 1193.2              | 0.01804                      | 3.1757                   |
| 143.0                        | 128.3       | 354.69            | 326.7              | 866.6                      | 1193.3              | 0.01805                      | 3.1546                   |
| 144.0                        | 129.3       | 355.23            | 327.3              | 866.2                      | 1193.4              | 0.01805                      | 3.1337                   |
| 145.0                        | 130.3       | 355.77            | 327.8              | 865.7                      | 1193.5              | 0.01806                      | 3.1130                   |
| 146.0                        | 131.3       | 356.31            | 328.4              | 865.2                      | 1193.6              | 0.01806                      | 3.0927                   |
| 147.0                        | 132.3       | 356.84            | 329.0              | 864.8                      | 1193.8              | 0.01807                      | 3.0726                   |
| 148.0                        | 133.3       | 357.38            | 329.5              | 864.3                      | 1193.9              | 0.01808                      | 3.0528                   |
| 149.0                        | 134.3       | 357.91            | 330.1              | 863.9                      | 1194.0              | 0.01808                      | 3.0332                   |
| 150.0                        | 135.3       | 358.43            | 330.6              | 863.4                      | 1194.1              | 0.01809                      | 3.0139                   |
| 152.0                        | 137.3       | 359.48            | 331.8              | 862.5                      | 1194.3              | 0.01810                      | 2.9760                   |
| 154.0                        | 139.3       | 360.51            | 332.8              | 861.6                      | 1194.5              | 0.01812                      | 2.9391                   |
| 156.0                        | 141.3       | 361.53            | 333.9              | 860.8                      | 1194.7              | 0.01813                      | 2.9031                   |
| 158.0                        | 143.3       | 362.55            | 335.0              | 859.9                      | 1194.9              | 0.01814                      | 2.8679                   |
| 160.0                        | 145.3       | 363.55            | 336.1              | 859.0                      | 1195.1              | 0.01815                      | 2.8336                   |
| 162.0                        | 147.3       | 364.54            | 337.1              | 858.2                      | 1195.3              | 0.01817                      | 2.8001                   |
| 164.0                        | 149.3       | 365.53            | 338.2              | 857.3                      | 1195.5              | 0.01818                      | 2.7674                   |
| 166.0                        | 151.3       | 366.50            | 339.2              | 856.5                      | 1195.7              | 0.01819                      | 2.7355                   |
| 168.0                        | 153.3       | 367.47            | 340.2              | 855.6                      | 1195.8              | 0.01820                      | 2.7043                   |
| 170.0                        | 155.3       | 368.42            | 341.2              | 854.8                      | 1196.0              | 0.01821                      | 2.6738                   |
| 172.0                        | 157.3       | 369.37            | 342.2              | 853.9                      | 1196.2              | 0.01823                      | 2.6440                   |
| 174.0                        | 159.3       | 370.31            | 343.2              | 853.1                      | 1196.4              | 0.01824                      | 2.6149                   |
| 176.0                        | 161.3       | 371.24            | 344.2              | 852.3                      | 1196.5              | 0.01825                      | 2.5864                   |
| 178.0                        | 163.3       | 372.16            | 345.2              | 851.5                      | 1196.7              | 0.01826                      | 2.5585                   |
| 180.0                        | 165.3       | 373.08            | 346.2              | 850.7                      | 1196.9              | 0.01827                      | 2.5312                   |
| 182.0                        | 167.3       | 373.98            | 347.2              | 849.9                      | 1197.0              | 0.01828                      | 2.5045                   |
| 184.0                        | 169.3       | 374.88            | 348.1              | 849.1                      | 1197.2              | 0.01830                      | 2.4783                   |
| 186.0                        | 171.3       | 375.77            | 349.1              | 848.3                      | 1197.3              | 0.01831                      | 2.4527                   |
| 188.0                        | 173.3       | 376.65            | 350.0              | 847.5                      | 1197.5              | 0.01832                      | 2.4276                   |
| 190.0                        | 175.3       | 377.53            | 350.9              | 846.7                      | 1197.6              | 0.01833                      | 2.4030                   |
| 192.0                        | 177.3       | 378.40            | 351.9              | 845.9                      | 1197.8              | 0.01834                      | 2.3790                   |
| 194.0                        | 179.3       | 379.26            | 352.8              | 845.1                      | 1197.9              | 0.01835                      | 2.3554                   |
| 196.0                        | 181.3       | 380.12            | 353.7              | 844.4                      | 1198.1              | 0.01836                      | 2.3322                   |
| 198.0                        | 183.3       | 380.96            | 354.6              | 843.6                      | 1198.2              | 0.01838                      | 2.3095                   |
| 200.0                        | 185.3       | 381.80            | 355.5              | 842.8                      | 1198.3              | 0.01839                      | 2.2872                   |
| 205.0                        | 190.3       | 383.88            | 357.7              | 840.9                      | 1198.7              | 0.01841                      | 2.2349                   |
| 210.0                        | 195.3       | 385.91            | 359.9              | 839.1                      | 1199.0              | 0.01844                      | 2.1821                   |
| 215.0                        | 200.3       | 387.91            | 362.1              | 837.2                      | 1199.3              | 0.01847                      | 2.1331                   |
| 220.0                        | 205.3       | 389.88            | 364.2              | 835.4                      | 1199.6              | 0.01850                      | 2.0862                   |
| 225.0                        | 210.3       | 391.80            | 366.2              | 833.6                      | 1199.9              | 0.01852                      | 2.0413                   |
| 230.0                        | 215.3       | 393.70            | 368.3              | 831.8                      | 1200.1              | 0.01855                      | 1.9984                   |
| 235.0                        | 220.3       | 395.56            | 370.3              | 830.1                      | 1200.4              | 0.01857                      | 1.9572                   |
| 240.0                        | 225.3       | 397.39            | 372.3              | 828.4                      | 1200.6              | 0.01860                      | 1.9176                   |
| 245.0                        | 230.3       | 399.19            | 374.2              | 826.6                      | 1200.9              | 0.01863                      | 1.8797                   |

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# GENERAL ENGINEERING DATA

## Properties of Saturated Steam and Saturated Water

| Pressure<br>Lbs. per Sq. In. |           | Temper-<br>ature<br>t<br>Degrees F. | Heat of<br>the<br>Liquid<br>Btu/lb. | Latent Heat<br>of<br>Evaporation<br>Btu/lb. | Total Heat<br>of Steam<br>h <sub>g</sub><br>Btu/lb. | Specific Volume<br>V     |                          |
|------------------------------|-----------|-------------------------------------|-------------------------------------|---------------------------------------------|-----------------------------------------------------|--------------------------|--------------------------|
| Absolute<br>P'               | Gage<br>P |                                     |                                     |                                             |                                                     | Water<br>Cu. ft. per lb. | Steam<br>Cu. ft. per lb. |
| 250.0                        | 235.3     | 400.97                              | 376.1                               | 825.0                                       | 1201.1                                              | 0.01865                  | 1.84317                  |
| 255.0                        | 240.3     | 402.72                              | 378.0                               | 823.3                                       | 1201.3                                              | 0.01868                  | 1.80802                  |
| 260.0                        | 245.3     | 404.44                              | 379.9                               | 821.6                                       | 1201.5                                              | 0.01870                  | 1.77418                  |
| 265.0                        | 250.3     | 406.13                              | 381.7                               | 820.0                                       | 1201.7                                              | 0.01873                  | 1.74157                  |
| 270.0                        | 255.3     | 407.80                              | 383.6                               | 818.3                                       | 1201.9                                              | 0.01875                  | 1.71013                  |
| 275.0                        | 260.3     | 409.45                              | 385.4                               | 816.7                                       | 1202.1                                              | 0.01878                  | 1.67978                  |
| 280.0                        | 265.3     | 411.07                              | 387.1                               | 815.1                                       | 1202.3                                              | 0.01880                  | 1.65049                  |
| 285.0                        | 270.3     | 412.67                              | 388.9                               | 813.6                                       | 1202.4                                              | 0.01882                  | 1.62218                  |
| 290.0                        | 275.3     | 414.25                              | 390.6                               | 812.0                                       | 1202.6                                              | 0.01885                  | 1.59482                  |
| 295.0                        | 280.3     | 415.81                              | 392.3                               | 810.4                                       | 1202.7                                              | 0.01887                  | 1.56835                  |
| 300.0                        | 285.3     | 417.35                              | 394.0                               | 808.9                                       | 1202.9                                              | 0.01889                  | 1.54274                  |
| 320.0                        | 305.3     | 423.31                              | 400.5                               | 802.9                                       | 1203.4                                              | 0.01899                  | 1.44801                  |
| 340.0                        | 325.3     | 428.99                              | 406.8                               | 797.0                                       | 1203.8                                              | 0.01908                  | 1.36405                  |
| 360.0                        | 345.3     | 434.41                              | 412.8                               | 791.3                                       | 1204.1                                              | 0.01917                  | 1.28910                  |
| 380.0                        | 365.3     | 439.61                              | 418.6                               | 785.8                                       | 1204.4                                              | 0.01925                  | 1.22177                  |
| 400.0                        | 385.3     | 444.60                              | 424.2                               | 780.4                                       | 1204.6                                              | 0.01934                  | 1.16095                  |
| 420.0                        | 405.3     | 449.40                              | 429.6                               | 775.2                                       | 1204.7                                              | 0.01942                  | 1.10573                  |
| 440.0                        | 425.3     | 454.03                              | 434.8                               | 770.0                                       | 1204.8                                              | 0.01950                  | 1.05535                  |
| 460.0                        | 445.3     | 458.50                              | 439.8                               | 765.0                                       | 1204.8                                              | 0.01959                  | 1.00921                  |
| 480.0                        | 465.3     | 462.82                              | 444.7                               | 760.0                                       | 1204.8                                              | 0.01967                  | 0.96677                  |
| 500.0                        | 485.3     | 467.01                              | 449.5                               | 755.1                                       | 1204.7                                              | 0.01975                  | 0.92762                  |
| 520.0                        | 505.3     | 471.07                              | 454.2                               | 750.4                                       | 1204.5                                              | 0.01982                  | 0.89137                  |
| 540.0                        | 525.3     | 475.01                              | 458.7                               | 745.7                                       | 1204.4                                              | 0.01990                  | 0.85771                  |
| 560.0                        | 545.3     | 478.84                              | 463.1                               | 741.0                                       | 1204.2                                              | 0.01998                  | 0.82637                  |
| 580.0                        | 565.3     | 482.57                              | 467.5                               | 736.5                                       | 1203.9                                              | 0.02006                  | 0.79712                  |
| 600.0                        | 585.3     | 486.20                              | 471.7                               | 732.0                                       | 1203.7                                              | 0.02013                  | 0.76975                  |
| 620.0                        | 605.3     | 489.74                              | 475.8                               | 727.5                                       | 1203.4                                              | 0.02021                  | 0.74408                  |
| 640.0                        | 625.3     | 493.19                              | 479.9                               | 723.1                                       | 1203.0                                              | 0.02028                  | 0.71995                  |
| 660.0                        | 645.3     | 496.57                              | 483.9                               | 718.8                                       | 1202.7                                              | 0.02036                  | 0.69724                  |
| 680.0                        | 665.3     | 499.86                              | 487.8                               | 714.5                                       | 1202.3                                              | 0.02043                  | 0.67581                  |
| 700.0                        | 685.3     | 503.08                              | 491.6                               | 710.2                                       | 1201.8                                              | 0.02050                  | 0.65556                  |
| 720.0                        | 705.3     | 506.23                              | 495.4                               | 706.0                                       | 1201.4                                              | 0.02058                  | 0.63639                  |
| 740.0                        | 725.3     | 509.32                              | 499.1                               | 701.9                                       | 1200.9                                              | 0.02065                  | 0.61822                  |
| 760.0                        | 745.3     | 512.34                              | 502.7                               | 697.7                                       | 1200.4                                              | 0.02072                  | 0.60097                  |
| 780.0                        | 765.3     | 515.30                              | 506.3                               | 693.6                                       | 1199.9                                              | 0.02080                  | 0.58457                  |
| 800.0                        | 785.3     | 518.21                              | 509.8                               | 689.6                                       | 1199.4                                              | 0.02087                  | 0.56896                  |
| 820.0                        | 805.3     | 521.06                              | 513.3                               | 685.5                                       | 1198.8                                              | 0.02094                  | 0.55408                  |
| 840.0                        | 825.3     | 523.86                              | 516.7                               | 681.5                                       | 1198.2                                              | 0.02101                  | 0.53988                  |
| 860.0                        | 845.3     | 526.60                              | 520.1                               | 677.6                                       | 1197.7                                              | 0.02109                  | 0.52631                  |
| 880.0                        | 865.3     | 529.30                              | 523.4                               | 673.6                                       | 1197.0                                              | 0.02116                  | 0.51333                  |
| 900.0                        | 885.3     | 531.95                              | 526.7                               | 669.7                                       | 1196.4                                              | 0.02123                  | 0.50091                  |
| 920.0                        | 905.3     | 534.56                              | 530.0                               | 665.8                                       | 1195.7                                              | 0.02130                  | 0.48901                  |
| 940.0                        | 925.3     | 537.13                              | 533.2                               | 661.9                                       | 1195.1                                              | 0.02137                  | 0.47759                  |
| 960.0                        | 945.3     | 539.65                              | 536.3                               | 658.0                                       | 1194.4                                              | 0.02145                  | 0.46662                  |
| 980.0                        | 965.3     | 542.14                              | 539.5                               | 654.2                                       | 1193.7                                              | 0.02152                  | 0.45609                  |
| 1000.0                       | 985.3     | 544.58                              | 542.6                               | 650.4                                       | 1192.9                                              | 0.02159                  | 0.44596                  |
| 1050.0                       | 1035.3    | 550.53                              | 550.1                               | 640.9                                       | 1191.0                                              | 0.02177                  | 0.42224                  |
| 1100.0                       | 1085.3    | 556.28                              | 557.5                               | 631.5                                       | 1189.1                                              | 0.02195                  | 0.40058                  |
| 1150.0                       | 1135.3    | 561.82                              | 564.8                               | 622.2                                       | 1187.0                                              | 0.02214                  | 0.38073                  |
| 1200.0                       | 1185.3    | 567.19                              | 571.9                               | 613.0                                       | 1184.8                                              | 0.02232                  | 0.36245                  |
| 1250.0                       | 1235.3    | 572.38                              | 578.8                               | 603.8                                       | 1182.6                                              | 0.02250                  | 0.34556                  |
| 1300.0                       | 1285.3    | 577.42                              | 585.6                               | 594.6                                       | 1180.2                                              | 0.02269                  | 0.32991                  |
| 1350.0                       | 1335.3    | 582.32                              | 592.2                               | 585.6                                       | 1177.8                                              | 0.02288                  | 0.31536                  |
| 1400.0                       | 1385.3    | 587.07                              | 598.8                               | 567.5                                       | 1175.3                                              | 0.02307                  | 0.30178                  |
| 1450.0                       | 1435.3    | 591.70                              | 605.3                               | 567.6                                       | 1172.9                                              | 0.02327                  | 0.28909                  |
| 1500.0                       | 1485.3    | 596.20                              | 611.7                               | 558.4                                       | 1170.1                                              | 0.02346                  | 0.27719                  |
| 1600.0                       | 1585.3    | 604.87                              | 624.2                               | 540.3                                       | 1164.5                                              | 0.02387                  | 0.25545                  |
| 1700.0                       | 1685.3    | 613.13                              | 636.5                               | 522.2                                       | 1158.6                                              | 0.02428                  | 0.23607                  |
| 1800.0                       | 1785.3    | 621.02                              | 648.5                               | 503.8                                       | 1152.3                                              | 0.02472                  | 0.21861                  |
| 1900.0                       | 1885.3    | 628.56                              | 660.4                               | 485.2                                       | 1145.6                                              | 0.02517                  | 0.20278                  |
| 2000.0                       | 1985.3    | 635.80                              | 672.1                               | 466.2                                       | 1138.3                                              | 0.02565                  | 0.18831                  |
| 2100.0                       | 2085.3    | 642.76                              | 683.8                               | 446.7                                       | 1130.5                                              | 0.02615                  | 0.17501                  |
| 2200.0                       | 2185.3    | 649.45                              | 695.5                               | 426.7                                       | 1122.2                                              | 0.02669                  | 0.16272                  |
| 2300.0                       | 2285.3    | 655.89                              | 707.2                               | 406.0                                       | 1113.2                                              | 0.02727                  | 0.15133                  |
| 2400.0                       | 2385.3    | 662.11                              | 719.0                               | 384.8                                       | 1103.7                                              | 0.02790                  | 0.14076                  |
| 2500.0                       | 2485.3    | 668.11                              | 731.7                               | 361.6                                       | 1093.3                                              | 0.02859                  | 0.13068                  |
| 2600.0                       | 2585.3    | 673.91                              | 744.5                               | 337.6                                       | 1082.0                                              | 0.02938                  | 0.12110                  |
| 2700.0                       | 2685.3    | 679.53                              | 757.3                               | 312.3                                       | 1069.7                                              | 0.03029                  | 0.11194                  |
| 2800.0                       | 2785.3    | 684.96                              | 770.7                               | 285.1                                       | 1055.8                                              | 0.03134                  | 0.10305                  |
| 2900.0                       | 2885.3    | 690.22                              | 785.1                               | 254.7                                       | 1039.8                                              | 0.03262                  | 0.09420                  |
| 3000.0                       | 2985.3    | 695.33                              | 801.8                               | 218.4                                       | 1020.3                                              | 0.03428                  | 0.08500                  |
| 3100.0                       | 3085.3    | 700.28                              | 824.0                               | 169.3                                       | 993.3                                               | 0.03681                  | 0.07452                  |
| 3200.0                       | 3185.3    | 705.08                              | 875.5                               | 56.1                                        | 931.6                                               | 0.04472                  | 0.05663                  |
| 3208.2                       | 3193.5    | 705.47                              | 906.0                               | 0.0                                         | 906.0                                               | 0.05078                  | 0.05078                  |

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# GENERAL ENGINEERING DATA

## Properties of Superheated Steam

$\bar{V}$  = specific volume, cubic feet per pound

$h_g$  = total heat of steam, Btu per pound

| Pressure<br>Lbs. per<br>Sq. In. |             | Sat.<br>Temp<br>$t$ |                    | Total Temperature—Degrees Fahrenheit ( $t$ ) |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |  |
|---------------------------------|-------------|---------------------|--------------------|----------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|--|
| Abs.<br>$P'$                    | Gage<br>$P$ |                     |                    | 350°                                         | 400°             | 500°             | 600°             | 700°             | 800°             | 900°             | 1000°            | 1100°            | 1300°            | 1500°            |  |
| 15.0                            | 0.3         | 213.03              | $\bar{V}$<br>$h_g$ | 31.939<br>1216.2                             | 33.963<br>1239.9 | 37.985<br>1287.3 | 41.986<br>1335.2 | 45.978<br>1383.8 | 49.964<br>1433.2 | 53.946<br>1483.4 | 57.926<br>1534.5 | 61.905<br>1586.5 | 69.858<br>1693.2 | 77.807<br>1803.4 |  |
| 20.0                            | 5.3         | 227.96              | $\bar{V}$<br>$h_g$ | 23.900<br>1215.4                             | 25.428<br>1239.2 | 28.457<br>1286.9 | 31.466<br>1334.9 | 34.465<br>1383.5 | 37.458<br>1432.9 | 40.447<br>1483.2 | 43.435<br>1534.3 | 46.420<br>1586.3 | 52.388<br>1693.1 | 58.352<br>1803.3 |  |
| 30.0                            | 15.3        | 250.34              | $\bar{V}$<br>$h_g$ | 15.859<br>1213.6                             | 16.892<br>1237.8 | 18.929<br>1286.0 | 20.945<br>1334.2 | 22.951<br>1383.0 | 24.952<br>1432.5 | 26.949<br>1482.8 | 28.943<br>1534.0 | 30.936<br>1586.1 | 34.918<br>1692.9 | 38.896<br>1803.2 |  |
| 40.0                            | 25.3        | 267.25              | $\bar{V}$<br>$h_g$ | 11.838<br>1211.7                             | 12.624<br>1236.4 | 14.165<br>1285.0 | 15.685<br>1333.6 | 17.195<br>1382.5 | 18.699<br>1432.1 | 20.199<br>1482.5 | 21.697<br>1533.7 | 23.194<br>1585.8 | 26.183<br>1692.7 | 29.168<br>1803.0 |  |
| 50.0                            | 35.3        | 281.02              | $\bar{V}$<br>$h_g$ | 9.424<br>1209.9                              | 10.062<br>1234.9 | 11.306<br>1284.1 | 12.529<br>1332.9 | 13.741<br>1382.0 | 14.947<br>1431.7 | 16.150<br>1482.2 | 17.350<br>1533.4 | 18.549<br>1585.6 | 20.942<br>1692.5 | 23.332<br>1802.9 |  |
| 60.0                            | 45.3        | 292.71              | $\bar{V}$<br>$h_g$ | 7.815<br>1208.0                              | 8.354<br>1233.5  | 9.400<br>1283.2  | 10.425<br>1332.3 | 11.438<br>1381.5 | 12.446<br>1431.3 | 13.450<br>1481.8 | 14.452<br>1533.2 | 15.452<br>1585.3 | 17.448<br>1692.4 | 19.441<br>1802.8 |  |
| 70.0                            | 55.3        | 302.93              | $\bar{V}$<br>$h_g$ | 6.664<br>1206.0                              | 7.133<br>1232.0  | 8.039<br>1282.2  | 8.922<br>1331.6  | 9.793<br>1381.0  | 10.659<br>1430.9 | 11.522<br>1481.5 | 12.382<br>1532.9 | 13.240<br>1585.1 | 14.952<br>1692.2 | 16.661<br>1802.6 |  |
| 80.0                            | 65.3        | 312.04              | $\bar{V}$<br>$h_g$ | 5.801<br>1204.0                              | 6.218<br>1230.5  | 7.018<br>1281.3  | 7.794<br>1330.9  | 8.560<br>1380.5  | 9.319<br>1430.5  | 10.075<br>1481.1 | 10.829<br>1532.6 | 11.581<br>1584.9 | 13.081<br>1692.0 | 14.577<br>1802.5 |  |
| 90.0                            | 75.3        | 320.28              | $\bar{V}$<br>$h_g$ | 5.128<br>1202.0                              | 5.505<br>1228.9  | 6.223<br>1280.3  | 6.917<br>1330.2  | 7.600<br>1380.0  | 8.277<br>1430.1  | 8.950<br>1480.8  | 9.621<br>1532.3  | 10.290<br>1584.6 | 11.625<br>1691.8 | 12.956<br>1802.4 |  |
| 100.0                           | 85.3        | 327.82              | $\bar{V}$<br>$h_g$ | 4.590<br>1199.9                              | 4.935<br>1227.4  | 5.588<br>1279.3  | 6.216<br>1329.6  | 6.833<br>1379.5  | 7.443<br>1429.7  | 8.050<br>1480.4  | 8.655<br>1532.0  | 9.258<br>1584.4  | 10.460<br>1691.6 | 11.659<br>1802.2 |  |
| 120.0                           | 105.3       | 341.27              | $\bar{V}$<br>$h_g$ | 3.7815<br>1195.6                             | 4.0786<br>1224.1 | 4.6341<br>1277.4 | 5.1637<br>1328.2 | 5.6813<br>1378.4 | 6.1928<br>1428.8 | 6.7006<br>1479.8 | 7.2060<br>1531.4 | 7.7096<br>1583.9 | 8.7130<br>1691.3 | 9.7130<br>1802.0 |  |
| 140.0                           | 125.3       | 353.04              | $\bar{V}$<br>$h_g$ | ...                                          | 3.4661<br>1220.8 | 3.9526<br>1275.3 | 4.4119<br>1326.8 | 4.8588<br>1377.4 | 5.2995<br>1428.0 | 5.7364<br>1479.1 | 6.1709<br>1530.8 | 6.6036<br>1583.4 | 7.4652<br>1690.9 | 8.3233<br>1801.7 |  |
| 160.0                           | 145.3       | 363.55              | $\bar{V}$<br>$h_g$ | ...                                          | 3.0060<br>1217.4 | 3.4413<br>1273.3 | 3.8480<br>1325.4 | 4.2420<br>1376.4 | 4.6295<br>1427.2 | 5.0132<br>1478.4 | 5.3945<br>1530.3 | 5.7741<br>1582.9 | 6.5293<br>1690.5 | 7.2811<br>1801.4 |  |
| 180.0                           | 165.3       | 373.08              | $\bar{V}$<br>$h_g$ | ...                                          | 2.6474<br>1213.8 | 3.0433<br>1271.2 | 3.4093<br>1324.0 | 3.7621<br>1375.3 | 4.1084<br>1426.3 | 4.4508<br>1477.7 | 4.7907<br>1529.7 | 5.1289<br>1582.4 | 5.8014<br>1690.2 | 6.4704<br>1801.2 |  |
| 200.0                           | 185.3       | 381.80              | $\bar{V}$<br>$h_g$ | ...                                          | 2.3598<br>1210.1 | 2.7247<br>1269.0 | 3.0583<br>1322.6 | 3.3783<br>1374.3 | 3.6915<br>1425.5 | 4.0008<br>1477.0 | 4.3077<br>1529.1 | 4.6128<br>1581.9 | 5.2191<br>1689.8 | 5.8219<br>1800.9 |  |
| 220.0                           | 205.3       | 389.88              | $\bar{V}$<br>$h_g$ | ...                                          | 2.1240<br>1206.3 | 2.4638<br>1266.9 | 2.7710<br>1321.2 | 3.0642<br>1373.2 | 3.3504<br>1424.7 | 3.6327<br>1476.3 | 3.9125<br>1528.5 | 4.1905<br>1581.4 | 4.7426<br>1689.4 | 5.2913<br>1800.6 |  |
| 240.0                           | 225.3       | 397.39              | $\bar{V}$<br>$h_g$ | ...                                          | 1.9268<br>1202.4 | 2.2462<br>1264.6 | 2.5316<br>1319.7 | 2.8024<br>1372.1 | 3.0661<br>1423.8 | 3.3259<br>1475.6 | 3.5831<br>1527.9 | 3.8385<br>1580.9 | 4.3456<br>1689.1 | 4.8492<br>1800.4 |  |
| 260.0                           | 245.3       | 404.44              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 2.0619<br>1262.4 | 2.3289<br>1318.2 | 2.5808<br>1371.1 | 2.8256<br>1423.0 | 3.0663<br>1474.9 | 3.3044<br>1527.3 | 3.5408<br>1580.4 | 4.0097<br>1688.7 | 4.4750<br>1800.1 |  |
| 280.0                           | 265.3       | 411.07              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 1.9037<br>1260.0 | 2.1551<br>1316.8 | 2.3909<br>1370.0 | 2.6194<br>1422.1 | 2.8437<br>1474.2 | 3.0655<br>1526.8 | 3.2855<br>1579.9 | 3.7217<br>1688.4 | 4.1543<br>1799.8 |  |
| 300.0                           | 285.3       | 417.35              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 1.7665<br>1257.7 | 2.0044<br>1315.2 | 2.2263<br>1368.9 | 2.4407<br>1421.3 | 2.6509<br>1473.6 | 2.8585<br>1526.2 | 3.0643<br>1579.4 | 3.4721<br>1688.0 | 3.8764<br>1799.6 |  |
| 320.0                           | 305.3       | 423.31              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 1.6462<br>1255.2 | 1.8725<br>1313.7 | 2.0823<br>1367.8 | 2.2843<br>1420.5 | 2.4821<br>1472.9 | 2.6774<br>1525.6 | 2.8708<br>1578.9 | 3.2538<br>1687.6 | 3.6332<br>1799.3 |  |
| 340.0                           | 325.3       | 428.99              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 1.5399<br>1252.8 | 1.7561<br>1312.2 | 1.9552<br>1366.7 | 2.1463<br>1419.6 | 2.3333<br>1472.2 | 2.5175<br>1525.0 | 2.7000<br>1578.4 | 3.0611<br>1687.3 | 3.4186<br>1799.0 |  |
| 360.0                           | 345.3       | 434.41              | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 1.4454<br>1250.3 | 1.6525<br>1310.6 | 1.8421<br>1365.6 | 2.0237<br>1418.7 | 2.2009<br>1471.5 | 2.3755<br>1524.4 | 2.5482<br>1577.9 | 2.8898<br>1686.9 | 3.2279<br>1798.8 |  |

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# GENERAL ENGINEERING DATA

## Properties of Superheated Steam

$\bar{V}$  = specific volume, cubic feet per pound  
 $h_g$  = total heat of steam, Btu per pound

| Pressure<br>Lbs. per<br>Sq. In. |           | Sat.<br>Temp. | Total Temperature—Degrees Fahrenheit (t) |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |
|---------------------------------|-----------|---------------|------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Abs.<br>P'                      | Gage<br>P | t             |                                          | 500°             | 600°             | 700°             | 800°             | 900°             | 1000°            | 1100°            | 1200°            | 1300°            | 1400°            | 1500°            |
| 380.0                           | 365.3     | 439.61        | $\bar{V}$<br>$h_g$                       | 1.3606<br>1247.7 | 1.5598<br>1309.0 | 1.7410<br>1364.5 | 1.9139<br>1417.9 | 2.0825<br>1470.8 | 2.2484<br>1523.8 | 2.4124<br>1577.4 | 2.5750<br>1631.6 | 2.7366<br>1686.5 | 2.8973<br>1742.2 | 3.0572<br>1798.5 |
| 400.0                           | 385.3     | 444.60        | $\bar{V}$<br>$h_g$                       | 1.2841<br>1245.1 | 1.4763<br>1307.4 | 1.6499<br>1363.4 | 1.8151<br>1417.0 | 1.9759<br>1470.1 | 2.1339<br>1523.3 | 2.2901<br>1576.9 | 2.4450<br>1631.2 | 2.5987<br>1686.2 | 2.7515<br>1741.9 | 2.9037<br>1798.2 |
| 420.0                           | 405.3     | 449.40        | $\bar{V}$<br>$h_g$                       | 1.2148<br>1242.4 | 1.4007<br>1305.8 | 1.5676<br>1362.3 | 1.7258<br>1416.2 | 1.8795<br>1469.4 | 2.0304<br>1522.7 | 2.1795<br>1576.4 | 2.3273<br>1630.8 | 2.4739<br>1685.8 | 2.6196<br>1741.6 | 2.7647<br>1798.0 |
| 440.0                           | 425.3     | 454.03        | $\bar{V}$<br>$h_g$                       | 1.1517<br>1239.7 | 1.3319<br>1304.2 | 1.4926<br>1361.1 | 1.6445<br>1415.3 | 1.7918<br>1468.7 | 1.9363<br>1522.1 | 2.0790<br>1575.9 | 2.2203<br>1630.4 | 2.3605<br>1685.5 | 2.4998<br>1741.2 | 2.6384<br>1797.7 |
| 460.0                           | 445.3     | 458.50        | $\bar{V}$<br>$h_g$                       | 1.0939<br>1236.9 | 1.2691<br>1302.5 | 1.4242<br>1360.0 | 1.5703<br>1414.4 | 1.7117<br>1468.0 | 1.8504<br>1521.5 | 1.9872<br>1575.4 | 2.1226<br>1629.9 | 2.2569<br>1685.1 | 2.3903<br>1740.9 | 2.5230<br>1797.4 |
| 480.0                           | 465.3     | 462.82        | $\bar{V}$<br>$h_g$                       | 1.0409<br>1234.1 | 1.2115<br>1300.8 | 1.3615<br>1358.8 | 1.5023<br>1413.6 | 1.6384<br>1467.3 | 1.7716<br>1520.9 | 1.9030<br>1574.9 | 2.0330<br>1629.5 | 2.1619<br>1684.7 | 2.2900<br>1740.6 | 2.4173<br>1797.2 |
| 500.0                           | 485.3     | 467.01        | $\bar{V}$<br>$h_g$                       | 0.9919<br>1231.2 | 1.1584<br>1299.1 | 1.3037<br>1357.7 | 1.4397<br>1412.7 | 1.5708<br>1466.6 | 1.6992<br>1520.3 | 1.8256<br>1574.4 | 1.9507<br>1629.1 | 2.0746<br>1684.4 | 2.1977<br>1740.3 | 2.3200<br>1796.9 |
| 520.0                           | 505.3     | 471.07        | $\bar{V}$<br>$h_g$                       | 0.9466<br>1228.3 | 1.1094<br>1297.4 | 1.2504<br>1356.5 | 1.3819<br>1411.8 | 1.5085<br>1465.9 | 1.6323<br>1519.7 | 1.7542<br>1573.9 | 1.8746<br>1628.7 | 1.9940<br>1684.0 | 2.1125<br>1740.0 | 2.2302<br>1796.7 |
| 540.0                           | 525.3     | 475.01        | $\bar{V}$<br>$h_g$                       | 0.9045<br>1225.3 | 1.0640<br>1295.7 | 1.2010<br>1355.3 | 1.3284<br>1410.9 | 1.4508<br>1465.1 | 1.5704<br>1519.1 | 1.6880<br>1573.4 | 1.8042<br>1628.2 | 1.9193<br>1683.6 | 2.0336<br>1739.7 | 2.1471<br>1796.4 |
| 560.0                           | 545.3     | 478.84        | $\bar{V}$<br>$h_g$                       | 0.8653<br>1222.2 | 1.0217<br>1293.9 | 1.1552<br>1354.2 | 1.2787<br>1410.0 | 1.3972<br>1464.4 | 1.5129<br>1518.6 | 1.6266<br>1572.9 | 1.7388<br>1627.8 | 1.8500<br>1683.3 | 1.9603<br>1739.4 | 2.0699<br>1796.1 |
| 580.0                           | 565.3     | 482.57        | $\bar{V}$<br>$h_g$                       | 0.8287<br>1219.1 | 0.9824<br>1292.1 | 1.1125<br>1353.0 | 1.2324<br>1409.2 | 1.3473<br>1463.7 | 1.4593<br>1518.0 | 1.5693<br>1572.4 | 1.6780<br>1627.4 | 1.7855<br>1682.9 | 1.8921<br>1739.1 | 1.9980<br>1795.9 |
| 600.0                           | 585.3     | 486.20        | $\bar{V}$<br>$h_g$                       | 0.7944<br>1215.9 | 0.9456<br>1290.3 | 1.0726<br>1351.8 | 1.1892<br>1408.3 | 1.3008<br>1463.0 | 1.4093<br>1517.4 | 1.5160<br>1571.9 | 1.6211<br>1627.0 | 1.7252<br>1682.6 | 1.8284<br>1738.8 | 1.9309<br>1795.6 |
| 650.0                           | 635.3     | 494.89        | $\bar{V}$<br>$h_g$                       | 0.7173<br>1207.6 | 0.8634<br>1285.7 | 0.9835<br>1348.7 | 1.0929<br>1406.0 | 1.1969<br>1461.2 | 1.2979<br>1515.9 | 1.3969<br>1570.7 | 1.4944<br>1625.9 | 1.5909<br>1681.6 | 1.6864<br>1738.0 | 1.7813<br>1794.9 |
| 700.0                           | 685.3     | 503.08        | $\bar{V}$<br>$h_g$                       | ...              | 0.7928<br>1281.0 | 0.9072<br>1345.6 | 1.0102<br>1403.7 | 1.1078<br>1459.4 | 1.2023<br>1514.4 | 1.2948<br>1569.4 | 1.3858<br>1624.8 | 1.4757<br>1680.7 | 1.5647<br>1737.2 | 1.6530<br>1794.3 |
| 750.0                           | 735.3     | 510.84        | $\bar{V}$<br>$h_g$                       | ...              | 0.7313<br>1276.1 | 0.8409<br>1342.5 | 0.9386<br>1401.5 | 1.0306<br>1457.6 | 1.1195<br>1512.9 | 1.2063<br>1568.2 | 1.2916<br>1623.8 | 1.3759<br>1679.8 | 1.4592<br>1736.4 | 1.5419<br>1793.6 |
| 800.0                           | 785.3     | 518.21        | $\bar{V}$<br>$h_g$                       | ...              | 0.6774<br>1271.1 | 0.7828<br>1339.3 | 0.8759<br>1399.1 | 0.9631<br>1455.8 | 1.0470<br>1511.4 | 1.1289<br>1566.9 | 1.2093<br>1622.7 | 1.2885<br>1678.9 | 1.3669<br>1735.7 | 1.4446<br>1792.9 |
| 850.0                           | 835.3     | 525.24        | $\bar{V}$<br>$h_g$                       | ...              | 0.6296<br>1265.9 | 0.7315<br>1336.0 | 0.8205<br>1396.8 | 0.9034<br>1454.0 | 0.9830<br>1510.0 | 1.0606<br>1565.7 | 1.1366<br>1621.6 | 1.2115<br>1678.0 | 1.2855<br>1734.9 | 1.3588<br>1792.3 |
| 900.0                           | 885.3     | 531.95        | $\bar{V}$<br>$h_g$                       | ...              | 0.5869<br>1260.6 | 0.6858<br>1332.7 | 0.7713<br>1394.4 | 0.8504<br>1452.2 | 0.9262<br>1508.5 | 0.9998<br>1564.4 | 1.0720<br>1620.6 | 1.1430<br>1677.1 | 1.2131<br>1734.1 | 1.2825<br>1791.6 |
| 950.0                           | 935.3     | 538.39        | $\bar{V}$<br>$h_g$                       | ...              | 0.5485<br>1255.1 | 0.6449<br>1329.3 | 0.7272<br>1392.0 | 0.8030<br>1450.3 | 0.8753<br>1507.0 | 0.9455<br>1563.2 | 1.0142<br>1619.5 | 1.0817<br>1676.2 | 1.1484<br>1733.3 | 1.2143<br>1791.0 |
| 1000.0                          | 985.3     | 544.58        | $\bar{V}$<br>$h_g$                       | ...              | 0.5137<br>1249.3 | 0.6080<br>1325.9 | 0.6875<br>1389.6 | 0.7603<br>1448.5 | 0.8295<br>1505.4 | 0.8966<br>1561.9 | 0.9622<br>1618.4 | 1.0266<br>1675.3 | 1.0901<br>1732.5 | 1.1529<br>1790.3 |
| 1050.0                          | 1035.3    | 550.53        | $\bar{V}$<br>$h_g$                       | ...              | 0.4821<br>1243.4 | 0.5745<br>1322.4 | 0.6515<br>1387.2 | 0.7216<br>1446.6 | 0.7881<br>1503.9 | 0.8524<br>1560.7 | 0.9151<br>1617.4 | 0.9767<br>1674.4 | 1.0373<br>1731.8 | 1.0973<br>1789.6 |
| 1100.0                          | 1085.3    | 556.28        | $\bar{V}$<br>$h_g$                       | ...              | 0.4531<br>1237.3 | 0.5440<br>1318.8 | 0.6188<br>1384.7 | 0.6865<br>1444.7 | 0.7505<br>1502.4 | 0.8121<br>1559.4 | 0.8723<br>1616.3 | 0.9313<br>1673.5 | 0.9894<br>1731.0 | 1.0468<br>1789.0 |
| 1150.0                          | 1135.3    | 561.82        | $\bar{V}$<br>$h_g$                       | ...              | 0.4263<br>1230.9 | 0.5162<br>1315.2 | 0.5889<br>1382.2 | 0.6544<br>1442.8 | 0.7161<br>1500.9 | 0.7754<br>1558.1 | 0.8332<br>1615.2 | 0.8899<br>1672.6 | 0.9456<br>1730.2 | 1.0007<br>1788.3 |

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 $h_g$  = total heat of steam, Btu per pound

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|---------------------------------|-------------|--------------------------|--------------------|----------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Abs.<br>$P'$                    | Gage<br>$P$ |                          |                    | 650°                                         | 700°             | 750°             | 800°             | 900°             | 1000°            | 1100°            | 1200°            | 1300°            | 1400°            | 1500°            |
| 1200.0                          | 1185.3      | 567.19                   | $\bar{V}$<br>$h_g$ | 0.4497<br>1271.8                             | 0.4905<br>1311.5 | 0.5273<br>1346.9 | 0.5615<br>1379.7 | 0.6250<br>1440.9 | 0.6845<br>1499.4 | 0.7418<br>1556.9 | 0.7974<br>1614.2 | 0.8519<br>1671.6 | 0.9055<br>1729.4 | 0.9584<br>1787.6 |
| 1300.0                          | 1285.3      | 577.42                   | $\bar{V}$<br>$h_g$ | 0.4052<br>1261.9                             | 0.4451<br>1303.9 | 0.4804<br>1340.8 | 0.5129<br>1374.6 | 0.5729<br>1437.1 | 0.6287<br>1496.3 | 0.6822<br>1554.3 | 0.7341<br>1612.0 | 0.7847<br>1669.8 | 0.8345<br>1727.9 | 0.8836<br>1786.3 |
| 1400.0                          | 1385.3      | 587.07                   | $\bar{V}$<br>$h_g$ | 0.3667<br>1251.4                             | 0.4059<br>1296.1 | 0.4400<br>1334.5 | 0.4712<br>1369.3 | 0.5282<br>1433.2 | 0.5809<br>1493.2 | 0.6311<br>1551.8 | 0.6798<br>1609.9 | 0.7272<br>1668.0 | 0.7737<br>1726.3 | 0.8195<br>1785.0 |
| 1500.0                          | 1485.3      | 596.20                   | $\bar{V}$<br>$h_g$ | 0.3328<br>1240.2                             | 0.3717<br>1287.9 | 0.4049<br>1328.0 | 0.4350<br>1364.0 | 0.4894<br>1429.2 | 0.5394<br>1490.1 | 0.5869<br>1549.2 | 0.6327<br>1607.7 | 0.6773<br>1666.2 | 0.7210<br>1724.8 | 0.7639<br>1783.7 |
| 1600.0                          | 1585.3      | 604.87                   | $\bar{V}$<br>$h_g$ | 0.3026<br>1228.3                             | 0.3415<br>1279.4 | 0.3741<br>1321.4 | 0.4032<br>1358.5 | 0.4555<br>1425.2 | 0.5031<br>1486.9 | 0.5482<br>1546.6 | 0.5915<br>1605.6 | 0.6336<br>1664.3 | 0.6748<br>1723.2 | 0.7153<br>1782.3 |
| 1700.0                          | 1685.3      | 613.13                   | $\bar{V}$<br>$h_g$ | 0.2754<br>1215.3                             | 0.3147<br>1270.5 | 0.3468<br>1314.5 | 0.3751<br>1352.9 | 0.4255<br>1421.2 | 0.4711<br>1483.8 | 0.5140<br>1544.0 | 0.5552<br>1603.4 | 0.5951<br>1662.5 | 0.6341<br>1721.7 | 0.6724<br>1781.0 |
| 1800.0                          | 1785.3      | 621.02                   | $\bar{V}$<br>$h_g$ | 0.2505<br>1201.2                             | 0.2906<br>1261.1 | 0.3223<br>1307.4 | 0.3500<br>1347.2 | 0.3988<br>1417.1 | 0.4426<br>1480.6 | 0.4836<br>1541.4 | 0.5229<br>1601.2 | 0.5609<br>1660.7 | 0.5980<br>1720.1 | 0.6343<br>1779.7 |
| 1900.0                          | 1885.3      | 628.56                   | $\bar{V}$<br>$h_g$ | 0.2274<br>1185.7                             | 0.2687<br>1251.3 | 0.3004<br>1300.2 | 0.3275<br>1341.4 | 0.3749<br>1412.9 | 0.4171<br>1477.4 | 0.4565<br>1538.8 | 0.4940<br>1599.1 | 0.5303<br>1658.8 | 0.5656<br>1718.6 | 0.6002<br>1778.4 |
| 2000.0                          | 1985.3      | 635.80                   | $\bar{V}$<br>$h_g$ | 0.2056<br>1168.3                             | 0.2488<br>1240.9 | 0.2805<br>1292.6 | 0.3072<br>1335.4 | 0.3534<br>1408.7 | 0.3942<br>1474.1 | 0.4320<br>1536.2 | 0.4680<br>1596.9 | 0.5027<br>1657.0 | 0.5365<br>1717.0 | 0.5695<br>1777.1 |
| 2100.0                          | 2085.3      | 642.76                   | $\bar{V}$<br>$h_g$ | 0.1847<br>1148.5                             | 0.2304<br>1229.8 | 0.2624<br>1284.9 | 0.2888<br>1329.3 | 0.3339<br>1404.4 | 0.3734<br>1470.9 | 0.4099<br>1533.6 | 0.4445<br>1594.7 | 0.4778<br>1655.2 | 0.5101<br>1715.4 | 0.5418<br>1775.7 |
| 2200.0                          | 2185.3      | 649.45                   | $\bar{V}$<br>$h_g$ | 0.1636<br>1123.9                             | 0.2134<br>1218.0 | 0.2458<br>1276.8 | 0.2720<br>1323.1 | 0.3161<br>1400.0 | 0.3545<br>1467.6 | 0.3897<br>1530.9 | 0.4231<br>1592.5 | 0.4551<br>1653.3 | 0.4862<br>1713.9 | 0.5165<br>1774.4 |
| 2300.0                          | 2285.3      | 655.89                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1975<br>1205.3 | 0.2305<br>1268.4 | 0.2566<br>1316.7 | 0.2999<br>1395.7 | 0.3372<br>1464.2 | 0.3714<br>1528.3 | 0.4035<br>1590.3 | 0.4344<br>1651.5 | 0.4643<br>1712.3 | 0.4935<br>1773.1 |
| 2400.0                          | 2385.3      | 662.11                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1824<br>1191.6 | 0.2164<br>1259.7 | 0.2424<br>1310.1 | 0.2850<br>1391.2 | 0.3214<br>1460.9 | 0.3545<br>1525.6 | 0.3856<br>1588.1 | 0.4155<br>1649.6 | 0.4443<br>1710.8 | 0.4724<br>1771.8 |
| 2500.0                          | 2485.3      | 668.11                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1681<br>1176.7 | 0.2032<br>1250.6 | 0.2293<br>1303.4 | 0.2712<br>1386.7 | 0.3068<br>1457.5 | 0.3390<br>1522.9 | 0.3692<br>1585.9 | 0.3980<br>1647.8 | 0.4259<br>1709.2 | 0.4529<br>1770.4 |
| 2600.0                          | 2585.3      | 673.91                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1544<br>1160.2 | 0.1909<br>1241.1 | 0.2171<br>1296.5 | 0.2585<br>1382.1 | 0.2933<br>1454.1 | 0.3247<br>1520.2 | 0.3540<br>1583.7 | 0.3819<br>1646.0 | 0.4088<br>1707.7 | 0.4350<br>1769.1 |
| 2700.0                          | 2685.3      | 679.53                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1411<br>1142.0 | 0.1794<br>1231.1 | 0.2058<br>1289.5 | 0.2468<br>1377.5 | 0.2809<br>1450.7 | 0.3114<br>1517.5 | 0.3399<br>1581.5 | 0.3670<br>1644.1 | 0.3931<br>1706.1 | 0.4184<br>1767.8 |
| 2800.0                          | 2785.3      | 684.96                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1278<br>1121.2 | 0.1685<br>1220.6 | 0.1952<br>1282.2 | 0.2358<br>1372.8 | 0.2693<br>1447.2 | 0.2991<br>1514.8 | 0.3268<br>1579.3 | 0.3532<br>1642.2 | 0.3785<br>1704.5 | 0.4030<br>1766.5 |
| 2900.0                          | 2885.3      | 690.22                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.1138<br>1095.3 | 0.1581<br>1209.6 | 0.1853<br>1274.7 | 0.2256<br>1368.0 | 0.2585<br>1443.7 | 0.2877<br>1512.1 | 0.3147<br>1577.0 | 0.3403<br>1640.4 | 0.3649<br>1703.0 | 0.3887<br>1765.2 |
| 3000.0                          | 2985.3      | 695.33                   | $\bar{V}$<br>$h_g$ | ...                                          | 0.0982<br>1060.5 | 0.1483<br>1197.9 | 0.1759<br>1267.0 | 0.2161<br>1363.2 | 0.2484<br>1440.2 | 0.2770<br>1509.4 | 0.3033<br>1574.8 | 0.3282<br>1638.5 | 0.3522<br>1701.4 | 0.3753<br>1763.8 |
| 3100.0                          | 3085.3      | 700.28                   | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 0.1389<br>1185.4 | 0.1671<br>1259.1 | 0.2071<br>1358.4 | 0.2390<br>1436.7 | 0.2670<br>1506.6 | 0.2927<br>1572.6 | 0.3170<br>1636.7 | 0.3403<br>1699.8 | 0.3628<br>1762.5 |
| 3200.0                          | 3185.3      | 705.08                   | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 0.1300<br>1172.3 | 0.1588<br>1250.9 | 0.1987<br>1353.4 | 0.2301<br>1433.1 | 0.2576<br>1503.8 | 0.2827<br>1570.3 | 0.3065<br>1634.8 | 0.3291<br>1698.3 | 0.3510<br>1761.2 |
| 3300.0                          | 3285.3      | ...                      | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 0.1213<br>1158.2 | 0.1510<br>1242.5 | 0.1908<br>1348.4 | 0.2218<br>1429.5 | 0.2488<br>1501.0 | 0.2734<br>1568.1 | 0.2966<br>1623.9 | 0.3187<br>1696.7 | 0.3400<br>1759.9 |
| 3400.0                          | 3385.3      | ...                      | $\bar{V}$<br>$h_g$ | ...                                          | ...              | 0.1129<br>1143.2 | 0.1435<br>1233.7 | 0.1834<br>1343.4 | 0.2140<br>1425.9 | 0.2405<br>1498.3 | 0.2646<br>1565.8 | 0.2872<br>1631.1 | 0.3088<br>1695.1 | 0.3296<br>1758.5 |

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# GENERAL ENGINEERING DATA

## Properties of Superheated Steam

$\bar{V}$  = specific volume, cubic feet per pound  
 $h_g$  = total heat of steam, Btu per pound

| Absolute Pressure<br><br>Lbs. per Sq. In. |           | Total Temperature—Degrees Fahrenheit (t) |        |        |        |        |        |        |        |        |        |        |        |        |
|-------------------------------------------|-----------|------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                                           |           | 200°                                     | 400°   | 500°   | 600°   | 700°   | 800°   | 900°   | 1000°  | 1100°  | 1200°  | 1300°  | 1400°  | 1500°  |
| 3500                                      | $\bar{V}$ | 0.0164                                   | 0.0183 | 0.0199 | 0.0225 | 0.0307 | 0.1364 | 0.1764 | 0.2066 | 0.2326 | 0.2563 | 0.2784 | 0.2995 | 0.3198 |
|                                           | $h_g$     | 176.0                                    | 379.1  | 487.6  | 608.4  | 779.4  | 1224.6 | 1338.2 | 1422.2 | 1495.5 | 1563.6 | 1629.2 | 1693.6 | 1757.2 |
| 3600                                      | $\bar{V}$ | 0.0164                                   | 0.0183 | 0.0198 | 0.0225 | 0.0302 | 0.1296 | 0.1697 | 0.1996 | 0.2252 | 0.2485 | 0.2702 | 0.2908 | 0.3106 |
|                                           | $h_g$     | 176.3                                    | 379.3  | 487.6  | 608.1  | 775.1  | 1215.3 | 1333.0 | 1418.6 | 1492.6 | 1561.3 | 1627.3 | 1692.0 | 1755.9 |
| 3800                                      | $\bar{V}$ | 0.0164                                   | 0.0183 | 0.0198 | 0.0224 | 0.0294 | 0.1169 | 0.1574 | 0.1868 | 0.2116 | 0.2340 | 0.2549 | 0.2746 | 0.2936 |
|                                           | $h_g$     | 176.7                                    | 379.5  | 487.7  | 607.5  | 768.4  | 1195.5 | 1322.4 | 1411.2 | 1487.0 | 1556.8 | 1623.6 | 1688.9 | 1753.2 |
| 4000                                      | $\bar{V}$ | 0.0164                                   | 0.0182 | 0.0198 | 0.0223 | 0.0287 | 0.1052 | 0.1463 | 0.1752 | 0.1994 | 0.2210 | 0.2411 | 0.2601 | 0.2783 |
|                                           | $h_g$     | 177.2                                    | 379.8  | 487.7  | 606.9  | 763.0  | 1174.3 | 1311.6 | 1403.6 | 1481.3 | 1552.2 | 1619.8 | 1685.7 | 1750.6 |
| 4200                                      | $\bar{V}$ | 0.0164                                   | 0.0182 | 0.0197 | 0.0222 | 0.0282 | 0.0945 | 0.1362 | 0.1647 | 0.1883 | 0.2093 | 0.2287 | 0.2470 | 0.2645 |
|                                           | $h_g$     | 177.6                                    | 380.1  | 487.8  | 606.4  | 758.6  | 1151.6 | 1300.4 | 1396.0 | 1475.5 | 1547.6 | 1616.1 | 1682.6 | 1748.0 |
| 4400                                      | $\bar{V}$ | 0.0164                                   | 0.0182 | 0.0197 | 0.0222 | 0.0278 | 0.0846 | 0.1270 | 0.1552 | 0.1782 | 0.1986 | 0.2174 | 0.2351 | 0.2519 |
|                                           | $h_g$     | 178.1                                    | 380.4  | 487.9  | 605.9  | 754.8  | 1127.3 | 1289.0 | 1388.3 | 1469.7 | 1543.0 | 1612.3 | 1679.4 | 1745.3 |
| 4600                                      | $\bar{V}$ | 0.0164                                   | 0.0182 | 0.0197 | 0.0221 | 0.0274 | 0.0751 | 0.1186 | 0.1465 | 0.1691 | 0.1889 | 0.2071 | 0.2242 | 0.2404 |
|                                           | $h_g$     | 178.5                                    | 380.7  | 487.9  | 605.5  | 751.5  | 1100.0 | 1277.2 | 1380.5 | 1463.9 | 1538.4 | 1608.5 | 1676.3 | 1742.7 |
| 4800                                      | $\bar{V}$ | 0.0164                                   | 0.0182 | 0.0196 | 0.0220 | 0.0271 | 0.0665 | 0.1109 | 0.1385 | 0.1606 | 0.1800 | 0.1977 | 0.2142 | 0.2299 |
|                                           | $h_g$     | 179.0                                    | 380.9  | 488.0  | 605.0  | 748.6  | 1071.2 | 1265.2 | 1372.6 | 1458.0 | 1533.8 | 1604.7 | 1673.1 | 1740.0 |
| 5200                                      | $\bar{V}$ | 0.0164                                   | 0.0181 | 0.0196 | 0.0219 | 0.0265 | 0.0531 | 0.0973 | 0.1244 | 0.1458 | 0.1642 | 0.1810 | 0.1966 | 0.2114 |
|                                           | $h_g$     | 179.9                                    | 381.5  | 488.2  | 604.3  | 743.7  | 1016.9 | 1240.4 | 1356.6 | 1446.2 | 1524.5 | 1597.2 | 1666.8 | 1734.7 |
| 5600                                      | $\bar{V}$ | 0.0163                                   | 0.0181 | 0.0195 | 0.0217 | 0.0260 | 0.0447 | 0.0856 | 0.1124 | 0.1331 | 0.1508 | 0.1667 | 0.1815 | 0.1954 |
|                                           | $h_g$     | 180.8                                    | 382.1  | 488.4  | 603.6  | 739.6  | 975.0  | 1214.8 | 1340.2 | 1434.3 | 1515.2 | 1589.6 | 1660.5 | 1729.5 |
| 6000                                      | $\bar{V}$ | 0.0163                                   | 0.0180 | 0.0195 | 0.0216 | 0.0256 | 0.0397 | 0.0757 | 0.1020 | 0.1221 | 0.1391 | 0.1544 | 0.1684 | 0.1817 |
|                                           | $h_g$     | 181.7                                    | 382.7  | 488.6  | 602.9  | 736.1  | 945.1  | 1188.8 | 1323.6 | 1422.3 | 1505.9 | 1582.0 | 1654.2 | 1724.2 |
| 6500                                      | $\bar{V}$ | 0.0163                                   | 0.0180 | 0.0194 | 0.0215 | 0.0252 | 0.0358 | 0.0655 | 0.0909 | 0.1104 | 0.1266 | 0.1411 | 0.1544 | 0.1669 |
|                                           | $h_g$     | 182.9                                    | 383.4  | 488.9  | 602.3  | 732.4  | 919.5  | 1156.3 | 1302.7 | 1407.3 | 1494.2 | 1572.5 | 1646.4 | 1717.6 |
| 7000                                      | $\bar{V}$ | 0.0163                                   | 0.0180 | 0.0193 | 0.0213 | 0.0248 | 0.0334 | 0.0573 | 0.0816 | 0.1004 | 0.1160 | 0.1298 | 0.1424 | 0.1542 |
|                                           | $h_g$     | 184.0                                    | 384.2  | 489.3  | 601.7  | 729.3  | 901.8  | 1124.9 | 1281.7 | 1392.2 | 1482.6 | 1563.1 | 1638.6 | 1711.1 |
| 7500                                      | $\bar{V}$ | 0.0163                                   | 0.0179 | 0.0193 | 0.0212 | 0.0245 | 0.0318 | 0.0512 | 0.0737 | 0.0918 | 0.1068 | 0.1200 | 0.1321 | 0.1433 |
|                                           | $h_g$     | 185.2                                    | 384.9  | 489.6  | 601.3  | 726.6  | 889.0  | 1097.7 | 1261.0 | 1377.2 | 1471.0 | 1553.7 | 1630.8 | 1704.6 |
| 8000                                      | $\bar{V}$ | 0.0162                                   | 0.0179 | 0.0192 | 0.0211 | 0.0242 | 0.0306 | 0.0465 | 0.0671 | 0.0845 | 0.0989 | 0.1115 | 0.1230 | 0.1338 |
|                                           | $h_g$     | 186.3                                    | 385.7  | 490.0  | 600.9  | 724.3  | 879.1  | 1074.3 | 1241.0 | 1362.2 | 1459.6 | 1544.5 | 1623.1 | 1698.1 |
| 9000                                      | $\bar{V}$ | 0.0162                                   | 0.0178 | 0.0191 | 0.0209 | 0.0237 | 0.0288 | 0.0402 | 0.0568 | 0.0724 | 0.0858 | 0.0975 | 0.1081 | 0.1179 |
|                                           | $h_g$     | 188.6                                    | 387.3  | 490.9  | 600.3  | 720.4  | 864.7  | 1037.6 | 1204.1 | 1333.0 | 1437.1 | 1526.3 | 1607.9 | 1685.3 |
| 10000                                     | $\bar{V}$ | 0.0161                                   | 0.0177 | 0.0189 | 0.0207 | 0.0233 | 0.0276 | 0.0362 | 0.0495 | 0.0633 | 0.0757 | 0.0865 | 0.0963 | 0.1054 |
|                                           | $h_g$     | 190.9                                    | 388.9  | 491.8  | 600.0  | 717.5  | 854.5  | 1011.3 | 1172.6 | 1305.3 | 1415.3 | 1508.6 | 1593.1 | 1672.8 |
| 11000                                     | $\bar{V}$ | 0.0161                                   | 0.0176 | 0.0188 | 0.0205 | 0.0229 | 0.0267 | 0.0335 | 0.0443 | 0.0562 | 0.0676 | 0.0776 | 0.0868 | 0.0952 |
|                                           | $h_g$     | 193.2                                    | 390.5  | 492.8  | 599.9  | 715.1  | 846.9  | 992.1  | 1146.3 | 1280.2 | 1394.4 | 1491.5 | 1578.7 | 1660.6 |
| 12000                                     | $\bar{V}$ | 0.0161                                   | 0.0176 | 0.0187 | 0.0203 | 0.0226 | 0.0260 | 0.0317 | 0.0405 | 0.0508 | 0.0610 | 0.0704 | 0.0790 | 0.0869 |
|                                           | $h_g$     | 195.5                                    | 392.1  | 493.9  | 599.9  | 713.3  | 841.0  | 977.8  | 1124.5 | 1258.0 | 1374.7 | 1475.1 | 1564.9 | 1648.8 |
| 13000                                     | $\bar{V}$ | 0.0160                                   | 0.0175 | 0.0186 | 0.0201 | 0.0223 | 0.0253 | 0.0302 | 0.0376 | 0.0466 | 0.0558 | 0.0645 | 0.0725 | 0.0799 |
|                                           | $h_g$     | 197.8                                    | 393.8  | 495.0  | 600.1  | 711.9  | 836.3  | 966.8  | 1106.7 | 1238.5 | 1356.5 | 1459.4 | 1551.6 | 1637.4 |
| 14000                                     | $\bar{V}$ | 0.0160                                   | 0.0174 | 0.0185 | 0.0200 | 0.0220 | 0.0248 | 0.0291 | 0.0354 | 0.0432 | 0.0515 | 0.0595 | 0.0670 | 0.0740 |
|                                           | $h_g$     | 200.1                                    | 395.5  | 496.2  | 600.5  | 710.8  | 832.6  | 958.0  | 1092.3 | 1221.4 | 1340.2 | 1444.4 | 1538.8 | 1626.5 |
| 15000                                     | $\bar{V}$ | 0.0159                                   | 0.0174 | 0.0184 | 0.0198 | 0.0218 | 0.0244 | 0.0282 | 0.0337 | 0.0405 | 0.0479 | 0.0552 | 0.0624 | 0.0690 |
|                                           | $h_g$     | 202.4                                    | 397.2  | 497.4  | 600.9  | 710.0  | 829.5  | 950.9  | 1080.6 | 1206.8 | 1326.0 | 1430.3 | 1526.4 | 1615.9 |
| 15500                                     | $\bar{V}$ | 0.0159                                   | 0.0173 | 0.0184 | 0.0198 | 0.0217 | 0.0242 | 0.0278 | 0.0329 | 0.0393 | 0.0464 | 0.0534 | 0.0603 | 0.0668 |
|                                           | $h_g$     | 203.6                                    | 398.1  | 498.1  | 601.2  | 709.7  | 828.2  | 947.8  | 1075.7 | 1200.3 | 1319.6 | 1423.6 | 1520.4 | 1610.8 |

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## GLOSSARY OF TECHNICAL TERMS

### Absolute Pressure

The sum of the gauge and the atmospheric pressure. For instance, if the steam gauge on the boiler shows 50 pounds, the absolute pressure of the steam is 64.7 pounds.

### Accuracy

The capability of an instrument to follow the true value of a given phenomenon. Often confused with *inaccuracy*, which is the departure from the true value into which all causes of error are lumped—including hysteresis, nonlinearity, drift, and temperature effect. While this definition is unique, the word accuracy is often incorrectly used as a synonym for *repeatability*, which is defined elsewhere.

### Actuator, Linear

An electric or pneumatic device that sets a valve, damper or linkage a straight line motion.

### Actuator, Rotary

An electric or pneumatic device that sets a valve, damper or linkage a circular motion.

### Actuator, Differential

An electric or pneumatic device that creates differential motion between two shafts.

### Ambient Temperature

The prevailing temperature in the immediate vicinity or the temperature of the medium surrounding an object.

### Analog Input / Output

A continuous or numerical value signal. Typically, provided in 4-20 mADC or 1-5 VDC signals.

### Annunciator

A device that shows the source of events. Annunciators typically provide the date and time of plant alarms and events.

### Assured Low Fire Cutoff

Modulates the boiler to low fire before shutting the boiler down.

### Atmospheric Pressure

The pressure due to the weight of the atmosphere. It is expressed in pounds per square inch or inches of mercury column. One inch of mercury is equivalent to .49 lbs. per square inch atmospheric pressure at sea level is 14.7 lbs. per square inch or 30 inch mercury column.

### Automatic Atomizer Post Purge

This term refers to a burner management system (flame safeguard system) feature that enables the oil atomizer's oil tube to be purged with atomizing medium as part of a normal automatic shutdown. The shutdown sequence requires starting the igniter to ensure all unburned fuel is combusted. This feature requires an automated atomizing media valve and atomizer arrangement. This feature leaves the gun clean and ready for the next start request.

### Bias

A constant voltage or other force which fixes the operating point or the point of initial response in a particular device.

### Blockware

The PCC-III uses a "Blockware" configuration language. Functions (AIN, PID, LOALM, F(x)...) are simply copied into a configuration, and then the control signals are "wired" from block to block.

### Boiler Control System

*See Combustion Control*

### Boiler Efficiency

The efficiency of a burner-boiler combination is simply the amount of useful energy leaving the system expressed as a percentage of the chemical energy in the fuel entering the system.

Two methods:

- Input/Output - difficult to obtain fuel flow, steam flow and steam quality measurements with degree of accuracy required. With 80% efficiency a 5% change can have a major impact
- Efficiency "By Losses" method - Boiler/burner assumed to be a black box

Consider all energies leaving the system. Boiler efficiency ordinarily means the combined efficiency of boiler, furnace and burners and is arrived at by determining the ratio between the heat actually absorbed by the water and the total heat of the fuel released in the boiler furnace.

### British Thermal Unit (Btu):

The quantity of heat necessary to raise one pound of water one degree Fahrenheit.

### Burner Management System

Or flame safeguard system, is a control system that is dedicated to boiler safety, operator assistance in the starting and stopping of fuel preparation and burning equipment, and the prevention of mis-operation of and damage to fuel preparation and fuel burning equipment.

### Building Automation System

General term used to describe a system that is used to monitor and control individual room temperatures, lighting and/or security. These systems may include boiler room monitoring over a communication interface.

### Calorific or Heat Value

The total heat, in Btu generated per pound of liquid or solid fuel, or per cubic foot of gas at the standard temperature of 60 degrees Fahrenheit and pressure of 30 inches mercury. Fuels containing hydrogen have two heat values, the gross (higher heating value), and net (lower heating value). The gross heat value is the heat produced by complete combustion when the water vapor formed is condensed and gives up its latent heat. The net heat value is the heat produced when the water formed by combustion escapes without being condensed.

### Carbon Dioxide (CO<sub>2</sub>)

Carbon dioxide is the product of complete combustion of carbon and oxygen.

### Carbon Monoxide (CO)

Caused by incomplete combustion of hydrocarbon fuels. Excessive CO levels in a furnace lower efficiency and can be explosive.



## GLOSSARY OF TECHNICAL TERMS

### Characterizer Curve, F(x)

Function block that generates a block output based on a user generated output vs. input profile (i.e.  $y=f(x)$ ).

### Combustion

Combustion, in its most basic sense, is the process whereby the hydrogen and carbon in fuels is combined with oxygen from the air to release heat. The chemical union of the combustible material with oxygen, with the resultant generation of light and heat. In the combustion of fuel, each particle of fuel, previously heated to kindling temperature, is brought into contact with the proper amount of oxygen causing the fuel to oxidize as completely as possible.

### Combustion Air Composition

By Volume

- 20.95% oxygen,  $O_2$
- 79.05% nitrogen,  $N_2$

By Weight

- 23.14% oxygen
- 76.86% nitrogen

Can be up to 9%  $H_2O$  by volume in summer

Traces of argon and  $CO_2$

### Combustion, Complete

The complete oxidation of the fuel, regardless of whether it is accomplished with an excess amount of oxygen or air, or just the theoretical amount required for perfect combustion.

### Combustion Control

1. Maintain proper fuel to air ratio at all times
2. Too little air causes unburned fuel losses
3. Too much air causes excessive stack losses
4. Improper fuel air ratio can be DANGEROUS
5. Always keep fuel to air ratio SAFE
6. Interface with burner management for:
  - Purge
  - Low fire light-off
  - Modulate fuel and air when safe to do so

### Combustion Control, Jackshaft (single point positioning)

Air control dampers and fuel flow metering valves are mechanically linked. One actuator simultaneously moves both fuel and air in order to maintain the desired system temperature or pressure. It is assumed that a given position will always provide a particular fuel flow and air flow.

### Combustion Control, Parallel Positioning

The fuel control valves are positioned by one actuator while the air control damper is positioned by a second actuator. For every particular firing rate, there is one and only one position for the fuel valves and a corresponding position for the air damper. For digital controllers, the fuel/air ratio is varied by creating a digital curve of fuel position vs. air position.

### Combustion Control, Fully Metered

Both the fuel flow and the air flow are accurately measured. For every particular firing rate, there is one and only one setpoint value for fuel flow, and there is only one corresponding setpoint for air flow. Generally, the air flow setpoint is generated as a characterized function of the fuel flow rate. Cross limiting prevents the measured fuel flow from exceeding the value corresponding to the measured

air flow. Separate closed loop controllers are used for both fuel and air flow control.

### Combustion, Perfect

The complete oxidation of the fuel, with the exact theoretical (stoichiometric) amount of oxygen (air) required.

### Combustion Rate or Heat Release

The number of Btu per hour released per cubic foot of combustion space or furnace volume.

### Condensation

The change of state of a substance from a vapor into a liquid due to cooling.

### Dead Band

The region or zone where changes in input cause no change in output, independent of the direction in which the input is changing. In this respect, dead band differs slightly from hysteresis, which is dead-band attributable only to changing direction. Also called *dead zone*. See *hysteresis*.

### Drum Level Control

See *Feedwater Control*

### Emissions, PPM

Parts per million – Indicates emission levels on a volume basis. Sometimes may be shown as ppm. Part per million must be referenced and corrected to some oxygen level (excess air level) which, for industrial boilers, is typically 3% oxygen. Actual measurements recorded during boiler testing are usually in ppm.

### Emissions, PPMC

A “corrected” value is one that has been adjusted for an EPA established excess oxygen level, which varies depending on the fired equipment application. The value for industrial boilers and HTHW generators is 3% “dry”  $O_2$  (for duct burner or direct-fired air heaters, the value is 15% “dry”  $O_2$ ). As an example, a “corrected” NOx emissions level for industrial boilers or HTHW generators is calculated as follows:

Corrected NOx, ppmc =

“Dry”, ppm x  $((20.9 - 3) \div (20.9 - \text{“Dry” } O_2\%))$

### Emissions, lb/MMBtu

Pounds per Million Btu – Indicates emission levels on a mass basis. Emission levels are shown in pounds of pollutant per million Btu input. This level is useful when hourly or annual emission levels must be determined.

### Converting Emissions between PPM & lb/MMBtu

Although emission levels can be given in many different units, the most common are ppmc (corrected to 3% oxygen) and lb/MMBtu. Conversion between these two types of units is very simple, however, it does depend on the fuel type and excess air level.

### Emissions, TPY

Tons Per Year – Indicates emission levels on a mass basis. This unit corresponds to the annual pollutant levels.

### Evaporation Actual

The total quantity of water in pounds evaporated from feed water at any temperature into steam at any pressure.

## GLOSSARY OF TECHNICAL TERMS

### NOx Emissions Conversion at 3% O<sub>2</sub>

#### No. 2 & No. 6 Oil

$$\text{ppmc} = (\text{lbs/MMBtu}) \times 750$$
$$\text{lbs/MMBtu} = \text{ppmc}/750$$

#### Natural Gas

$$\text{ppmc} = (\text{lbs/MMBtu}) \times 850$$
$$\text{lbs/MMBtu} = \text{ppmc}/850$$

### CO Emissions Conversions at 3% O<sub>2</sub>

#### No. 2 Oil

$$\text{ppmc} = (\text{lbs/MMBtu}) \times 1290$$
$$\text{lbs/MMBtu} = \text{ppmc}/1290$$

#### No. 6 Oil

$$\text{ppmc} = (\text{lbs/MMBtu}) \times 1260$$
$$\text{lbs/MMBtu} = \text{ppmc}/1260$$

#### Natural Gas

$$\text{ppmc} = (\text{lbs/MMBtu}) \times 1370$$
$$\text{lbs/MMBtu} = \text{ppmc}/1370$$

### Fine Particulate Matter (PM2.5)

Produced from any source that burns ash-containing fuels. Also formed from reaction of other pollutants (acid rain, NOx, SOx, organics) Causes increased respiratory disease, lung damage, cancer, premature death, reduced visibility; surface soiling.

### Flame Safeguard System

*See Burner Management System*

### Flue Gas Monitoring, Safety

High stack temperature switch indicates rising stack temperature. High stack temperature can be an indicator of low water level, excessive tube fouling or short circuiting.

High stack oxygen switch indicates poor combustion conditions.

### Heat Capacity

The ability of a body to absorb heat. Heat capacity is measured by the number of Btus that may be stored in a unit volume of a substance at a specific temperature. It is a function of the substance's weight, specific heat, and temperature difference.

### Heat, Latent

1. The heat required to change the physical state of a substance without changing its temperature.
2. Latent heat of water vapor in stack
3. Fixed amount depending on hydrogen in fuel
4. About 5% of fuel input for fuel oil
5. About 9% of fuel input for natural gas
6. Assumes a non-condensing boiler (typical)

### Heat, Sensible

Sensible heat is defined as the heat energy stored in a substance as a result of an increase in its temperature.

- Sensible heat of stack gases
- Typically around 10% of fuel input
- Increased mass flow and stack temperature increase the loss

### Heat, Specific

The quantity of heat for any substance (expressed in Btu) required to raise a unit of weight or volume of that substance one degree F. at a given temperature. For example, the specific heat of water is 1.0. meaning that 1 Btu is required to raise the temperature of 1 pound of water 1 degree F. This term "Heat, Specific" is most important to anyone using heat generating equipment, for knowing the specific heat of a substance to be heated, knowing the temperature to which the substance must be raised and knowing approximately the thermal efficiency of the heating equipment, you can calculate the amount of fuel consumption for the operation. This, of course, is important in selecting the proper sized burner for the job.

### Heat, Temperature

Heat is a form of energy. Temperature indicates a result of heat energy, namely, the intensity, or the pressure of heat on a particular substance. For example, take two different substances, such as fuel oil and water. Suppose each is at a temperature of 60° F. Now, if the temperature of each is raised to 100° F., each has undergone a rise of 40° but the amount of heat in each is vastly different. Illustration: for water (100° - 60°) x 1 (specific heat of water) = 40 Btu per lb. = the amount of heat in the water above 60° F. for oil (100° - 60°) x .5 (specific heat of oil) = 20 Btu per lb. = the amount of heat in the oil above 60° F.

### Heat Release Rate

The number of Btus per hour released per square foot of water-cooled furnace enclosure surface.

### "Volumetric" Heat Release Rate

The number of Btus per hour released per cubic foot of combustion chamber or furnace volume.

### Heat Loss

The quantity of heat (expressed in Btus per hour) passing through a given section of material, such as a furnace wall, and therefore not available for useful work.

### Heat Transfer

The term employed in describing qualitatively or quantitatively, the transfer of heat from a relatively hot substance to a cooler substance. The actual transfer of heat from one substance to another, such as from flame to work being heated, is accomplished by radiation, conduction or convection. Any one or a combination of these means may accomplish the transfer of heat.

- **Conduction:** the flow of heat from one part of a body to another part of the same body, or from one body to another in physical contact with it without displacement of the particles of the body. For example: the passage of heat along an iron bar one end of which is held in a fire.
- **Convection:** the process of heating a substance by the motion of warmer fluids or gases, in contact with the substance. Thus water tubes in a boiler may be heated by means of the hot products of combustion sweeping over them. The surfaces of the boiler tubes are thus heated by convection, then conduct the heat through the metal of the tubes to the inner surface in contact with the water where the heat is transferred

## GLOSSARY OF TECHNICAL TERMS

by a combination of conduction and convection to the water.

- **Radiation:** The transfer of heat between bodies separated from each other by an appreciable distance. Radiation of heat takes place between bodies of different temperatures at all distances apart and follows the laws for the radiation of light. The heat rays proceed in straight lines and the intensity of the rays radiated from any one source varied inversely as the square of their distances from the source.

### Hysteresis

The summation of all effects, under constant environmental conditions, which causes the output of an instrument to assume different values at a given stimulus point when that point is approached first with increasing stimulus and then with decreasing stimulus. Hysteresis specifically includes backlash. The word is most typically applied to the relationship between magnetizing force and magnetic flux density in an iron core transformer. In the instrumentation field, hysteresis is the same as *dead band*.

### Lead Boiler

The lead boiler is the first boiler to start and the last boiler to stop.

### Series Modulation

The lead boiler is modulated according to load and the lag boilers are base loaded at a pre-determined value for peak efficiency.

### Unison (Parallel) Modulation

All boilers fire at the same firing rate. This mode is required for most hot water boilers in order to achieve the supply header setpoint temperature. Assuming that the water flow is proportioned among the boilers, unequal firing rates would cause unequal boiler outlet temperatures, and would result in a "blended" water supply temperature.

### Lag Boiler

The lag boiler is the next boiler to start and first to stop.

### Low Fire Shutdown

Boilers are brought to minimum fire position prior to shutting off.

### National Fire Protection Association (NFPA)

NFPA is dedicated to protecting people and their property from the devastating effects of fire. In some way, virtually every building, process, service, design, and installation in society today is affected by codes and standards developed through NFPA's true consensus system. Through NFPA's National Fire Codes®, as well as its education and community outreach programs, NFPA is a worldwide advisor on fire safety and protection. Boiler firing systems in the USA follow the guidelines of the NFPA's 85 (previously 8501 & 8502) code.

### Nitrogen Dioxide (NO<sub>2</sub>)

Produced from any source that burns fuel....causes lung irritation and damage and reacts in the atmosphere to form ozone and acid rain.

### NRTL

UL is an example of a product safety organization known generically as a Nationally Recognized Testing Laboratory

(NRTL). NRTLs provide independent evaluation, testing, and certification of the safety of electrical products. The term NRTL and the requirements for recognition are established by the Occupational Safety and Health Act (OSHA) 29 CFR1910, which requires that all electrical equipment used in employee workplaces be NRTL-approved where such approval is available.

### Outdoor Reset

For heating plants, the hot water setpoint can be adjusted based on the outside temperature. This is called "outdoor reset."

### Oxygen Trim

A sensor measures flue gas oxygen and a closed loop controller compares the actual oxygen level to the desired oxygen level. The air (or fuel) flow is trimmed by the controller until the oxygen level is corrected. The desired oxygen level for each firing rate must be entered into a characterized setpoint curve generator. For dual fuel burners, independent curves must be entered. The control strategy must include variable gain (ratio trimming) and setpoint lead/lag logic to prevent control oscillation.

Oxygen trim maintains the lowest possible burner excess air level from low to high fire. Burners that don't have oxygen trim must run with extra excess air to allow safe operation during variations in weather, fuel, and linkage. Extra fuel is burned to heat the extra excess air and it leaves the stack as lost energy. Oxygen trim minimizes excess air and saves fuel.

### Ozone (O<sub>3</sub>)

Formed when Reactive Organic Gases (ROG) and nitrogen oxides react in the presence of sunlight. ROG sources include any source that burns fuel; solvents; petroleum processing and storage; and pesticides. ROG causes breathing difficulties, lung tissue damage, vegetation damage, damage to rubber and some plastics.

### "Pulser AI"

The PWC has Pulse inputs, 0.6 ppm - 4000 Hz, 0-15 VDC. These inputs allow PWC to receive inputs from pulse output devices that are low cost flow meter and KW meter options. Typically, existing meters can be retro-fitted with pulsers.

### PID Control

"Proportional + Integral + Derivative" control algorithms continuously change the output signal until the setpoint equals the process (or desired) variable. Most accurate control logic available.

### Range

A statement of the upper and lower limits between which an instrument's input may be received and for which the instrument is calibrated.

### Repeatability

1. The maximum deviation from the mean of corresponding data points taken from repeated tests under identical conditions.

2. The maximum difference in output for any given identically repeated stimulus with no change in other test conditions. (The word *accuracy* is often used incorrectly as a synonym for *repeatability*.)



## GLOSSARY OF TECHNICAL TERMS

### SCADA

Supervisory Control And Data Acquisition--also referred to as a remote control and monitoring system.

### Sensitivity

The property of an instrument which determines scale factor. As commonly used, the word is often short for *maximum sensitivity*, or the minimum scale factor with which an instrument is capable of responding.

### Setback

The hot water setpoint can be changed depending on the time of day, day of week or week of year. Reducing the heater temperature (or "setback") during unoccupied times saves energy.

### SPST

Refers to relay or switch contacts. Single Pole, Single Throw has two contacts--a common and a normally open contact.

### SPDT

Refers to relay contacts. Single Pole, Double Throw has three contacts--a common, a normally open, and a normally closed contact. The contacts change state when the relay is energized or the switch is thrown.

### Span

The reach or spread between two established limits such as the difference between high and low values of physical measurement.

### Steam, Saturated

Saturated steam is water vapor at the temperature of the boiling point corresponding to pressure.

### Steam, Wet

Wet steam is either saturated or superheated steam which contains moisture.

### Steam, Dry

Dry steam is either saturated or superheated steam containing no moisture.

### Steam, Superheated

Superheated steam is steam heated to a temperature above that corresponding to its saturated steam pressure.

### Therm

A unit originally adopted by many gas companies for measuring and billing the gas to customers. One therm is equivalent to 100,000 Btu.

### Thermal Expansion

Thermal expansion is the increase in volume or linear dimensions of materials when heated. The material returns to its original dimensions when cooled. This is not to be confused with permanent volume changes or growth which many materials undergo when heated.

### Thermal Shock

Thermal shock is the strain produced in a material due to sudden changes in temperature.

### Thermal Spalling

Thermal spalling the result of thermal shock, is defined as a fracture of the refractory material and occurs as the breaking off of pieces from the hot surfaces of the refractory.

### Thermistor

A semiconductor whose resistance is extremely temperature-sensitive. Like carbon, thermistors have negative temperature coefficients. They are used to compensate for temperature variations in other parts of a circuit and are also used as transducers.

### Thermocouple

A temperature-sensing device consisting of two dissimilar metal wires joined together at both ends to deliberately incur the Seebeck Effect. One wire of the circuit is opened (both output terminals are the same metal), and a small electromagnetic force (EMF) appears across the terminals upon application of heat at one junction. The magnitude of this EMF is proportional to the difference in temperature between the measuring junction (located at the point of measurement) and the reference junction (usually located in the measuring instrument or in a tumbler of ice water). Special alloys have been developed to serve as the dissimilar metals, such as constantan, alumel, chromel, and platinum-rhodium. These alloys are paired with each other or with pure-element metals such as copper and iron.

### UL508A

UL508A is an assembly standard, i.e. in addition to requiring that all components be approved, the standard addresses enclosure construction, wiring methods, overcurrent protection, and other aspects of how the components are applied and assembled in a control panel.

### Variable Speed Drives (VSD)

The Variable Speed Drive is a microprocessor-based device that accomplishes stepless speed control of an AC motor by adjusting both the outlet voltage and frequency. The following are different names for the same thing.

- Pulse Width Modulation (PWM)
- Adjustable Frequency Drive (AFD)
- Variable Frequency Drives (VFD)
- Variable Speed Drives (VSD)
- Inverters
- Frequency Converters, Drives

### Volt-ampere

A unit of apparent power equal to the product of volts times amperes without taking into account the power factor. Volt-amperes times power factor equals power in watts.

### Vortex Dampers

Vortex dampers or Inlet control vanes give an initial spin (or vortex) to air entering a centrifugal fan. By adjusting angle of vanes the degree of spin and volumetric output are regulated.

### Watt

The practical unit for power and therefore the rate at which energy is converted to work or dissipated as heat. In the case of electricity, power (in watts) equals the product of voltage (in volts) times in-phase current (in amperes). For DC, power equals the product of voltage and current; for AC, it equals the product of voltage, current, and power factor.







