



Field Project Management Commissioning Manual

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Field Project Management

The task of the Field Project Manager is to plan, coordinate, execute and then close out a project to achieve specific goals and meet a specific success criteria. This requires the FPM to work independently to manage and maintain control of each project they have been assigned to commission.

This includes obtaining a complete knowledge of the scope of responsibilities that Preferred Utilities has agreed to, and ensuring the scope boundaries are maintained and not exceeded unless approvals or change orders have been obtained.

The FPM must maintain an up to date record and schedule of the work performed, the work yet to be completed and a record of labor hours, both already used and what will be required to complete the project. This end shall be accomplished by using the tools provided in this manual.

The style of project management that is most affective as it relates to our projects is more of a critical path system. Each task to be performed is usually at the mercy of an earlier task that has yet to be completed. For example, the limit switches can't be checked until power is brought to the panel. Or the boil-out can't be performed until water is available to the boiler. It is necessary for the FPM to identify which task are the critical mild stones that need to be completed before you can start the commissioning process.

Clear and concise communication with the job site coordinators and the Preferred Project Engineer is paramount in managing a successful commissioning project. The job site coordinator needs to know exactly what you need to have completed or in place for you to efficiently perform your work. They also need to be aware of what any delays in their work will do to your predicted completion schedule. All communications must be in writing. If the understanding or discussion was verbal than you much confirm your understanding of that conversation with a follow up email. The Preferred Project Engineer must be copied on all communications between you and the job site coordinator.

The contents of this manual provide a variation of sample instructions, schedules and tools that will assist the FPM in completing a successful project. They range from simplified to very detailed. Depending on the size and complexity of the project the FPM should follow the samples that best suit the job.

Completed documentation is the key to closing out a project. There are many forms provided to use to document each step or task completed during that job. This documentation is proof that you performed the required task and the results of the completed task.

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**The following Power Point Presentation was given by Gil Sy
at the CIBO Boiler Operations, Maintenance and Performance
Conference on May 25, 2016.**

**The presentation reviews the typical procedure for managing
the installation, start-up and commissioning of a Low NOx
Burner installation on a new boiler.**

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CIBO

Boiler Operations, Maintenance and...
Performance Conference

Low NOx Burner Start-up and Operation

MAY 25, 2016



Low NOx burners typically should not take longer to commission than a conventional burner.

Ultra-low NOx (single digit NOx emission) burner does take longer to commission. The control system must be configured to provide air-fuel ratio adjustment and flexibility for tighter controls capability. This includes characterizing the flow control valve and air damper to match the burner characteristic.



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Sponsor a pre-commissioning installation review

Coordinate a drawing review session between the manufacturer and the installation contractor to ensure that all the manufacturer's requirements are highlighted and understood. Minimizes rework.



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Commissioning schedule is always Compressed

- Ensure that the general installation contractor has all the installation manuals and as built drawings
- Realistic completion schedule from the general installation contractor
 - Piping contractor for:
 - steam
 - gas
 - DA and feedwater
 - condensate
 - blowdown
 - chemical treatment
 - instrumentation
 - Electrical contractor to all major equipment
 - Refractory contractor (if existing boiler)
 - Insulation Contractor
 - Steam vent system for load simulation and performance testing
- Commissioning Readiness Checklist from major suppliers



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Major Equipment

- Provide a commissioning readiness checklist so it can be shared with the general installation contractor
- Ensure that all gas, instrument, feedwater lines and steam lines are cleaned.
- Identify all the new major equipment that will require commissioning, i.e. DA
- Prioritize equipment installation completion schedule
- Provide advance notice on commissioning schedule to the major equipment supplier as soon as possible
- Request a target schedule from your major equipment manufacturers
- Involve your key operators in the readiness checklist
- Schedule for third party testing company if required



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Schedule

- Request or create a Target Commissioning Schedule
- Plan on retaining one of each of the trades during the commissioning stage or involve your in house electrician and maintenance crew should additional work be required.
- To control cost, plan on 8 hours days, stipulate if weekend work is required
- Plan for adequate run time after commissioning
- Plan for training days. Allow time for training your operators and E&I (electrical and instrument) techs
- Calibration gases if required on order
- Required boil-out chemicals are on order



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Target Commissioning Schedule

Inspect overall installation

- Perform lock-out tag out
- Coordinate with VFD start-up engineer on readiness of VFD
- Check FD Fan Installation, check rotation and alignment
- Burner Refractory Throat, correctly installed per manufacturer's drawing if field installed or undamaged if factory installed
- Verify fuel nozzle placement and orientation
- Review overall fuel piping supply run and ensure that all field gas piping has been inspected, cleaned and gas blows performed
- Ensure that all the instrumentation field piping and impulse lines are installed correctly
- Verify that all low voltage control wires are wired on separate conduit and if ran thru cable trays, ensure that there is adequate separation with the high voltage wires



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Target Commissioning Schedule

Inspect overall installation, continued

- Verify that all shipped loose items are installed and wired correctly, i.e. draft actuator linkage, transmitters, VFDs,
- Verify that all other major equipment to support the boiler commissioning are complete, i.e. DA, condensate tanks



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Target Commissioning Schedule

This process will require assistance from the plant E&I tech or electrical contractor

- Remove lock out tags
- Perform loop checks for the burner management system and combustion control system
- Calibrate existing transmitters.
- Check calibration on new transmitters
- Check O₂ analyzer with calibration gas
- Stroke flow control valves, damper actuators, VFDs,
- Follow up on installation corrections
- Fill boiler with water thru DA system
- Perform safety trip test
- Perform initial light-off and prove main flame
- Line up steam and feedwater lines



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Target Commissioning Schedule

Initiate Boil-out Process

- Review boil-out procedure
- Coordinate boil-out schedule with the facility for support
- Add boil-out chemical
- Start boil-out process
- Perform and record safety trip test and witness by the customer



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Target Commissioning Schedule

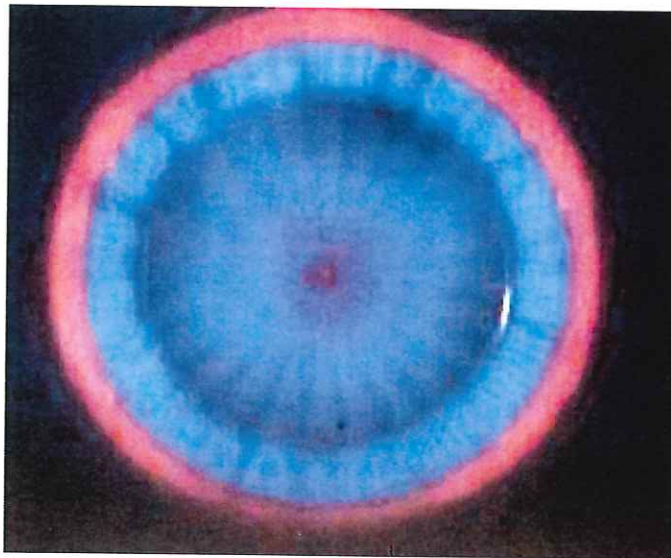
Complete Boil-out Process

- Drain boiler and refill
- Warm-up boiler
- Enter air, FGR and fuel curves. Each point may take 10-15 minutes to set and stabilize data points.
- Boiler steam vent may be required to simulate steam load in order to set the burner combustion. Ensure that condensate tank has adequate make-up for the DA requirements when venting steam.
- Run boiler on automatic controls, check air-fuel ratio and repeatability
- Tune all controllers; boiler master, O₂ trim, drum level, SCR, draft controls and de-superheater if provided
- Perform steam blows if required
- Train operators on alarms and event graphics screens
- Train E&I Techs on trouble shooting graphics screens



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Planning, coordination guarantees a
SUCCESSFUL
Commissioning
and
Installation



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Typical Start-up and Commissioning Procedures

The following procedure is presented as a typical sequence of a project start-up. However, these are guidelines that can be modified to suit each project as long as the basic concept is maintained.

- 1). Sign in with security or the front desk as required and meet with the site contacts.
- 2). Obtain any required safety training and/or site rules and determine the mandatory safety equipment, PPE, to be worn while on site. Review the site policies and procedures for lockout/tag out, confined space entry, fall protection, etc. Submit to any mandatory drug test if required.
- 3). With the site contact, find out the current job schedule and time line of events.

Identify the critical milestones in the schedule that affect your onsite schedule. Most importantly the boil out target dates, refractory curing schedules, hydrostatic testing, etc. Inform the contact of your companies' policies on site hours, weekend work and that we require two weeks advanced notice for scheduling a return to the site. Ask what daily documentation is required by them from you (time record, description of work performed, etc.)
- 4) Based on the specifications, confirm what documentation is required and if it needs to be witnessed an/or signed off by the customer's engineer or representative. How much lead time is required to notify the designated witness.
- 5) Organize a job status report form to track your progress and establish what must be done to complete the start-up. Attach an updated copy daily to the APPS service file.

- 6) Review the installation of equipment supplied or other equipment that will affect the scope of supply regardless of who supplied the equipment. Check all equipment supplied for installation damage. Check the installation of flow elements and transmitters, impulse lines, location of RTDs and thermocouples, O2 Analyzers, opacity monitors, etc. Insure that the installation is up to the established industry standards and manufacturers recommendations. It is important to distinguish between poor workmanship and the ability of the equipment to function as installed.

Remember, there is a difference between recommending an installation is changed vs. insisting that it be changed. Avoid possible back charges!

Confirm that the correct transmitter is matched with the correct flow elements and that the calibration and operating data (PSI, #/hr, SCFH, GPM, etc.) matches actual site conditions. If discrepancies are found, notify the Preferred Project Engineer and advise them of the discrepancies so they can be addressed.

After confirming the results of your inspection, immediately inform the site contact if any changes are required. Supply a punchlist type document. Give one copy to the customer, one copy to the project manager and one copy for the job file for future reference.

- 7) Visually check all field wiring and ring out if required. Insure that:

- All field wiring is terminated and not just tucked in the J-box.
- Signal wire shields are grounded at only 1 end and as shown on the print.
Insure that all other shields are taped off to avoid shorts to ground.
- Check for loose terminal screws and stray strands that can short.
- Insure all unused shield wires are insulated to prevent contact to ground.

- Confirm that 3 phase power wires are separate from the VSD to motor wiring.
- Confirm is the recommended VSD shielded cable is used.
- Confirm that all AC and DC voltage wires are in separate conduits.
- Inspect the entire installation for industry standard practices.

- 8) Confirm that the input voltage supply to our panel is correct.
- 9) Open all fused circuits and energize the panel. Perform loop checks on all circuits by simulating the signal source and insure that the correct PV range and engineering units are illustrated on all displays, recorders and SCADA Systems associated with that loop. After the loop check quickly confirm the operation and calibration of the transmitter or field device. Do not perform the full calibration on non-essential transmitter until you have verified that there are no possibilities that the range will be changed to suit the actual field conditions. Transmitters or meters that will be relied on by other contractors (i.e. burner or boiler) to perform their work must be calibrated and confirmed before start-up takes place.
- 10) Stroke all valves and actuator. Insure all units are set up for a full stroke. These items may require additional work after start-up to maximize controllability. Stroke air dampers and gas valves for equal percentage (slow opening) and stroke oil and feedwater valves for linear operation. Change the actuator cams if required.
- 11) Cycle the BMS and confirm that all limit switches are wired correctly and that the appropriate action is taken when the switch trips and that the correct message is illustrated on the BMS display. Use a "Safety Limit Check Sheet" to document this work.

- 12) Confirm with the mechanical contractor or site inspectors that the fuel supply systems and fuel trains have been properly pressure tested, purged, and are ready to be placed in service.
- 13) Establish a minimum fire for boiler warm up.

Note: Preferred Instruments is not obligated to man a jobsite for operating the controls during boil out or refractory curing unless specified in the sales order. We will set up the controls for a minimum fixed fire so that the operator can start and stop the burner as needed during these procedures.

- 14) Simulate condition required to confirm the operation of the **primary safety limits**, low water cutouts, high-pressure switches, etc.
- 15) Operate boiler/burner through the entire firing range so that the maximum firing rate can be established. Set up the fuel scaling block so that the maximum firing rate input from the fuel meter is 100% to the configuration. Re-span the air flow transmitter so that the required air for maximum rate reads approximately 85%. The system is now ready for final tuning.
- 15) Perform the final calibrations on all the remaining transmitters so that the final recorded data is accurate.
- 16) Learn or plot the F(X) curves (VFD, damper and O2 trim, also the feedforward to the draft controller if applicable). Note: if there is insufficient load available to tune the boiler to the higher firing rates, limit the firing rate demand to the highest load the controls have been tuned to until such time full load operation is available.
- 17) Operate fuel and air in auto with boiler master in manual and confirm F(X) curves are properly controlling to the O2 set points. Fine tune the VFD curve as required

to obtain the desired O₂. Verify that the current PID tuning does not cause hunting, control instability and that the controls properly respond to the process being controlled.

- 18) Confirm that the minimum settings for the fuel and air controllers provide reliable light off on all fuels.
- 19) Re-examine the stroking of the fuel valves and the FD and ID damper actuators. Re-stroke and recalibrate as required to obtain the best possible operations and controllability. Do not try to compensate with the controls what could easily be corrected mechanically. Perform the final calibration and documentation of the remainder of the field transmitters.
- 20) Operate the system in auto and perform the final tuning on all PID blocks as required.
- 19) Record final combustion and operational data.
- 20) Correct the documentation for the BMS limit switches if any changes have been made.
- 21) Insure that the final documentation for the transmitter calibrations are correct and note any changes from the original ranges. For future reference, advise the project engineer on where the Bill of Materials need to be updated to reflect the new calibrations.
- 22) Inquire about and confirm any outstanding punchlist items that remain as open issues. Note outstanding RMAs on any equipment that has been returned to the factory for repair or replacement.
- 23) Back up all controller configurations. Save copies to your laptop for future reference.

- 24) Return all marked up prints, BOM, PLC programs and copies of the controller configurations to the factory engineering department for final review and O&M manual revisions.



Initial Job Information Package for Commissioning

This preliminary information package is a minimum of what the Field Project Manager should have plus anything else you feel is pertinent to the project.

- Copy of the sales order showing all the project information such as the SO number, PO number, customer and ship to address.
- Names of job site contacts for scheduling information and correspondence.
- Copy of specifications that pertain to start-up service, calibration, demonstration, acceptance, performance requirements, documentation required to close out the project, etc.
- A copy of the accepted proposal and any subsequent change orders.
- Copies of all as shipped control programs including PLC ladder logic.
- "As Built" electrical prints, blockware prints, I/O sheets, Sequence of Operations, etc.
- On boiler/burner/controls packages, copies of any factory fire test data.
- Copies of the O&M manuals for the boiler and burner (if not by Preferred).
- Factory calibration sheets for vendor provided instruments where applicable (annubars, orifice plates, vortex meters, Sierra Insertion meters, etc.)
- Up to date copies of the Bill of Materials and P&IDs.
- Any other relevant information or correspondence that constitutes a verbal agreement between PUMC and the customer.

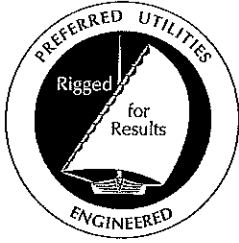
In addition, upon reviewing the BOMs, upload and vendor manuals for equipment you are unfamiliar with.

Preferred Services

Equipment Start-up and Commissioning Status Report

Job Number:	Customer:	Start Date:
Job Name:	Address:	Revision Date:
Address:		Estimated days remaining:
	Site Contact:	
	Office #	(note: use one form per boiler/burner)
Plant #	Cell #	Boiler #

Description	Est. Days	Actual	% Done	Notes/ Comments
1) Installation Supervision				
1A) Installation Inspection of Equipment				
2) Field Wiring Check-out				
3) Instrument Loop Checks				
4) Instrument/ Xmitter Calibrations				
5) BMS Limit Checks (Form 367)				
6) Prestart Checks/ Boilout				
7) Fuel/Air Curves- Gas				
8) Fuel/Air Curves- Oil				
9) Final PID Tuning				
10) Calibration Documentaion- Form 411A				
11) SCADA System				
12) Final Customer Punchlist Completion				
13) Operator Training				



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Target Commissioning Schedule

W.N. Best X-plus Burners and BMU Full Metering System

Customer:

Babcock & Wilcox Power Generation Group
900 B&W Drive
West Point, MS 39773

Job:

Thyssen Krupp Stainless Steel USA, LLC.
1 Thyssen Krupp Drive
Calvert, Al 36513-1300

The following proposed daily activity schedule is for the commissioning of three X-plus Burners firing Natural Gas only and having BurnerMate Universal Burner Management, Fully Metered Combustion Controls and Two Element Drum Level Control systems.

It is required that the plant has installed the necessary provisions for a steam vent and silencer system to ensure that adequate boiler capacity load shedding can be achieved to properly set up the burners. During the venting process, condensate returns will not be available to the DA tank. The plant shall make necessary preparations to ensure that there is adequate water supply to the DA to maintain the necessary boiler drum level for continuous high load boiler operation for extended periods of time.

Attached are copies of the forms that will be used to document the start up and commissioning of this equipment. They include a Safety Limits Check Sheet, a Transmitter Set-up Sheet and a Combustion Performance Data Sheet.

The below schedule does not allow for the commissioning of the Plant Wide Controller which also controls the feedwater pumps and DA tank levels.

A total of (24) 8-hour days for equipment start up and commissioning service has been allowed along with (2) additional 8-hour days for operator training. The below is assuming that all three X-plus burners and controls can be commissioned at the same time.

Week One

1. Inspect the overall installation of the field devices, flow and pressure transmitters, gas meter, steam flow nozzles, etc., both piping and wiring and insure that they are per the manufacturers instructions. Advise the contractor if any changes are required. (4 hours total)
2. Enter the furnaces and install the gas injectors, center fired nozzles and tertiary air plates. (2 hour per burner) Note that the refractory throats and the burner alignments have already been inspected during a previous visit. (16 hours)
3. Inspect all field wiring to the control panel and ensure they are properly landed. Disconnect any field wires not properly landed or incomplete in the field. Check the power supply to the panel to ensure the correct voltage is provided. Check the panel power, neutral and earth ground terminal and insure there are no shorts to ground. Apply power to the panel. (4 hours per boiler)
4. Perform a loop check on all transmitters wired to the control panel. Record all transmitter data and ensure that each transmitter is properly tagged and configured for its intended duty. Provide documentation for each level, flow and pressure transmitter. (4 hours per boiler)
5. Stroke, calibrate and set up the gas valve, FD damper and the FGR damper servos on each burner. (2 hours per burner)

Week Two

1. Set up the initial parameters in the BMU and cycle the burner. With the electrician, check the burner fan rotations. Confirm the operation of the low water cutoffs and the flame safeguard systems. Establish a minimum fire in preparation for boiler boil out. (3 hours per burner)
2. Fire each boiler and warm them up according to B&W recommendations and make them ready for the chemical boil out process. (4 hours total)
3. During the boiler boil out, set and/or confirm the remainder of the safety limits except the high pressure cutout switches. These will be set at a later date when the boilers are up to pressure. Confirm the operation of all other field devices if possible during the boil out. (Assuming the boil out will take at least 24 hours plus allowing for the boiler to cool down and the waterside flushed. We are assuming the remainder of this week to complete the task.)

Week Three

1. Fire all boilers and proceed to warm them up in accordance to B&W instructions. Place the drum level control in automatic and perform the initial loop tuning. Again confirm the proper operation of all low water cutoffs, high and low level alarms and the flame safeguard systems. Leave instruction with the plant personnel for additional overnight warm up. (8 hours total)
2. After the boilers are close to normal operating pressure, set the Operating Steam Pressure and the High Steam Pressure limit switches. (1 to 2 hours per boiler)
3. Start bringing up the firing rate in 10% increments and set up the fuel/air ratio curve to obtain the desired emissions levels. Record data after each load increment is completed. Confirm that the gas flow meter is reading the correct estimated flow. Steam flow will be hard to determine if correct due to the venting process. Confirm that the burner input is set for the maximum rated input at 100% firing rate. Place the firing rate loop in automatic and perform the initial PID tuning as required. Simulate a load change with the steam vent and observe the loop behavior. (16 hours per boiler)
4. Continue item #3 on the other two burners. (10 hours)

Week Four

1. Continue with and complete the set up and tuning of all three boilers as required. Complete the required documentation for each of the burners and controls. (24 hours)
2. Provide operator training using the O&M Manuals as scheduled by the plant supervisor. (16 hours or less as required)

Seven (7) days including travel time is allowed for one year of warranty service starting from the day the commissioning data is complete and turned over to B&W.



Target Commissioning Schedule

W.N. Best X-Plus Burner with BMU Full Metering System

Gas Only

ThyssenKrup Steel and Stainless USA LLC

February 16, 2009

The Preferred Start-up Engineer will perform the following activity on a daily basis. It is required that the plant has installed the necessary provisions for a steam vent and silencer system to ensure that adequate boiler capacity load shedding can be achieved to properly set the burner. During the venting process, condensate returns will not be available to the DA. The plant shall make necessary preparation to ensure that there is adequate make-up water to the DA to maintain the necessary boiler drum level for a continuous boiler operation at high load for at least 30 minutes to an hour (required for emission source testing as well).

This Target Schedule **does not include any time for DA Start-up.**

I. Day 1 and 2:

A. Inspect Overall Installation

- Verify that all proper documentation and drawings that are on the jobsite are of the latest revision
- Burner Refractory Throat Installation, Reference Burner Refractory Throat Drawings
- Check Burner for Concentricity with the Refractory Throat
- Verify Burner Spud Orientation for X or Plus Flame Pattern
- Review Fuel Piping Devices and Instrumentation to ensure completeness. Reference P&ID drawing and Bills of Materials provided with the Burner Documentation
- Verify that gas pilot train PRV, main gas train PRV, pilot vent valve and main gas train vent valve are all individually and piped in a ventilated area per NFPA 85 requirements. Pipe sizing must also meet NFPA 85 requirements.
- Verify the installation of all critical safety trip devices with P&ID
- Verification of Fuel Line Supply Pressures and set pressure regulating valve to required settings
- Verify that all shipped loose flow elements, transmitter impulse lines, and orifice flanges are piped correctly. Ensure that all flow measuring device straight line piping requirements are met.
- Verify wiring on low water level float switches and probes
- Inspect to ensure that all low voltage (24 Vdc, 1-5 Vdc, 4-20mA dc...) are wired in separate conduits from high voltage (120Vac, 220 Vac..). Also, ensure that the flame scanner wiring are in a separate conduit.
- Verify impulse line for high drum pressure switches and transmitters are correctly piped. See Preferred Utilities Mfg. Corp. instrumentation recommendations
- Verify that all draft sensor/transmitter piping are sloped downward (from process connection) to the transmitter or draft gauge or pressure switch and provided with necessary drip legs at the instrument to assure that there is no possibility of moisture buildup on either side of the instrument diaphragms that will indicate incorrect readings.

B. Check Control Panel Wiring Field Devices for Readiness

- Ensure that all field wiring to the combustion control transmitters have been completed. These transmitters are as follows:
 - Drum Pressure
 - Air Flow
 - Gas Flow
 - Drum Level
 - Steam Flow
 - O2 analyzers with the Preferred Cable 7 wire cable (P/N 190130). See Preferred Instruments ZP Probe Manual
 - Stack temperature sensor with thermocouple type J wire
- Ensure that all shielded wires are properly terminated with proper grounding. See attached wiring recommendations.
- Ensure that all wiring from the control system to the final servo drives is completed. Wiring to all servo drives must use the BMU cables provided by Preferred Instruments. These drives are also equipped with position feedback except as noted.
 - Burner Air Damper
 - Gas Fuel Flow Control Valve
 - F.D. Fan VFD
 - Draft damper actuator with position switches
- If provided, ensure that the draft damper position is properly indicated and actual position is represented correctly with the marker.
- If provided, ensure that the draft damper position switches are properly wired (NO or NC).
- Ensure that drum level relay probes and float switches are wired
- Ensure that the low water level by-pass "Deadman Pushbutton" is wired
- Ensure that all position feedback signals are wired to the required terminal numbers at the control panel.
- Ensure that the Remote Emergency Stop (if any) is wired .
- Ensure that the High and Excess Steam pressure switches PSH and PSHH are wired to the Control Panel Terminals.
- Ensure that the Minimum Air Flow switch is wired to the Control Panel terminals.
- Ensure that the Purge Air Flow Switch (if provided) is wired to the Control Panel terminals.
- Ensure that the Low Instrument Air Pressure switch (if required) the Control Panel terminals.
- Ensure that the Piping Tack Junction Box terminals are wired to the Control Panel terminals.

C. Set the following Servo to correct stroke:

- Burner Air Damper
- Main Gas Flow Control Valve
- Draft Damper (if provided)

D. Perform Loop Checks

Perform the following loop checks for the following devices pertaining to the Combustion Controls:

- Boiler Drum Pressure Transmitter
- Boiler Drum Level Transmitter
- Combustion Air Flow Transmitter
- Fuel Gas Flow Transmitter
- Boiler Outlet Flue Gas Temperature Transmitter (if provided)

- Economizer Outlet Flue Gas Temperature Transmitter (if provided)
- Economizer Feedwater Inlet Temperature Transmitter (if provided)
- Economizer Feedwater Outlet Temperature Transmitter (if provided)
- Steam Flow Transmitter
- Stack O2 Analyzer (if provided)

The Preferred Instruments O2 probe was factory calibrated. Ensure that the plant has the calibration gases in place. Cal gas should be 2% and 8% O2 for low and high calibration points.

E. Check Communication Wiring to existing DCS (if applicable). Reference Preferred Instruments "Z" Communication Interface Drawing

F. Check and Set All Servo Motor Stroking

Check Final Drive Linkage Stroking from 0-100% signal on the following actuators:

- Burner Air Damper
- Fuel Gas Flow Control Valve
- Draft Damper (if provided)
- Feedwater Flow Control Valve

G. Re-site scanners as required.

H. Light Off Burner Pilot and set Burner Low Fire for Boiler Out *on Natural Gas* . After the main flame has been established as low fire, set low firer position switch and mechanical down stop

II. Day 3 to Day 6 (Allowed Four Days for the Boil-Out Process)

A. Proceed with boiler boil out. Reference Boiler Manufacturer Requirements.

B. Cure all refractory as per boiler manufacturer recommendations while performing Boil-Out Process.

C. Perform the following applicable safety trip test while boiling out the boiler:

Safety Limit Switch	Nomenclature	Trip Point	Units
Gas SSO Valve Proof Of Closure Switch	ZSC-XXXX	N/A	N/A
Aux Low Water Cutout Switch	ALWCO	N/A	N/A
Low Water Cutout Switch	LWCO-XXXX	N/A	N/A
High Gas Pressure Switch	PSH-XXXX		psig
Low Gas Pressure Switch	PSL-XXXX		psig
Force Draft Fan Motor Starter Interlock	XMS-XXXX	N/A	N/A
Minimum Air Flow Switch	FSL-XXXX		"w.c.
Purge Air Flow Switch	PFSL-XXXX		"w.c.
Low Instrument Air Switch (If Provided)	PSL-XXXX		psig

Note: See Day 7-8 for testing High Steam Drum Pressure and Excess Steam Drum Pressure Switches.

D. Witness the following test:

1. ☐ Pilot flame detection test: _____ Flame Signal Reading
2. ☐ Pilot flame failure test
3. ☐ Main flame detection test: _____ Flame Signal Reading

4. ☐ Main flame failure test
5. ☐ Low Water Alarm
6. ☐ Low Water Cutout
7. ☐ High Water Alarm
8. ☐ Operating Pressure Trip
9. ☐ Low Water By-Pass Pushbutton Test

Test Performed By: _____

Test Witnessed By: _____

F. Check DCS interface to ensure that required readings are met. Test feedwater valve remote control (if Drum Level Control is by DCS).

III. Day 6

Complete boiler out process. Flush boiler as required. Inspect internals as per boiler manufacturer's requirements.

IV. Day 7-8

Proceed to warm up boiler. Follow Boiler Manufacturer Instructions. Perform additional refractory curing if required.

Test all boiler low and high water cutout probe relays and low water cutout switches (LWCO and ALWCO) to ensure that they are functional and trips the burner as required.

Set and test boiler Excess Steam Drum Pressure and High Steam Drum Pressure switches to ensure that the burner trips as required. Test Boiler Drum Relief Valves per Boiler Manufacturer Instructions.

Set burner for natural gas firing. Modulate burner from low fire to high fire manually. Check O₂ trim function. Set drum level controller and tune. Allow four hours for customer acceptance test.

V. Day 9

Perform boiler overall tuning while boiler is on line or with steam vent. Tune all controllers if additional tuning is required. Allow four hours for operator training.

- Simulate low water level alarms on the Drum Level Controller.
- Simulate low Stack O₂ and check O₂ Trim Tuning on both fuels.
- Check boiler response to load demand

VI. Day 10-11

- Allow four hours additional operator training should additional questions come up after overnight operation
- Leave Site Travel back

Note: Additional Training can be provided but at a per diem rate. We recommend splitting training to two four hour sessions should questions arise during the first day of operation and therefore can be answered the following day.



Target Commissioning Schedule

W.N. Best X-Plus Burner with BMU Full Metering System Gas or Fuel Oil

The Preferred Start-up Engineer will perform the following activity on a daily basis. **It is required that the plant has installed the necessary provisions for a steam vent and silencer system to ensure that adequate boiler capacity load shedding can be achieved to properly set the burner. During the venting process, condensate returns will not be available to the DA. The plant shall make necessary preparation to ensure that there is adequate make-up water to the DA to maintain the necessary boiler drum level for a continuous boiler operation at high load for at least 30 minutes to an hour (required for emission source testing as well).**

On applications with steam turbines, the responsibility of the Steam Blow procedure and acceptance is with the end user. They are the most familiar with the turbine requirements. It is expected that the Steam Blows are to take 2-3 days. Preferred Utilities Start-up Engineer will be on site to assist the end user to meet their steam blow implementation and requirements.

This Target Schedule does not include any time for DA Start-up.

I. Day 1 and 2:

A. Inspect Overall Installation

- Verify that all proper documentation and drawings that are on the jobsite are of the latest revision
- Burner Refractory Throat Installation, Reference Burner Refractory Throat Drawings
- Check Burner for Concentricity with the Refractory Throat
- Verify Burner Spud Orientation for X or Plus Flame Pattern
- Review Fuel Piping Devices and Instrumentation to ensure completeness. Reference P&ID drawing and Bills of Materials provided with the Burner Documentation
- Verify the installation of all critical safety trip devices with P&ID
- Verification of Fuel Line Supply Pressures and set pressure regulating valve to required settings
- Verify that all shipped loose flow elements, transmitter impulse lines, and orifice flanges are piped correctly. Ensure that all flow measuring device straight line piping requirements are met.
- Verify wiring on low water level float switches and probes
- Verify impulse line for high drum pressure switches and transmitters are correctly piped. See Preferred Utilities Mfg. Corp. instrumentation recommendations

B. Check Control Panel Wiring Field Devices for Readiness

- Ensure that all field wiring to the combustion control transmitters have been completed. These transmitters are as follows:
 - Drum Pressure
 - Air Flow
 - Gas Flow

- Drum Level
- Steam Flow
- Feedwater Flow
- O2 analyzers with the Preferred Cable 7 wire cable (P?N 190130). See Preferred Instruments ZP Probe Manual
- Stack temperature sensor with thermocouple type J wire

- Ensure that all shielded wires are properly terminated with proper grounding. See attached wiring recommendations.
- Ensure that all wiring from the control system to the final servo drives are completed. These drives are also equipped with position feedback except as noted.
 - Burner Air Damper
 - Gas Fuel Flow Control Valve
 - Oil Flow Control Valve
 - F.D. Fan VFD
 - FGR Fan VFD (if FGR fan is provided)
 - Draft damper actuator with position switches
- Ensure that the draft damper position is properly indicated and actual position is represented correctly with the marker.
- Ensure that the draft damper position switches are properly wired (NO or NC).
- Ensure that drum level relay probes and float switches are wired
- Ensure that the low water level by-pass "Deadman Pushbutton" is wired
- Ensure that all position feedback signals are wired to the required terminal numbers at the control panel.
- Ensure that the Remote Emergency Stop (if any) is wired .
- Ensure that the High and Excess Steam pressure switches PSH and PSHH are wired to the Control Panel Terminals.
- Ensure that the Minimum Air Flow switch is wired to the Control panel terminals.
- Ensure that the Low Instrument Air Pressure switch (if required) the Control panel terminals.
- Ensure that the Piping Tack Junction Box terminals are wired to the Control Panel terminals.

C. Set the following Servo to correct stroke:

- Burner Air Damper
- Main Gas Flow Control Valve
- Main Oil Flow Control Valve (if provided)
- Atomizing Media Pressure Control Valve (if provided)
- Draft Damper (if provided)

D. Perform Loop Checks

Perform the following loop checks for the following devices pertaining to the Combustion Controls:

- Boiler Drum Pressure Transmitter
- Boiler Drum Level Transmitter
- Combustion Air Flow Transmitter
- Fuel Gas Flow Transmitter
- Fuel Oil Flow Transmitter (if provided)
- Boiler Outlet Flue Gas Temperature Transmitter (if provided)
- Economizer Outlet Flue Gas Temperature Transmitter (if provided)
- Economizer Feedwater Inlet Temperature Transmitter (if provided)
- Economizer Feedwater Outlet Temperature Transmitter (if provided)

- Steam Flow Transmitter (if provided)
- Feedwater Flow Transmitter (if provided)
- Draft Pressure Transmitter (if provided)
- Stack O2 Analyzer (if provided)

The Preferred Instruments O2 probe was factory calibrated. Ensure that the plant has the calibration gases in place. Cal gas should be 2% and 8% O2 for low and high calibration points.

E. Check Communication Wiring to existing DCS (if applicable). Reference Preferred Instruments "Z" Communication Interface Drawing

F. Check and Set All Servo Motor Stroking

Check Final Drive Linkage Stroking from 0-100% signal on the following actuators:

- Burner Air Damper
- Fuel Gas Flow Control Valves
- Atomizing Media Pressure Control Valve
- Draft Damper
- Feedwater Flow Control Valve

G. Re-site scanners as required.

H. Light Off Burner Pilot and set Burner Low Fire for Boiler Out *on Natural Gas*. After the main flame has been established as low fire, set low firer position switch and mechanical down stop

II. Day 3 to Day 6 (Allowed Four Days for the Boil-Out Process)

No Steam Superheater is provided by boiler manufacturer.

A. Proceed with boiler boil out. Reference Boiler Manufacturer Requirements.

B. Cure all refractory as per boiler manufacturer recommendations while performing Boil-Out Process.

C. Perform the following applicable safety trip test while boiling out the boiler:

Safety Limit Switch	Nomenclature	Trip Point	Units
Gas SSO Valve Proof Of Closure Switch	ZSC-XXXX	N/A	N/A
Aux Low Water Cutout Switch	ALWCO	N/A	N/A
Low Water Cutout Switch	LWCO-XXXX	N/A	N/A
High Gas Pressure Switch	PSH-XXXX		psig
Low Gas Pressure Switch	PSL-XXXX		psig
Force Draft Fan Motor Starter Interlock	XMS-XXXX	N/A	N/A
Minimum Air Flow Switch	FSL-XXXX		"w.c.
Purge Air Flow Switch	PFSL-XXXX		"w.c.
Low Oil Pressure Switch	LOP		psig
Low Instrument Air Switch (If Provided)	PSL-XXXX		psig
High Oil Pressure Switch	HOP		psig
Low Atomizing Media Pressure Switch	LAPS		psig
Low Atomizing Media-Oil Pressure Differential	LDPS		psig

D. Witness the following test:

1. ☐ Pilot flame detection test: _____ Flame Signal Reading
2. ☐ Pilot flame failure test
3. ☐ Main flame detection test: _____ Flame Signal Reading
4. ☐ Main flame failure test
5. ☐ Low Water Alarm
6. ☐ Low Water Cutout
7. ☐ High Water Alarm
8. ☐ Operating Pressure Trip
9. ☐ Low Water By-Pass Pushbutton Test

Test Performed By: _____

Test Witnessed By: _____

F. Check DCS interface to ensure that required readings are met. Test feedwater valve remote control (if Drum Level Control is by DCS).

III. Day 6

Complete boiler out process. Flush boiler as required. Inspect internals as per boiler manufacturer's requirements.

IV. Day 7-8

Proceed to warm up boiler. Follow Boiler Manufacturer Instructions. Perform additional refractory curing if required.

Set boiler Excess Steam Drum Pressure and High Steam Drum Pressure switches. Test Boiler Drum Relief Valves per Boiler Manufacturer Instructions.

Set burner for natural gas firing. Modulate burner from low fire to high fire manually. Check O₂ trim function. Set drum level controller and tune. Allow four hours for customer acceptance test.

V. Day 9 and 10

Set burner for fuel oil firing. Modulate burner from low fire to high fire manually. Check O₂ trim function. Allow four hours for customer acceptance test.

VI. Day 11

Perform boiler overall tuning while boiler is on line or with steam vent. Tune all controllers if additional tuning is required. Allow four hours for operator training.

- Simulate low water level alarms on the Drum Level Controller.
- Simulate low Stack O₂ and check O₂ Trim Tuning on both fuels.
- Check boiler response to load demand

VII. Day 12

- Allow four hours additional operator training should additional questions come up after overnight operation
- Leave Site Travel back

Note: Additional Training can be provided but at a per diem rate. We recommend splitting training to two four hour sessions should questions arise during the first day of operation and therefore can be answered the following day.



Target Commissioning Schedule

Oxy USA, Denver City Texas Facility

Todd Burner with Fireye E110 and Preferred Instruments PCC3 Full Metering System

The Preferred Start-up Engineer will perform the following activity on a daily basis. **It is required that the plant has installed the necessary provisions for a steam vent and silencer system to ensure that adequate boiler capacity load shedding can be achieved to properly set the burner. During the venting process, condensate returns will not be accomplished. The plant shall do necessary checks to ensure that there is adequate make-up water to the DA to maintain the necessary drum level for a continuous boiler operation at high load for at least 30 minutes to an hour (required for emission source testing as well).**

I. Day 1 and 2:

A. Inspect Overall Installation

- Burner Refractory Throat Installation, Reference Todd Drawing 9063608/10-2
- Burner Concentricity Check
- Verify Burner Spud Orientation (no Todd Drawings on hand, Halgo to provide))
- Verify Swirler Position, Reference Todd Drawing 9063608/10-2
- Review Fuel Piping Devices and Instrumentation to ensure completeness. Reference P&ID, Oxy Drawing WIL-CO2-DA 1387, WIL-CO2-DA 1387A, Todd Drawing 9063608/10-500, 10-550, 10-700, 10-800
- Verify the installation of all critical safety trip devices with P&ID
- Verification of Fuel Line Supply Pressures and set pressure regulating valve to required settings
-
- Verify Proper Piping, Orientation for flow elements and transmitters
- Verify wiring on low water level float switches and probes
- Verify impulse line for high drum pressure switches and transmitters are correctly piped. See attached instrumentation recommendations

B. Check Control Panel Wiring Field Devices for Readiness

- Ensure that all field wiring to the combustion control transmitters have been completed. These transmitters are as follows:
 - Drum Pressure
 - Air Flow
 - Gas Flow
 - Drum Level
 - Steam Flow
 - Feedwater Flow
 - Two O2 analyzers with the Preferred Cable 7 wire cable (P?N 190130). See Preferred Instruments ZP Probe Manual
 - Two stack temperature sensors with thermocouple type J wire
 - One new Wobbe index analyzers
 - One existing Wobbe index analyzers

Note: Ensure that the Wobbe analyzer output is selected for BTU value

- Ensure that all shielded wires are properly terminated with proper grounding. See attached wiring recommendations.
- Ensure that all wiring to the final analog drives are completed. These drives are:
 - F.D. Fan Inlet Vane Actuator
 - F.D. Fan Fresh Air Damper Actuator
 - Feedwater Flow Control Valve
 - Gas Fuel Flow Control Valve
- Ensure that drum level relay probes and float switches are wired
- Ensure that the low water level by-pass “Deadman Pushbutton” is wired across terminals 5 and 8 of the windbox junction box (line 206 of Todd wiring diagram 9063608-20-1, sheet 2 of 6)
- Ensure that the Fresh Air Damper and Fan Inlet Vane Damper “Low Fire Position” switches are wired across 22 and 23 , 24A and 25 respectively as shown in line 217 of Todd wiring diagram 9063608-20-1, sheet 2 of 6)
- Ensure that the fuel flow control valve “Low Fire” position switch is wired across terminals 23 and 24 of the piping rack junction box and from the junction box terminals to the same terminal numbers at the BMS panel.
- Ensure that the purge position switches for Fan Inlet Vane and Fresh Air Damper are wired across terminals 26 and 27, 27 and 28 as not clearly shown in line 218 of the Todd wiring diagram 9063608-20-1, sheet 2 of 6.
- Ensure that the Remote Emergency Stop (if any) is wired across terminals 16 and 17 as shown in line 211 of the Todd wiring diagram 9063608-20-1, sheet 2 of 6
- Ensure that the High and Excess Steam pressure switches PSH 801s and PSHH-801S are wired from the junction box terminals 13-14 and 14-15 of the BMS Panel Terminals as shown in line 211 of Todd wiring diagram 9063608-20-1, sheet 2 of 6
- Ensure that the Minimum Air Flow switch FSL-701 terminals 20-21 of the windbox Junction Box is wired to same terminal numbers in the BMS panel, line 211 of the Todd wiring diagram 9063608-20-1, sheet 2 of 6
- Ensure that the Low Instrument Air Pressure switch PSL-703 terminals 19-20 of the windbox junction box is wired to the same terminal numbers at the BMS panel, line 211 of the Todd wiring diagram 9063608-20-1, sheet 2 of 6
- Ensure that the Piping Tack Junction Box terminals 34 and 35 (pilot SSO and Main SSO valves) is wired to same terminal in the BMS panel, line 304 and 309 of the Todd wiring diagram 9063608-20-1, sheet 3 of 6

C. Set the following Actuator Position switches to correct positions

- FD Fan Inlet Vane Damper Purge Position
- FD Fan Inlet Vane Damper Low Fire Position
- Fresh Air Damper Purge Position
- Fresh Air Damper Low Fire Position
- Main Gas Flow Control Valve Low Fire Position
- Natural gas supply valve, FV 8829 Proof of Closure Switch (by Oxychem)
- CO2 gas valve FV 8953 Proof of Closure switch (by Oxychem)
- FGRU gas valve, PV 8950 Proof of Closure Switch (by Oxychem)

Note: After main gas light Off, the main gas Flow Control Valve low fire positions switch and mechanical down stop may have to be reset.

D. Perform Loop Checks

Perform the following loop checks for the following devices pertaining to the Combustion Controls (Reference Drawings WIL-CO2-DA 1387, WIL-CO2-DA 1387A, 9063608/10-500, 9063608/10-2, 9063608/10-700, 9063608/10-800:

Description	OxyChem Tag No.	John Zink Tag No. PT-	Transmitter Calibration Range	Control Signal	Controller Display Range	Comments
Boiler Drum Pressure Transmitter	PT-3653C	801T	0-330 psig	4-20ma	0-330 psig	
Boiler Drum Level Transmitter	LIT-3651C	PLT-803T	0-20"w.c.	4-20ma	'+10 to -10"	Controller inverts the signal so a loss of signal will indicate low water Superheated steam flow, 275 psig @ 510°F
Boiler Steam Flow Transmitter	FT-3673C	FT-802T	309.493"w.c.	4-20ma	0-60,000 PPH	
Boiler Feedwater Flow Transmitter	FT-3650C	FT-804T	0-154.157" w.c.	4-20ma	0-80,000 PPH	
Combustion Air Flow Transmitter	FT-3668C	FT-701T	0-3.343"w.c.	4-20ma	0-18,000 CFM	
Fuel Gas Flow Transmitter	FT-3666C	FT-501	78.755"w.c.	4-20ma	0-110,000 SCFH	
Wobbe Analyzer 1	AI-8950					
Wobbe Analyzer 2	?					
Oxygen Analyzer 1	AT-3601				0-10%	
Oxygen Analyzer 2	?				0-10%	
Stack Temperature 1	TT-3685				0-1000°F	
Stack Temperature 2	?				0-1000°F	

Check for calibration for both the Wobbe Index Analyzer (supplied by Oxychem). Ensure that plant has calibration gases for the Wobbe Index Analyzers. The Preferred Instruments O2 probe was factory calibrated. Ensure that the plant has the calibration gases in place. Cal gas should be 2% and 8% O2 for low and high calibration points.

E. Check Combustion Controls Critical Safety Inputs

During initial discussions with OxyChem, it was agreed that the Preferred Combustion Controllers will require the critical inputs below. Ensure that the following inputs are properly terminated as shown in the Todd wiring diagrams 9063608 20-1, sheet 5 and 6:

- CO2 Blend Gas Valve Close, Terminal F103
- Low BTU Gas Valve Close, Terminal F104
- Natural Gas Valve not Close, Terminal F105
- Remote Plant Master Selected, Terminal F101
- Remote Alarm Silence, Terminal F102
- Wobbe Analyzer #1 Fail, Terminals 34L-34LA, 120 VAC input
- Wobbe Analyzer #1 Running, Terminals 35L-35LA, 120 VAC Input
- Wobbe Analyzer #2 Fail, Terminals 34L-34LA, 120 VAC input
- Wobbe Analyzer #2 Running, Terminals 35L-35LA, 120 VAC Input
- Wobbe Analyzer Lead Selected signal to DCS, Terminals 3240 and 3241, Contact close, Wobbe Analyzer # 1 selected, Contact Open, Wobbe Analyzer 2 selected
- DCS Feedwater valve control signal to Preferred Controller, terminals 3144-3145
- DCS "Take Over" the Drum Level Control Command, 120 VAC input, terminals 3244 – 3245. See wiring requirements below from PCC 3 manual

120 Vac Discrete Inputs, "J" Board Isolated Neutrals

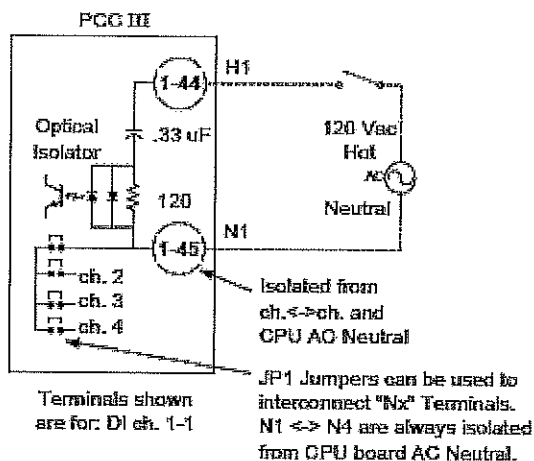
"J" Board Only

This example shows Discrete Input 1 on a "J" Option Board that is plugged into Slot 1.

Each Discrete Input has a separate isolated Neutral which is isolated from all other channels and from the CPU Neutral.

If isolation is not desired, jumpers on the JP1 jumper block interconnect the channel Neutrals. Each jumper connects an individual channel Neutral to an isolated inter-channel tie bus. Therefore two jumpers would have to be installed to connect the Neutrals of two different channels.

The CPU AC Neutral (terminal 1U) does not connect to the "J" board. An external wire must be run if these isolated Neutrals need to be connected.



D. Final Drive Stroking

Check Final Drive Linkage Stroking from 0-100% signal on the following actuators:

- Fan Inlet Vane Full Open
- Fresh Air Damper Full Open
- Fuel Gas Flow Control Valve Full Open

E. FGR Valve

Set the FGR valve to 60% open.

F. Light Off Burner Pilot and set Burner Low Fire for Boiler Out *on Natural Gas*. After the main flame has been established as low fire, set low firer position switch and mechanical down stop

II. Day 3

A. Proceed with boiler boil out.

B. Cure all refractory as per boiler manufacturer recommendations

C. Perform the following applicable safety trip test:

Safety Limit Switch	Nomenclature	Trip Point	Units
Gas SSO Valve Proof Of Closure Switch	ZSC-502/503	N/A	N/A
Aux Low Water Cutout Switch	ALWCO	N/A	N/A
Low Water Cutout Switch	LWCO-804	N/A	N/A
High Gas Pressure Switch	PSH-501		psig
Low Gas Pressure Switch	PSL-502		psig
Excess High Steam Pressure Switch	PSH-801		psig
High Steam Pressure Switch	PSHH-801		
Force Draft Fan Motor Starter Interlock	XMS-701	N/A	N/A
Minimum Air Flow Switch	FSL-701		"w.c.
Purge Air Flow Switch	PFSL-702		"w.c.
F.D. Fan Inlet Vane Damper Purge Switch	ZSH-701	N/A	N/A
F.D. Fan Inlet Vane Damper Low Fire Switch	ZSL-701	N/A	N/A
Fresh Air Damper Purge Position Switch	ZSH-702	N/A	N/A
Fresh Air Damper Low Fire Position Switch	ZSL-702	N/A	N/A

Fuel Low Fire Switch	ZSL-501	N/A	N/A
Low Oil Pressure Switch	LOP		psig
High Oil Pressure Switch	HOP		psig
Low Atomizing Media Pressure Switch	LAPS		psig
Low Atomizing Media-Oil Pressure Differential	LDPS		psig

D. Witness the following test:

1. ☐ Pilot flame detection test: _____ Flame Signal Reading
2. ☐ Pilot flame failure test
3. ☐ Main flame detection test: _____ Flame Signal Reading
4. ☐ Main flame failure test
5. ☐ Low Water Alarm
6. ☐ Low Water Cutout
7. ☐ High Water Alarm
8. ☐ Operating Pressure Trip
9. ☐ Low Water By-Pass Pushbutton Test

Test Performed By: _____

Test Witnessed By: _____

C. Check DCS interface to ensure that required readings are met. Test feedwater valve remote control.

III. Day 4

Complete boiler out process. Flush boiler as required.

IV. Day 5

Proceed to warm up boiler. This warm up period may take up to 3-4 hours. Set burner for natural gas firing. Modulate burner from low fire to high fire manually. Check O2 trim function. Set drum level controller and tune.

V. Day 6

Proceed to fire CO2 gas (natural gas with CO2 blend). Set burner on CO2 gas. Modulate burner from low fire to high fire. Check O2 Trim Function.

VI. Day 7

Proceed to fire FGRU gas (plant process gas). Set burner on FGRU gas. Modulate burner from low fire to high fire. Check O2 Trim Function.

Tune Fuel and Air Flow Controller, O2 Trim. Set O2 Trim minimum fire activation on block 96 of the O2 Probe Controller

VII. Day 8

Perform the following test:

- o Switch over logic. Simulate FGRU gas Wobbe (High Heating Value/Square root of Specific Gravity) change to lower value. The combustion controls should drive the burner to low fire when the HHV value gets below 550 BTU/SCF. Final Wobbe value to be determined by OxyChem. Once the burner has driven to low fire, increase BTU

value to above 550 BTU/SCF. Burner should be released to modulation when the Submaster/Fuel Flow Controller Low Fire Override Push Button is activated.

- Test that the burner can also be released for modulation if the natural gas supply valve, FV 8829, is open and CO2 gas valve FV 8953 and FGRU gas valve, PV 8950 are proven closed.
- Test that the burner **will not be released** for modulation if either of the above CO2 gas valve FV 8953 and FGRU gas valve, PV 8950 **are not proven close.**
- Test low O2 conditions for trip and alarm by simulating the low O2 conditions.
- Simulate failed Wobbe index switchover from #1 to # 2 Wobbe analyzer.
- Simulate low water level alarms on the Drum Level Controller.
- Select Wobbe Analyzer and test Wobbe analyzer selector push button on the Drum Level Controller

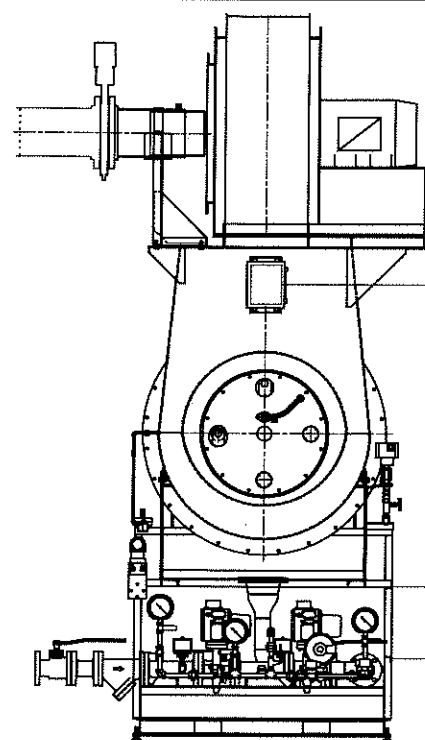
VIII. Day 9

Witness and test boiler for automatic operation. Tune controllers if required.

VIII. Day 10

Start Training on the burner and controls.

IX. Leave Site Travel back

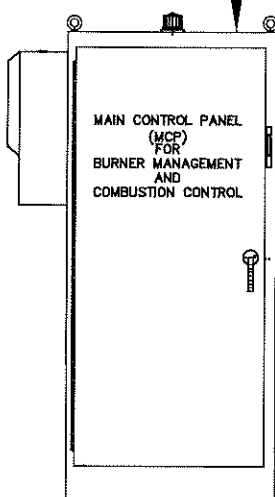
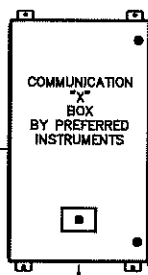
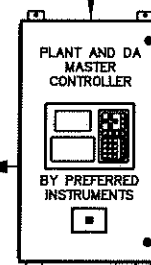


Burner Windbox Junction Box to Main Control Panel (BMS/CCS)						
Tag Number	Device	Voltage/Signal	Interface Point	Winbox Junction Box Terminal Number	Main Control Panel Terminal Number	Device Supplier
IX-157	Ignition Transformer	120 VAC	BMS	51	151	PUMC
		Neutral	BMS	N1	N1	

Boiler No. 1 Piping Rack Junction Box to Main Control Panel (BMS/CCS)						
Tag Number	Burner and Piping Rack Device	Voltage / Signal	Interface Point	Piping Rack Junction Box Terminal Number	Main Control Panel Terminal Number	Device Supplier
Not Applicable	Operating Power	120 VAC	BMS	F1	F1	PUMC
		Neutral	BMS	N	N1	PUMC
		Ground	BMS	G	G	PUMC
PSH-191	Pressure Switch High, Boiler Drum	120 VAC	BMS	111	111	PUMC
PSH-191	Pressure Switch High, Boiler Drum	120 VAC	BMS	32	132	PUMC
FSL-111	Flow Switch Low, Combustion Air	120 VAC	BMS	33	133	PUMC
ALWCO	Aux Low Water Cutout, Float Type	120 VAC	BMS	36	136	B&W
FSH-111	Flow Switch High, Combustion Air	120 VAC	BMS	46	146	PUMC
OSV-155A/155B/155C	Pilot SSO Valves and Vent Valve	120 VAC	BMS	52	152	PUMC
OSV-155A/155B/155C	Main Gas SSO Valves and Vent Valve	120 VAC	BMS	56	156	PUMC
ZSC-155A/155B	VCS, Main SSO Valves Proof of Closure Switch, Nat Gas	120 VAC	BMS	48	148	PUMC
PT-181	Drum Pressure Transmitter	4-20 mA	CCS	A1-A-B-C	A1-A-B-C	PUMC
FT-112	Combustion Air Flow Transmitter	4-20 mA	CCS	A10-A-B-C	A10-A-B-C	PUMC

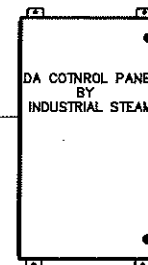
Boiler Mounted Field Devices Interface						
Tag Number	Device	Voltage/Signal	Interface Point	Field Device Termination	MCC Control Panel Terminal	Device Supplier
16B-A-15	High Water Level Probe	Capacitance Type	BMS	3	W3	B&W
16B-A-14	Low Water Alarm Relay	Capacitance Type	BMS	2	W2	B&W
16B-A-15	Low/Low Water Level Probe	Capacitance Type	BMS	C1	WCW1	B&W
16B-A-15	Water Level Probe Current	Capacitance Type	BMS	C1	WCW1	B&W
ALWCO	Low Water Cutout Float	120 VAC	BMS	NO	F1/155	B&W
Not Applicable	Blow Down By-pass Push Button	120 VAC	BMS		W1/131	PUMC
16B-A-4	Feedwater Flow Control Valve	4-20mA	CCS		A8-A/B/C	B&W

Plant Wide Controller Interface with Main Control Panel (BMS/CCS), DA Control Panel and Field Devices						
Tag Number	Device/Function	Voltage/Signal	Interface Point	Device/Panel Terminal Number	PWC Control Panel Terminal Number	Device Supplier
Not Applicable	Power, 120 VAC, 12 Amps	120 VAC			H	PUMC
		Neutral			N	PUMC
		Ground			G	PUMC
Not Applicable	Profibus Communication to X-Box, SDW-109982-1	Communication		1/2/7	B10H1	PUMC
Not Applicable	Steam Header Pressure Transmitter	4-20ma		+/-	1/2	Chester Engineers
Not Applicable	Recycle Limits, Boiler 1	120 VAC	CCS/Main Control Panel	159	1	PUMC
Not Applicable	Boiler No. 1 Lockout	120 VAC	CCS/Main Control Panel	160	2	PUMC
Not Applicable	Recycle Limits, Boiler 2	120 VAC	CCS/Main Control Panel	259	3	PUMC
Not Applicable	Boiler No. 2 Lockout	120 VAC	CCS/Main Control Panel	260	5	PUMC
Not Applicable	Recycle Limits, Boiler 3	120 VAC	CCS/Main Control Panel	359	6	PUMC
Not Applicable	Boiler No. 3 Lockout	120 VAC	CCS/Main Control Panel	360	7	PUMC
Not Applicable	Boiler No. 1 Control Panel Neutral	Neutral	Boiler No. 1 Control Panel	N1	25	PUMC
Not Applicable	Boiler No. 2 Control Panel Neutral	Neutral	Boiler No. 2 Control Panel	N1	25	PUMC
Not Applicable	Boiler No. 3 Control Panel Neutral	Neutral	Boiler No. 3 Control Panel	N1	26	PUMC
Not Applicable	Boiler No. 4 Control Panel Neutral	Neutral	Boiler No. 4 Control Panel	N1	26	PUMC
Not Applicable	Boiler No. 1 Start Circuit	120 VAC Source	Boiler No. 1 Control Panel	F1	1	PUMC
Not Applicable	Boiler No. 2 Start Circuit	120 VAC Source	Boiler No. 2 Control Panel	F1	1	PUMC
Not Applicable	Boiler No. 3 Start Circuit	120 VAC Source	Boiler No. 3 Control Panel	F1	2	PUMC
Not Applicable	Boiler No. 4 Start Circuit	120 VAC Source	Boiler No. 4 Control Panel	F1	2	PUMC



Ship Loose Field Devices and Instrumentation to Main Control Panel (BMS/CCS)						
Tag Number	Field Device	Voltage / Signal	Device Interface Point	Field Device Termination	Main Control Panel Terminal Number	Device Supplier
BE-154	Flame Scanner	120 VAC	BMS	Quick Disconnect Connector	F1	PUMC
		Neutral	BMS		N1	
		24 VDC	BMS		100	
		4-20mA	CCS		131	
TE-115	Air Temperature Transmitter	1-5 VDC	CCS	H	A3-A/B/C	PUMC
ASAT-126	Stack O ₂ Analyzer	High Voltage	CCS	1	161	PUMC
		Low Voltage	CCS	2	162	
			CCS	3A	A3-A/B/C	
			CCS	3B	A3-A/B/C	
TT-127	Stack Temperature		CCS	3C	A3-A/B/C	PUMC
FCV-124 (10B-Q)	FOK Damper and Actuator with Position Feedback and Position Switches	Control	CCS		Quick Disconnect	PUMC
LT-194LT-121	Drum Level Transmitter	4-20mA	CCS		A5-A/B/C	PUMC
FEPT-191	Steam Flow Transmitter	4-20mA	CCS		A7-A/B/C	PUMC
10B-A-4	Feedwater Flow Control Valve	4-20mA	CCS		A8-A/B/C	B&W
PT-162	Nat Gas Flow Transmitter	4-20mA	CCS		A9-A/B/C	PUMC
Not Applicable	Blow Down By-pass Push Button	120 VAC	BMS		W1/131	B&W
Not Applicable	VFD in the Panel to FC Fan Motor	460 VAC, 3 Phase, 60 Hz	BMS			PUMC
Not Applicable	Profibus Communication from Plant DCS to Control Panel				TK	Cat Cable

DA Control Panel to Preferred Instruments Plant Master and DA Controller Control Panel (D-25)						
Tag Number	Device/Function	Voltage / Signal	Interface Point	Device/Panel Terminal Number	PWC Control Panel Terminal Number	Device Supplier
Not Applicable	Power, 120 VAC, 12 Amps	120 VAC			H	PUMC
		Neutral			N	PUMC
		Ground			G	PUMC
Not Applicable	Profibus Communication from Control Panel to X-Box, SDW-109982-1	Communication				PUMC
Not Applicable	Boiler Feedpump #1 Running	120 VAC	DA Control Panel	P1	9	Industrial Steam
Not Applicable	Boiler Feedpump #2 Running	120 VAC	DA Control Panel	P2	10	Industrial Steam
Not Applicable	Boiler Feedpump #3 Running	120 VAC	DA Control Panel	P3	11	Industrial Steam
Not Applicable	Boiler Feedpump Running Neutral Source	Neutral	DA Control Panel	2	12	Industrial Steam
Not Applicable	Boiler Feedpump #4 Running	120 VAC	DA Control Panel	P4	13	Industrial Steam
D-11	DA High Water Level Alarm	120 VAC	DA Control Panel	3	14	Industrial Steam
D-12	DA Low Water Level Alarm	120 VAC	DA Control Panel	4	15	Industrial Steam
Not Applicable	DA Low Water Cutoff Alarm	120 VAC	DA Control Panel	5	17	Industrial Steam
Not Applicable	DA Alarm	120 VAC	DA Control Panel	AL	18	Industrial Steam
D-18	DA Level Analog Input	4-20 mA	DA Control Panel	6	AL5.2 - Terminal 5	Industrial Steam
D-28	DA Pressure Analog Input	4-20 mA	DA Control Panel	11	AL5.2 - Terminal 5	Industrial Steam



JOB: THYSEN KRUPP STEEL USA
CALVERT, ALABAMA 36513
CUST: BABCOCK & WILCOX
CONTRACT NO. 201-3568/69/70
REF. DWGS:

Boiler No. 1, 2 and 3, Main Control Panel (BMS/CCS) Interface						
Tag Number	Device/Function	Voltage / Signal	Interface Point	Control Panel Terminal Number	Main Control Panel Terminal Number	Device Supplier
Not Applicable	Profibus Communication from Control Panel to X-Box, SDW-109982-1	Communication				PUMC

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PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Mfg. Corp.

BOILER #1
FIELD WIRING INTERFACE

FILE S10998A_5

REVISIONS
INIT DATE

SUPERSEDES:
SCALE:
DRN: GS 6/14/09
APPR'D:
SDW-10998A-5

Bay Park Water Pollution Control Plant
Central Heating Plant
III B 2, Spec 15 BAK

Installation Testing
Instrument & Control System Start-up Procedures

General:

The intent of this procedure is to test and demonstrate that all control loops are functional under actual operating conditions with all available boilers, chillers, and system water distribution pumps operating.

Prior to starting this test, all Instrument calibration tests, and loop tests should have been completed.

Prior to starting this test, all Motor Control Center VFD tests should have been completed.

Prior to starting this test, all Boiler/Burner safety interlock and combustion setup and testing should have been completed. (With Oxygen trim "Nulled" out).

If the plant heating / process load is small or not fully connected, then the temporary connections to the XHRL exchanger to convert it into a dummy heat load should be in place. This will allow testing boiler lead / lag start-stop automatic functions.

Hot and chilled water distribution pump speed control testing will not be possible until actual plant loads totaling more than a minimum pump speed equivalent load are connected and in service.

Sequence of System Start-up:

Demonstrate BPCP panel effectively trips boiler limit circuits for: excess combustible gas, low available fresh air (via ATC HVAC interlock), manual boiler trip pushbutton activation, Hot water balancing valve closed, excess opacity, and excess flue gas temperature.

Disconnect Oxygen trim I/P transducer until after burner combustion setup is completed.

Put Boilers into "LOCAL" control mode. Outlet temperature control will be from burner integral modulation controls.

Boiler manufacturer tests safety interlocks, sets up combustion fuel-air ratios, and NOx levels for each fuel. Boiler demonstrates maximum Btu output capacity using manual pump speed control of Effluent/XHRL exchanger pumps for generation of Dummy heat load as required.

- Put Boiler Draft (outlet damper) control loop in automatic and tune while burner combustion is being setup. Required before Burner NOx setup is started.
- After completion of burner setup, re-connect, place in automatic and tune the burner oxygen trim system. Set up each boiler's controller for each of the three fuels.
- Put the Boiler In "REMOTE" mode, place the Boiler Master in Automatic, and tune the boiler outlet temperature control system. Use XHRL/Effluent exchanger system is necessary to produce dummy load to test temperature control.
- Connect a simulator to the digester sphere pressure xmtr input to the BPCP.
Demonstrate that simulated changes in digester sphere pressure will cause any single boiler to change from purchased fuel to digester fuel and back to purchased fuel.
- When sufficient actual plant heating load is available, connect the actual digester sphere pressure transmitter to the digester level controller. Tune and demonstrate automatic operation of fuel change-over, and burner modulation in response to available sphere pressure with low water temperature override.
- When sufficient actual plant heating load is available in any given hot water distribution zone to operate a pump above minimum speed for an extended period, place speed controller in automatic, tune, and demonstrate automatic pump speed operation based on zone return temperature.
- When sufficient actual plant heating load is available for 75% of one boilers output, use the XHRL/Effluent exchanger dummy load to create a two boiler total load. Place Plant master in automatic, tune and demonstrate automatic operation by manually varying the dummy load. Varying the dummy load should result in automatically calling a lag boiler into operation.
- Create artificial lead and lag boiler trips to demonstrate that the third lag and if necessary the standby boiler will automatically start in order to maintain system water temperature.
- Set up alternate boilers to burn Gas and Oil to demonstrate that selected Primary Purchased Fuel will be burned even though the boilers are out of sequence.
- Demonstrate that Natural gas will not be burned when Lilco notifies that Natural Gas should be curtailed.
- Use SCADA system trend plots to verify that each boiler and zone Btu/Hr calculation is accurate and cross checks against the connected load.
- Verify Natural Gas SCADA log sheet usage against Lilco meter and Oil SCADA log sheet usage against multiple day oil tank level decline.
- Verify Strip chart recorder operation against SCADA system trend plots.

If possible the Chillers should be in operation and connected to the Engine Room dummy load air handlers.

Each loop should be tested from input device, through the control device, through the monitor/alarm circuits, through the SCADA computer workstation, and back to the final control element.

Bay Park Water Pollution Control Plant
Central Heating Plant
III B 2, Spec 15 BAK

Installation Testing
Instrument & Control System Start-up Procedures

General:

The intent of this procedure is to test and demonstrate that all control loops are functional; prior to operating the boilers, chillers, or system water distribution pumps.

Each loop should be tested from input device, through the control device, through the monitor/alarm circuits, through the SCADA computer workstation, and back to the final control element.

A loop includes:

- Field Inputs from: sensors, transmitters, switches, or PLC communications
- Panel mounted monitors and controls: displays, graphic annunciator lamps, recorder pens, loop controller, PLC input, Panel mounted switches
- SCADA workstation: Visual displays, Visual alarms, historical data logging, alarm logging associated with the loop under test.
- Panel mounted Control outputs from: Single loop controllers, PLC outputs, and hand switches
- Field Mounted Outputs (Final Control Devices): 4-20 mA control devices, VFD drive inputs, electric actuators for valves and dampers

Prior to performing any loop test, the field wiring should be tested for continuity, meggered for absence of grounds, and terminated.

Transmitters will be checked for proper installation, calibration and operation verified under a separate test procedure (which may be done before or after Loop testing). For the purposes of Loop testing, transmitter output signal generators (4-20 mA, freq., etc...) will be used instead of the actual transmitter output to test the operation of each loop. These signal generators will be connected at each field device to insure all field wiring is fully tested back to the control panels.

Field Switches will be activated by the process variable whenever possible; however, temporary jumpers or opening of circuits (at the physical field device) may be used if the device can not be activated by the process.

The BPCP, CPCP, Remote Annunciator Panel, and SCADA computer workstation must all be operational in order to perform loop testing.

Records of Individual Loop tests will be kept in three "log books" as each Loop is tested:

- 1) The first Logbook will be a dedicated set of BPCP, CPCP, Mosaic Graphic Panels (3) and RACP loop wiring diagrams (SDW-1743-1, SDW 1745-1, SDW-1746-1, SDW-1750-1, SDW-1751-1). As each "Loop" is tested, the

technician and inspector will initial and date the portion of the drawing that shows the equipment. The above drawings are laid out in a functional loop by loop manner.

- 2) The written Control Logic Sequence of Operations descriptions will be used for testing of control logic sequences. As each "Loop" control logic is tested, the technician and inspector will initial and date the portion of the Control Logic that describes the tested control logic.
- 3) A spreadsheet / checklist for SCADA system functions (display, alarm, historical trending, and control), that relates each field input to each possible SCADA function will be used to record the testing of each SCADA function for each Loop test. As each "Loop" is tested, the technician and inspector will initial and date the portion of the SCADA logic that is successfully tested.

Control logic will typically be tested for proper general reaction on an individual loop basis. That is does the firing rate increase when the boiler temperature falls, does the valve open (not close) when commanded, etc. However, Total system logic typically will not be tested until the majority of mechanical systems are operational. For example, the Boiler submaster can be tested, but the Boiler Lead/Lag logic can not until several boilers and the distribution system are operational.

Types of Loop Tests:

Analog Transmitters:

Temperature xmtrs; Water, oil, natural gas, and digester gas flow xmtrs, Pressure xmtrs, Oxygen Analyzers, CO/NO Analyzers, Opacity Monitors, oil tank level xmtrs, etc... will be simulated in at the field device with a signal generator.

The display and alarm devices will be observed in the BPCP, CPCP, & RACP for proper operation and proper engineering units displayed. The display and alarm screens will be observed on the SCADA workstation for proper operation and proper engineering units displayed. When connected to a loop controller, varying the signal generator signal will be used to test for proper control action.

Analog Control Outputs:

4-20 mA firing rate control to each burner, 4-20 mA fuel pressure trim to each burner for Oxygen trim control, 4-20 mA firing rate control to each pump VFD, and Boiler outlet damper actuator modulation action.

Each modulating control will be tested by putting the controller in Manual and varying the control signal, and then observing the desired control reaction at the controlled device.

The Boiler Master, Boiler Oxygen trim controller, and Boiler Draft controller will be tested in Automatic mode with a simulated xmtr input with the burner fuel supplies manually valved off.

Each Pump Speed Controller will be tested in Automatic mode with a simulated xmtr input with the pump VFD 3 phase power disconnected.

Motorized Valves:

Oil tank suction and return motorized valves will be cycled from hand switches on CPCP panel. Actual valve position versus panel indicator lights will be verified as well as related SCADA displays. Suction and Return valves will be purposely misaligned in various combinations to tested valve failure alarms.

Boiler Water Balancing motorized valves will be cycled from hand switches on BPCP panel. Actual valve position versus panel indicator lights will be verified as well as related SCADA displays.

Oil, Natural Gas, and Digester Gas header shutoff valves will be tested for proper sequenced opening and tripping by operating the Boiler Plant Master trip pushbutton in the BPCP. Actual valve position versus panel indicator lights will be verified as well as related SCADA displays.

Manual Valve Position Switches:

All "ZS_ xxxx" tag valve position monitoring switches will be activated by partially closing and then fully opening each valve. Actual valve position versus panel indicator lights will be verified as well as related SCADA displays.

Pump Hand-Off-Auto switches in BPCP and CPCP:

Each pump will be momentarily energized (ie "bumped") to verify that the proper switch is controlling the proper pump. System feedback (flow switch) can not be observed until the system is filled with water and a flow path to the plant is established. MCC feedback via Genius I/O communications will be observed.

Oil Leak Sensors:

Test Switches at each sensor location will be activated to verify wiring and display of alarms on CPCP and on SCAD system

Oil Tank Outdoor Overfill Alarm Panels:

The Overfill test function on each tank gauge will be used to verify proper wiring and operation of each outdoor overfill panel.

Video Cameras:

Each video camera remote control will be demonstrated. VCR record and playback capability will be demonstrated.

Fuel Oil Systems Startup and Commissioning Procedures

1. Documents to obtain before going to the site:
 - PDF of O&M manual.
 - Electrical Drawings.
 - Bill of Material including Ship loose items.
 - Site information and contacts.
2. Once on site meet with the job contact and obtain any required safety training and/or any other site rules. Is Flash Arc certification required to open a panel that is energized.
3. Survey the installation of the fuel oil system to include:
 - Panel mounting, location and accessibility.
 - Skid mounting (secured to the floor), accessibility.
 - Field devices for correct installation and location.
 - Proper flow directions for flow switches, manifolds and valves both Motorized ball valves and solenoid valves.
4. Verify proper piping for inlet and outlet pipes from storage tanks, pump skids, filtration systems, boiler loops and day tanks.
5. Verify wiring terminations, both field devices and panel factory wiring. Ensure terminals are tight.
6. Verify wiring at each field device such as, valves, leak sensors, level transmitters (4-20mA, ultrasonic, wire floats, HLT's and PLS to name a few).
7. If a storage tank is in the system either above ground or in ground, verify installation of level sensors and leak sensors (both HD-A2 and PLS).
8. If an HLT has been installed verify proper location of the Barometric sensor.
9. If a wire float has already been installed discuss with installer to ensure that they followed the installation manual for proper float placement on wire. If there are any doubts, be safe and check it personally.
10. Discuss with electricians what voltages are being provided to the panels (120vac, 208vac, 460vac) Once confirmed that power is provided to the panel power up panel (advice is to ensure if panel is controlling pumps that they are in the off position so it doesn't start until ready) Measure voltage coming into panel and if there is a Transformer verify control voltage to controller. Document this information on startup forms.

11. Inspect controllers – PLC, PWC or FSC and ensure it is in run mode and function lights are sequencing correctly.
12. View the alarm screen and identify any alarms that are active and work to identify where they are located and clear them if possible (note, with a new start up you will get low level alarms until oil is pumped into storage tanks and day tanks).
13. Scroll through the screens (OIT and PWC) and verify that all information is correct and displaying properly. (this is a good troubleshooting tool to verify that flow switches are wired correctly, level and leak PLS switches are in the close position for empty state and that pressure and temperature indicators are correct) (note, if this is a FSC node network, verify at each node also)
14. If oil has already been delivered and put in the storage tank, take a depth reading of oil and verify that it is reading correctly at the D4A fuel sentry, correct if not. Verify that volume settings are correct for the D4A and that the proper inputs are operating (level, leak, etc.)
 - During this function, you can check alarms for high-high, high, low and low-low alarms by going into the D4A set up screens and adjust the volumes to verify operation.
 - Another way to do this is to have the wire float removed from the tank and move the float and wire up and down to engage those alarms.
15. Test leak alarms both PLS, RBS and HD-A2 and verify that they were recorded in the alarms page and events once cleared.
16. Now, you are ready to pump fuel to either a day tank, or boiler loop. Verify that at the pump set all valves are opened and strainer lids are tight to prevent leaking.
 - For Day tanks, the ideal situation is for it to be empty and if there is a return pump in the system you can fill the day tank to high level and observe and document switch settings and operation of the fill and drain operation.
 - If there isn't a return pump then there is only a one time fill for the day tank to the high level (and high-high or vent leak if so installed) then the operation of the day tank controls is complete.
 - For a boiler loop verify that all valves are open and then start the pump and allow time to fill the loop with oil and verify that it is circulating. Now, you can verify that the Back-Pressure Regulator valve is set to proper back pressure if so installed. (note- if there are no relays installed on the individual boilers for call for operation function then the system would be run in hand)

17. Now, you can test each leak alarm in the system and verify that it registers on the alarm screens (note, if this is a FSC node network, verify at each node also).
18. Once the system is filled with oil, verify while running the pumps oil discharge pressure and vacuum at the pump set and document on startup forms.
19. Additional equipment that might need to be inspected and tested would be – fill stations (FAAV) which have alarm bells, alarm lights, and or digital display of level. Also, be on the lookout for Fireomatic valves, ensure that they are installed properly with fusible link and in some cases, they have switches that are wired back to the control panel for status.
20. For Filtration systems, verify wiring terminations, piping inlet and outlet and tightness of filter and strainers.

Once all this has been completed, ensure that all important information is documented on the start-up, commissioning reports and download to the job dispatch for submission.

Dry Start up for Fuel oil pump Procedure

The following provides information and a step by step procedure on how to prime a fuel oil pump to ensure the pump will not become damaged.

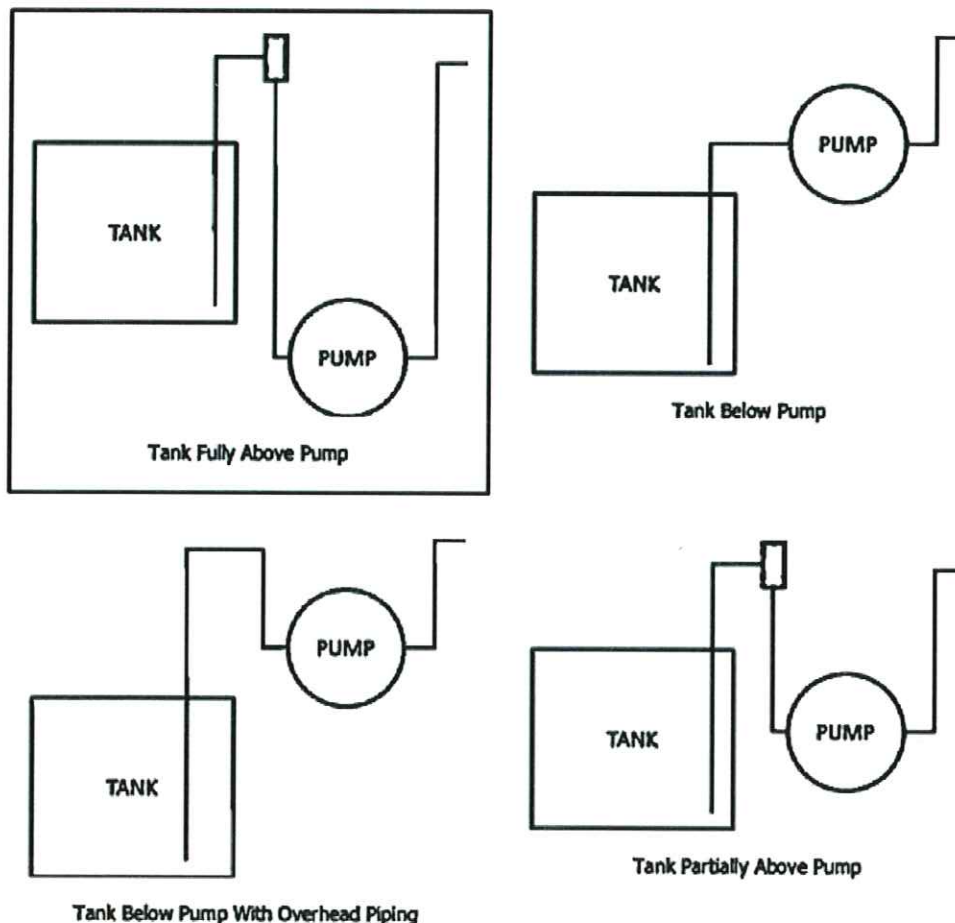
This can be applied to all pumps including duplex, simplex or filtration pumps.

The pumps that Preferred uses are self-priming, but there needs to be oil present to ensure that all pump parts are "wetted" to prevent damage to the pump.

Below is information to allow the technician or operator to accomplish this.

Please note that Return pumps on day tanks are in such a manner that the only requirement to prime them is to have oil present in the day tank.

Typical suction pipe arrangements for fuel oil systems



Above are 4 typical piping arrangements for suction lines to fuel oil supply systems. Two are shown with Anti-siphon valves to prevent syphon action that will drain the storage tank in the event of a line break between the tank and the pump set.

Knowing which of these typical setups you have will determine how you prime the pump to place it in service.

Initial start-up for Dry Pumps

Wetted start up. Wetted is a term that means ensuring that all internal parts of the fuel oil pump are lubricated sufficiently to pull oil through the pump.

These pumps are self-priming, but will not run very long dry.

Pre-Startup of Pump

Before turning the HOA switch to Hand Check the following:

1. Open strainer (either duplex or simple type) and fill with oil, inspecting basket to insure no debris is present) Place lid back on strainer and tightened.
2. Are Vacuum and pressure gauges (liquid filled and dry) mounted on or near the pump? Gauges are the quickest and most accurate way of finding out what is happening in the pump.
3. Confirm good pump alignment with the drive motor?
4. Ensure that the piping is not placing a strain on the pump body.
5. Rotate the pump shaft by hand to be sure it turns freely.
6. Jog the pump by momentarily switching HOA switch into hand position to verify the rotation is correct.
7. Check for proper installation of the pressure relief valve. The discharge must be going back to the storage tank. There also could be an internal relief on some models of pumps that should be pre-set at the factory. There must be no valves between the relief valve and the outlet of the pump. Refer to your commissioning documents to confirm relief valve settings. This should be 15 PSI higher than the maximum system operating pressure.
8. Make sure suction piping is properly connected and sealed, and valves are open. Ask the installer if the pipe has been pressure tested.
9. Make sure the discharge piping is properly connected and sealed, valves on pump set are open, and there is a place for the liquid to go. Typically, this will be to a Day tank or a Boiler supply loop.
10. Make sure all OSHA guards are in place before running the pump.

First Time Starting Pumps

Place the HOA switch in Hand. The pump should begin to deliver liquid within 15 second! If not, turn the pump HOA to off. Do not run the pump without liquid flow longer than 30 seconds or the pump may become damaged.

Observe your suction and discharge gauges. Suction gauges are compound gauges in that they read vacuum and pressure. Ideal vacuum is between 8 and 10 inches of mercury. Review Pre-Startup steps 1 through 10. Consider what the suction and discharge gauges indicate. If everything appears in order, re-prime the pump.

Turn the HOA switch to hand. If nothing is flowing within 30 seconds, stop the pump. The pump is not a compressor, it will not build up much air pressure. It may be necessary to vent discharge line until liquid begins to flow. This can be done by opening a valve downstream of the pump discharge.

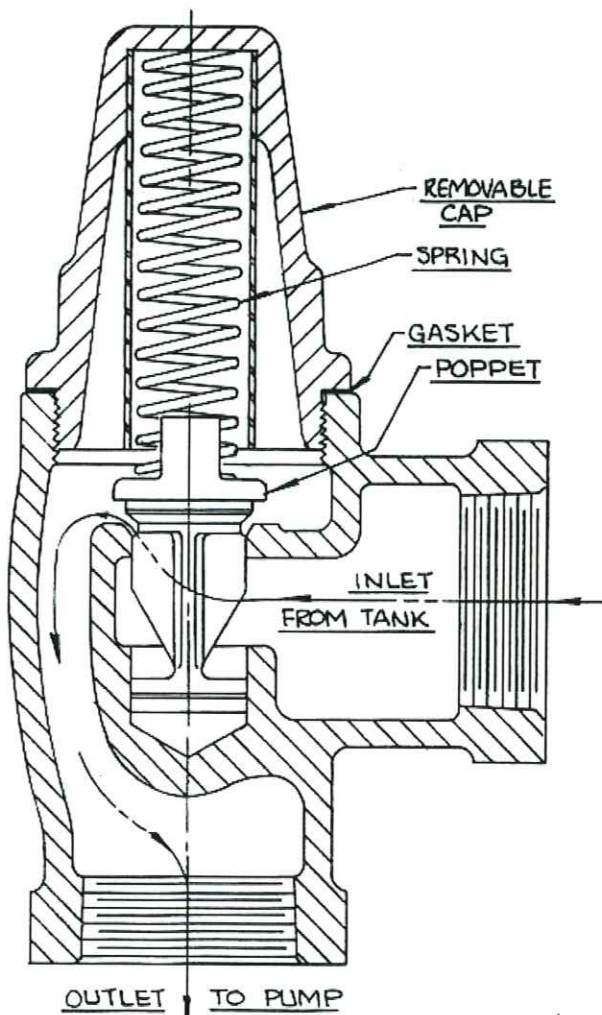
If there is an Anti-syphon valve mounted at the highest point of the suction line on top of the storage tank, it is always recommended that you fill the suction line from that point. Ideally a suction line from a storage tank has a dip tube going down to the bottom of the tank with a foot valve installed to keep line filled with oil once primed.

Priming from the anti-syphon valve will allow you to fill the suction pipe to the inlet of the pump and the line going to the tank.

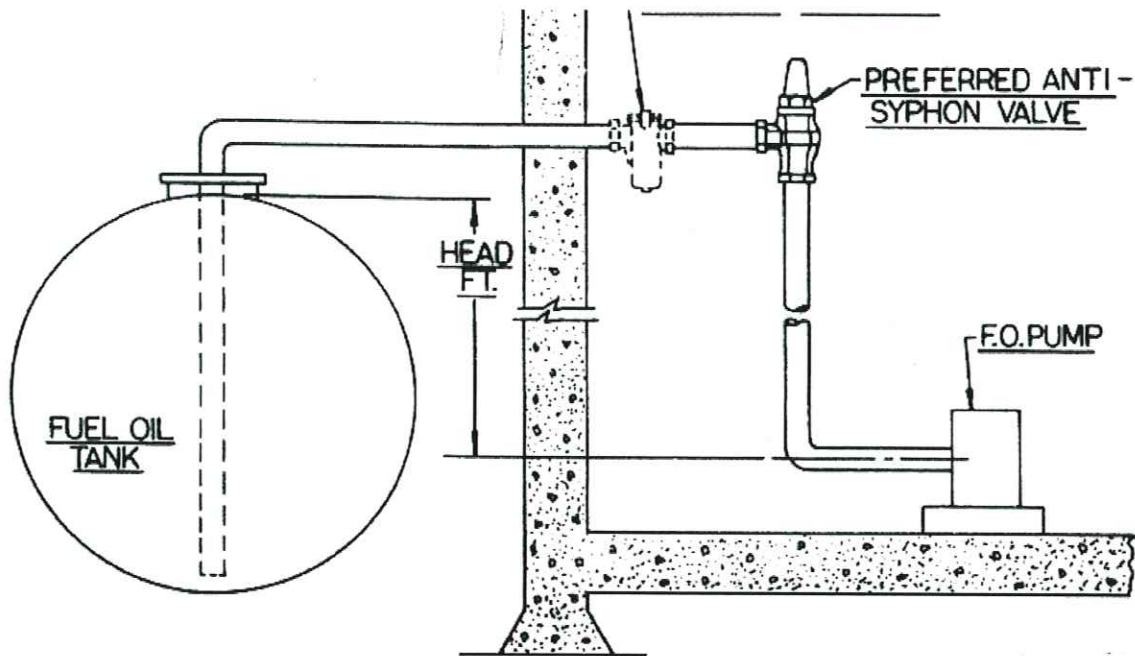
Priming an Anti-Syphon Valve

When an Anti-syphon valve is installed it is recommended that the suction line be filled from the Anti-syphon valve to assist the pump with sufficient fuel to pick up the prime from the tank.

This is a cutaway drawing of the Preferred Model A Anti-Syphon valve showing the inlet and outlet ports and the flow direction of the oil.



The below is a typical piping arrangement for the Model A Anti-Syphon valve. The valve must always be located at the highest of the piping system and above the storage tank.



To prime the suction line from the anti-Syphon valve:

1. First ensure there is no pressure remaining in the line from the contractor's testing.
2. Remove the cap, the spring and poppet.
3. Fill the valve and line with oil until it reaches the top. Ideally this should fill back towards the tank and down towards the inlet of the pump. Ideally there is a check valve or foot valve at the tank to keep the oil from draining back into the tank.
4. Replace the spring, poppet and the cap. Ensure the cap gasket is in place.
5. Proceed using the above instruction for starting a pump for the first time.
6. Note that the oil in the pipe between the valve and pump will offset the pressure from the spring.

Using the above procedures will allow you to prime the pump and then and fill the discharge lines.

Troubleshooting

The following is presented to assist troubleshooting why the pump will not pick up the oil from the tank.

Vacuum Gauge – Suction Port

High vacuum reading would indicate:

1. The suction line is restricted, a valve closed, the strainer is plugged, etc.
2. The suction line is too small.
3. The liquid is too viscous to flow through the piping.
4. The lift required is too high.

A flutter, jumping or erratic reading would indicate:

1. The liquid is vaporizing, possibly due to a high vacuum.
2. Liquid is coming in to the pump in slugs, possibly an air leak or insufficient liquid above the end of the suction pipe (tank is very low).
3. Vibration from cavitation, pump misalignment, or damaged parts (coupling).

Pressure Gauge – Discharge Port

High reading would indicate:

1. High viscosity, undersized pipe diameter, and/or too long a discharge line.
2. The outlet or day tank strainer or filter is plugged.
3. The pressure relief valve is set too high.
4. A valve in the discharge line is completely or partially closed.
5. The line is partially plugged due to buildup of solidified product (paraffin) or a foreign object (rag) was left in the line.
6. Liquid in the pipe is not up to temperature. (normally when using #4 or #6 oil)

Low reading would indicate:

1. Pressure relief valve set too low.
2. Pressure relief valve poppet not seating properly.
3. The pump has too much internal clearance.
4. The bypass valve around pump partially open.
5. The pump is damaged or worn.

Flutter, jumping or erratic reading would indicate:

1. Cavitation
2. Liquid in coming to the pump in slugs.
3. Air leak in the suction line.
4. Vibrating from misalignment or mechanical problems.

Miscellaneous

The pump does not pump oil:

1. Pump lost it's prime due to air leaks or low level in the tank.
2. The suction lift is too high.
3. The pump rotating is incorrect.
4. The motor does not come up to full speed.
5. The strainer is clogged.
6. The bypass valve is open, pressure relief valve set too low or pressure relief valve poppet stuck open.
7. The pump is worn out.
8. Any changes in the liquid, piping system or operation that would help explain the trouble, e.g. different liquid, additional lines or process changes.

Pump starts, then loses its prime:

1. The supply tank is empty.
2. The liquid is vaporizing in the suction line (too high a vacuum).
3. There are air leaks or air pockets in the suction line.
4. The pump is worn out.

Pump is Noisy:

1. The pump is cavitating (liquid vaporizing in the suction line) or being starved (heavy liquid cannot get to pump fast enough). Increase the suction pipe size and/or reduce the length, or decrease the pump speed. If the pump is above the liquid, raise the liquid level closer to the center line of the inlet port. If the liquid is above the pump, increase the head of the liquid.
2. Check alignment.
3. If the base is not bolted down or piping not properly supported will result in vibration and noisy operation.

Pump not delivering up to capacity:

1. The pump is starving or cavitating – See pump is noisy, item 1.
2. The strainer partially clogged.
3. Air leak somewhere in the suction line.
4. Running too slow. Is the motor the correct speed and wired up correctly?
5. Pressure relief valve is set too low, stuck open or has damaged poppet seat.
6. The bypass line around the pump partially opened.
7. The pump is worn out.

Pump requires more power than estimated (stalls motor):

1. The pump outlet pressure is too high.
2. Liquid is more viscous than the pump is designed to handle.
3. The system pressure relief valve set too high.
4. The pump is misaligned.

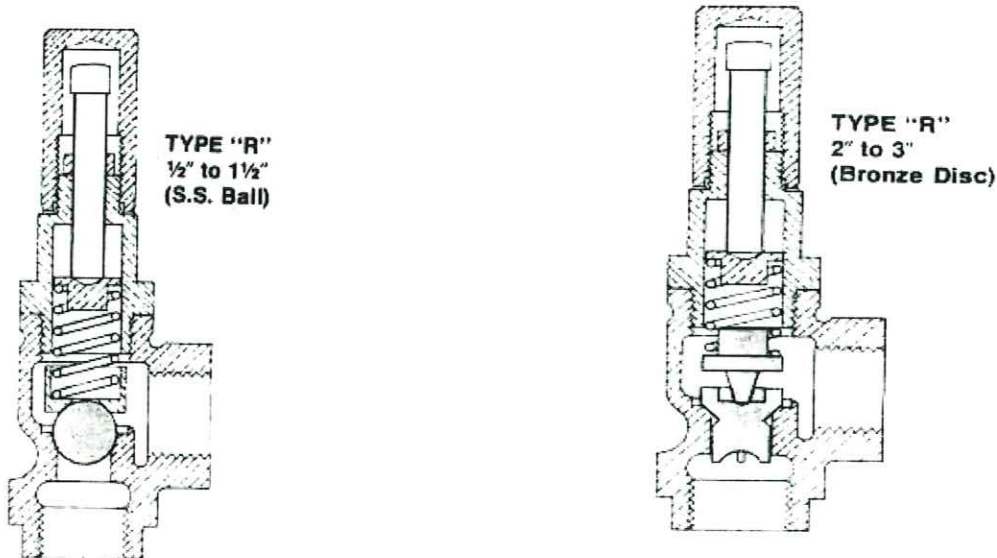
Additional Information

If the relief valve is suspected to be causing issues with priming, you can check the relief valve settings (which are preset at the factory to be 15 PSI above the maximum operating pressure of the system pressure)

During initial priming of the pump it may become necessary to lower the relief pressure to allow for oil to discharge through the relief valve and back to the supply tank to prime the lines.

Once this is done follow the below steps to reset the pressure setting of the relief valve by using the discharge ball valve of the pump running to increase the discharge pressure of the pump until you set the set screw.

Checking Relief Valve Settings



Above are two different sized relief valves typical on Preferred Pumpsets. These relief valve can be either factory mounted or shipped loose and installed by the contractor. They must always be installed in an upright vertical position which places the inlet at the bottom.

To adjust the set pressure of the valve, remove the top cap, loosen the brass locknut and adjust the pressure with the steel set screw. By increasing the compression on the spring, screwing down the screw, you increase the set pressure within the limits of the spring range. Reversing the set screw lowers the set pressure. When the desired set pressure is reached, tighten the locknut and replace the top cap and gasket.

Note, ensure that the gasket and the surface of the valve is dry to prevent wicking of oil between the body and the cap.

Preferred Services

A Division of Preferred Utilities Mfg. Corporation

Prestart-up Pump Set Check Sheet

J#

Date:

Customer:

Job:

Service Engineer:

Pre-Startup Check List

The following must be completed before scheduling start-up or delays will result.

Panels

Panel securely mounted-
All field conduit runs are complete-
All field conduits in the top of the panel are sealed-
Panel cleaned of all metal chips and debris-
Line voltage and signal wires are not run in the same conduit-
Intrinsic ground for tank gauge installed-
Intrinsic safe circuits are run in a separate conduit-
Panel is properly grounded-
All field devices noted on Preferred electrical prints are installed-
Field wiring in the panel is complete-
Field wiring has been terminated at the correct field device-

Electrical Power Supply:

Power supply to panel is installed and correct: Volts AC- Phase-

Oil Pump Set Mechanical:

Base securely anchored to a permanent foundation-
All piping properly supported and not stressing pump set piping-
All piping in complete and has been leak tested-
If applicable, piping has been approved by the local inspectors-
Anti-syphon valve is at the highest point of the suction piping-
Shipping plug removed from the footvalve-
Oil is in the tank and oil is available for priming pumps-
Day tank or header being supplied is empty so system can be run tested-

Failure to have the above completed prior to scheduling start-up service will result in additional labor, travel and living expense charges due to delays beyond the control of Preferred Utilities or our scope of supply. These additional charges will be invoiced at our standard per dium rates applicable at the time.

Customer's Signature: _____ Date:

Please Print Name:

Preferred Services		
A Division of Preferred Utilities Mfg. Corporation		
Pump and Level Control Panel Start-up Record	J#	Date:
Customer:	Job:	Page 1 of 3
Service Engineer:	Electrical Checks	
Initial Inspection of Installation Before Power is Turned On:		
	Date	Initial
Panel securely mounted-		
All field conduit runs are complete-		
All field conduits that enter the top of the panel are sealed-		
Panel cleaned of all metal chips and debris-		
Line voltage and signal wires are not run in the same conduit-		
Intrinsically safe circuits are run in a separate conduit-		
Backplate nuts are tight-		
Check all wire terminals for tightness (both panel and field sides)		
Pump motor overloads are properly set and sealed-		
Panel is properly grounded-		
Intrinsic ground for tank gauge installed if required by local authorities-		
All field wiring in the panel is complete-		
All wiring has been terminated at the correct field device-		
Power Supply to Panel: Volts AC- Phase- Amps-		
After the above is complete turn power on to the panel and continue check out:		
Check correct control circuit power- Volts AC-		
	Date	Initial
Insure the primary controller is running its programs.		
Fill in system names.		
Job Notes or Comments:		

Preferred Utilities Manufacturing Corporation		Page 2 of 3
Pump and Level Control Panel Start-up Record	J#	Date:
Operational Checks		
Pump Permissive Alarm Operation: Upon alarm condition, the alarm horn sounds and the alarm light flashes. When the ASPB is activated the horn silences and the light becomes steady. The associated BMS output is also active. <u>Permissive alarms must shut off the pumps in both hand and auto operation.</u>		
Pump Permissive Alarms : Pump Set Leak Switches. Containment Leak Switches. Day Tank Leak Switches. Day Tank Vent Leak Switches. Day Tank High Level Switches.	Date	Initial
Pump Fail Operation : On a call for pump operation the flow switch must open and the pump starter auxiliary input must close within 15 seconds. If both of these conditions have not occurred within the time delay the pump fail logic will be active. After the delay period, if the flow switch closes the backup pump will immediately start.		
Pump Fail : Start pump and verify that flow switch is operational Simulate failure by jumpering 120VAC to Flow Switch Terminal and observing pump failure alarm. Repeat for other pumps.	Date	Initial
Pump automatic Operation : note: checks for 4 FSC controllers Set day tank switches to simulate oil between the pump on switch and the pump off switch. Close the pump on switch, the pump comes on. Open the pump on switch, the pump stays on. Open the pump off switch and the pump will stop.		
Day Tank pumps operations:		
Return pump operation: Hand operation and high level		

Preferred Utilities Manufacturing Corporation		Page 3 of 3	
Pump and Level Control Panel Start-up Record		J#	Date:
		Date	Initial
Pump Day Tank Low level Operation : Close any day tank low level switch. Both pumps will come on. Open the low level switch, the pump stay on. Open the high level switch and the pump will stop. You will now have both a high level and a low level alarm for that day tank.			
Alarms Requiring Manual Reset: Strainer D/P Alarm (10 Second Delay) Pump Fail Alarms (15 Second Delay) Day Tank Low Level Alarms			
BMS Outputs: Refer to the print and verify correct outputs are energized to the BMS		Date	Initial
Main Oil Tank Alarm Operation: Main Tank Low Level Main Tank Leak Main Tank Backup High/Low Levels Main Tank Overfill Level			
Main Oil Tank Remote Overfill Alarm Operation: When overfill condition is active the remote alarm horn rings until the remote ASPB is activated or until the horn has been ringing for 60 seconds. The overfill light flashes until it has been acknowledged. The light will stay on until the overfill condition clears.			
Final notes & comments:			
Customer's Signature: _____		Date: _____	
Please Print Name: _____			

Preferred Services	
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A Division of Preferred Utilities Mfg. Corporation

Pump Set Start-up Record Job:

Date: _____

Customer:

J#

Page 1 of 2

Service Engineer:

Mechanical Checks

Initial Inspection of Installation:

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Suction piping complete and leak tested-		
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Preferred Utilities Mfg. Corporation

Page 2 of 2

Pump Set Run Test:

Power supply checked and correct-
Motors checked for proper voltage wiring-
Pump/motor coupling realignments checked-
Suction piping primed with oil-
Pump/motor rotation checked-

Date Initial

Suction Pressure- Strainer in- _____ in. Hg

Supply Pressure- Design - _____ PSI Actual- _____ PSI

Relief valves set at- 45PSI

Abnormal noises noted?

Leaks noted?

Pump Motor Data:

Name Plate:

Pump ID					
VAC					
HP					
Phase					
Amps					

Actual Noted:

VAC					
Amps					

Additional Equipment Notes:

Date Initial

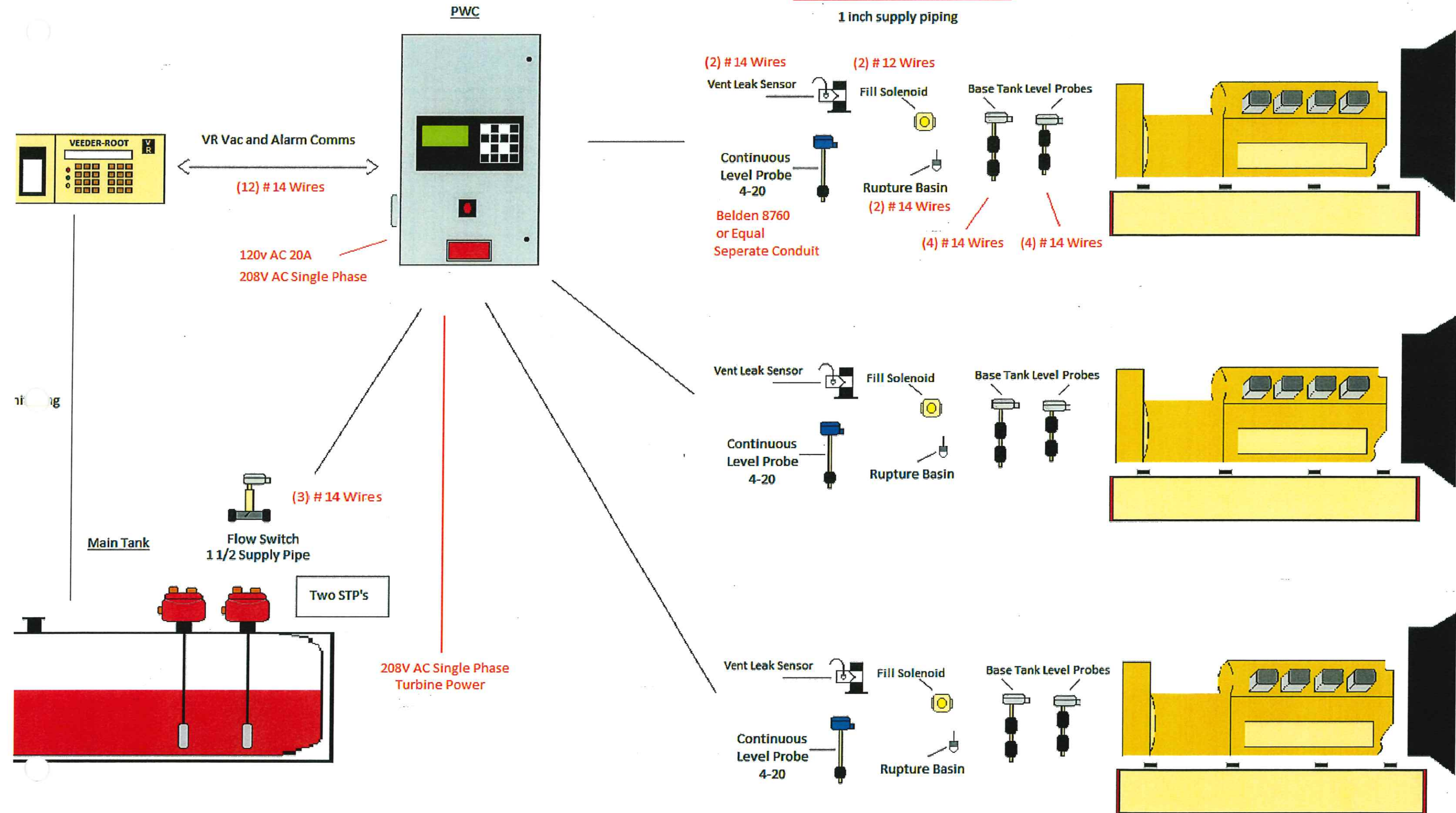
Customer's Signature: _____

Date: _____

Please Print Name: _____

Belly Tank Components

1 inch supply piping



Field Project Management Commissioning Manual

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- Williams & Davis
- Cleaver Brooks

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BABCOCK & WILCOX
OPERATING INSTRUCTIONS

Drying-Out

The drying-out of the refractories in the setting can be combined with the boiling-out process, except that the fires for the drying-out process should be operated for approximately 24 hours at an extremely low rate to warm the setting gradually, and then increased to the rate which will hold the pressure required for the boiling-out phase. The rate of firing must be so regulated that the gas temperature entering the superheater does not exceed safe values.

If the flue gases go to a refractory or refractory lined stack, the stack builder should be consulted for the stack drying-out and curing requirements.

PRESSURE

The firing rate should be so regulated to raise the pressure in the unit slowly to the boiling-out pressure. The recommended pressure for boiling-out is as follows:

1. Boil-out at operating pressure for all boilers up to 200 psig operating pressure.
2. For boilers over 200 psig operating pressure, boil-out at 200 psig or for one-half the operating pressure up to 600 psig, whichever is greater.
3. During the pressure raising period, some increases in water level will be noted in the steam drum. Blow down through continuous blowdown line to avoid flooding the steam drum.

DURATION

Because of the improbability than any two installations will require the same amount of cleaning, it is difficult to set a definite duration for the boiling-out period to cover all units. However, experience indicates that a period of 24 hours at the recommended pressure and chemical concentration is usually sufficient to clean the unit. Package boilers, (i.e. FM's) usually only require eight to twelve hours at the recommended pressure and chemical concentrations to obtain a satisfactory boil out. The condition from the internal inspection at the conclusion of the boil out process will be the indicator of satisfactory conditions or for the need for repeating the process.

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OPERATING INSTRUCTIONS

BLOWING-DOWN

Each piece of equipment should be blown-down at least every 4 hours to prevent pluggage of the drain. . Each blow down should last until the drain piping gets hot, which should happen relatively fast. This will verify that the drain is not plugged.

Continuous blowdown should be opened intermittently for removal of oil or grease accumulating at the steam drum water surface.

GAGE GLASSES

During the initial period of operation it is particularly important that the gage glass be cleaned and the water level clearly visible. If the gage glass is found to be dirty during the inspection following the boiling-out, take the water gage glass fittings apart, clean, and repack; also make sure that all connections between the gage glass and the drum, as well as the gage glass fittings and the water column drains, are free and clear.

GASKETED JOINTS

In the case of handhole or manhole fittings the internal pressure assists in compressing the gaskets and holding the joints tight. For best results, the force due to the internal pressure should be used to obtain maximum pressure on the handhole or manhole when tightening the nuts. Because of high temperature it is often impractical or dangerous to pull up the fittings with the boiler under full steam pressure, and it is, therefore, good practice to pull up the fittings under the maximum permissible hydrostatic pressure.

On new jobs gasketed joints of this type should be pulled up during erection under the hydrostatic test pressure of $1\frac{1}{2}$ times design pressure. After erection has been completed, the recommended procedure with respect to manholes and handholes which have been opened or disturbed is to replace the gaskets with new ones, and with the wrench provided for the purpose, to pull up the handhole and manhole nuts as tight as possible under a hydrostatic pressure equal to just a few percent less than normal full steam operating pressure. This will make it unnecessary to gag safety valves and to prevent leakage of water through the non-return valves into the steam line.

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In case of joints which the internal pressure tends to open, such as bolted safety valve flanges, pipe flanges in drain lines, etc., the recommended procedure is to pull the joints up as tight as possible before applying hydrostatic pressure, retightening during the hydrostatic pressure application, and retighten again immediately after the first raising and dropping of steam pressure when the pressure is zero but while the flange is still hot. It may be necessary to blow-out drain lines while the unit is first up to full steam pressure in order to bring them up to the desired temperature; then shut the drains to pull up the joints while the line is still hot.

PROCEDURE AFTER BOILING-OUT

After the completion of the boiling-out process, cool the boiler unit slowly to room temperature, drain, open and enter the steam and water drums to flush out or remove all foreign material, inspect for cleanliness and prepare the equipment for initial operation. Furnace and screen tubes that slope less than 60° to the horizontal and have heat supplied to the bottom side should be individually flushed with water from a hose. New gaskets should be installed on all manholes and handholes.

Where only traces of oil or grease remain, such as at tube ends, an additional boiling-out may be required. It may also be advisable to maintain above normal chemical concentrations and operate at 1/2 to 3/4 rating for several days, blowing down the boiler at least once a shift. If the drum surfaces are coated with deposits that leave the fingers oily when touched, an additional boiling-out should follow. Do not use carbon tetrachloride for cleaning traces of grease and oil from tube ends in the drum because it is a toxic poison when used in confined spaces.

OPERATING COMPANY'S RESPONSIBILITY

Unless a previous agreement specified otherwise, boiling-out, handling of gage glasses, pulling-up of gasketed joints, and any other preparations for regular operation are the responsibility of the Operating Company.

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OPERATING INSTRUCTIONS

BOILING-OUT PROCEDURES
FOR
NEW INDUSTRIAL BOILERS

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BABCOCK & WILCOX
OPERATING INSTRUCTIONS

INTRODUCTION

All new boilers should be boiled out when erection is complete even though they may not be needed for some indefinite time. In this case, they should be stored in accordance with 1K-7A313 "Storage of Industrial Boilers".

INSPECTION AND MECHANICAL CLEANING

The inspection and mechanical cleaning should be done just prior to the chemical boil-out. All drums, headers, supply pipes and tubes should be checked for debris by visual inspection. It is not necessary to remove all drum internals for special cleaning during boiling-out operations because the preservatives used are easily removed by the recommended procedures given here. Selected internals must be removed after boil-out to flush the roof (if not steam cooled), furnace, screen and any other tubes with less than a 60 degree slope from horizontal and heat applied to bottom side.

Immediately after the inspection and clearing out of any part or section, the possibility of accidentally accumulating additional foreign material should be avoided by closing all entrances to such parts with handhole fittings. Temporary closures such as plugs should not be used in this procedure because one of the major purposes of this final inspection and mechanical cleaning is to locate and remove such items as these. The external extremities of pipe lines should be blanked off while awaiting connecting parts. It should be a physical impossibility to make subsequent connections without first removing the temporary blanks.

No part or section should be closed until all passages to which the part permits access are free and clear of all foreign material, except that which can be removed by boiling-out. All parts should be closed immediately after approval. For boil-out service, any gasket that will fit can be used on manholes and handholes. These should all be removed following the boil-out and a regular service set of gaskets should be installed before the unit is ready for continuous operation.

The mechanical cleaning is the responsibility of the erection contractors.

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OPERATING INSTRUCTIONS

CONTROLS AND INTERLOCKS

The following list comprises the minimum controls, interlocks and indicating equipment required for operation during the boiling-out procedure:

1. Drum gage glass
2. Boiler pressure gage.
3. Safety and relief valves with gags and/or hydrostatic test plugs removed.
4. Continuous blowdown and drain valves in working order.
5. Thermocouples to indicate air heater gas inlet and outlet temperature.
6. Flame safety system in service.
7. Water level alarms and interlocks in service.
8. Steam drum thermocouples (on drum more than 4 inches thick).
9. Seal air and cooling water piping connected for operations where such connections are required.
10. Water sampling facilities.
11. Furnace pressure gage.
12. Portable thermocouples to indicate flue gas temperature entering the superheater, if unit has a superheater.

While it is not mandatory, it would be safer and easier if the controls have been checked out for remote-manual operation. It is also recommended that the unit be filled and the burner systems checked for proper operation prior to introduction of boil-out chemicals.

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BOILING-OUT

Water

The unit should be filled so that one-half inch of water shows in the drum gage glass. Filling should be through normal feedwater connections with water from the normal, treated supply if possible. If treated water is not available, filtered water may be used. The difference between the temperature of the water used for filling the unit and the temperature of the drum metal should be no more than 100°F for drums with expanded tubes. If a hydrostatic test is to be applied, the water should be at ambient temperature, but in no case should the resultant metal and water temperature be less than 70°F at the time of pressurizing. This temperature applies each time the unit is pressurized.

Chemicals

The chemicals to be used for the boiling-out process must be completely dissolved in water before being placed in the unit. It is desirable to pump the dissolved chemicals into the boiler through the normal chemical feed connection, or the chemical solution can be poured through the upper drum manhole bringing the water up to a level above half-way between the bottom of the drum and the lower lip of the manhole.

A good cleaning job can be done with the following combination of chemicals. The concentrations listed are for the full chemical compounds in terms of all water in the unit.

Hydrous trisodium phosphate ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$)	4600 PPM
Anhydrous disodium phosphate (Na_2HPO_4)	1000 PPM
Wetting agent or Detergent	250 PPM

The following example calculation will help to determine the approximate quantity of chemicals required for boil-out.

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Using the normal water holding capacity (found in the description section of this manual)

For an example calculation using 16,800 lbs. of water as the normal water holding capacity:

$$16,800 \text{ lbs. of water} \times .1199 \text{ (water conversion factor)} = 2,015 \text{ gallons of water}$$

Therefore: to get required Boil-out chemicals

$$\text{Hydrous trisodium phosphate } 4600 \text{ ppm} \times 16,800 \text{ lbs. of water}$$

$$\approx 78 \text{ lbs. of hydrous trisodium phosphate}$$

$$\text{Anhydrous disodium phosphate } 1000 \text{ ppm} \times 16,800 \text{ lbs. of water}$$

$$\approx 17 \text{ lbs. of anhydrous disodium phosphate}$$

$$\text{Wetting Agent or Detergent } 250 \text{ ppm} \times 2,015 \text{ gallons of water}$$

$$\approx 0.5 \text{ gallons of wetting agent or detergent}$$

As a precautionary measure, some operators use sodium sulphate or sodium nitrate to avoid caustic embrittlement conditions and sodium sulphite to prevent oxygen corrosion. These chemicals are used in addition to the boil-out chemicals suggested above. There are no objections to these precautions but the relatively short duration of the boiling-out period does not leave the unit sufficiently susceptible to attack from either source to warrant the additional treatment.

ECONOMIZERS AND SUPERHEATERS

Economizers, during the boiling-out procedure, should be handled in the same manner as during the starting-up period, i.e., the precautions for the operation of the vents, recirculators, feed valves, etc., called for in the starting-up instructions or requirements, should apply during boiling-out. Economizers designed for the high gas temperature zones and equipped with recirculating connections will automatically induce circulation of the chemically treated boiler water. In those economizers designed for low gas temperatures and having no recirculating connections, the only flow during the boiling-out will be that which results from economizer blowdown and the water fed

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to make-up the boiler blowdown. In this case, the initial draining of the solution within the steam drum, after the boil-out process and cool down, will be through the economizer inlet header drain. When the level within the steam drum has reduced to near the bottom of the steam drum sight glass, the drains on the boiler should also be opened to drain the complete system.

The superheater should be back-filled with condensate, and the superheater vent and drains should be left closed during the entire boil-out process.

FIRING

Precautions

CAUTION: BEFORE LIGHTING THE FIRE IT IS IMPORTANT TO TAKE THE FOLLOWING PRECAUTIONS:

1. Remove all structural timber from the furnace and from the gas passages.
2. Make connections so that all blow-off and drain valves can be used without danger to the construction or to the operating personnel. MAKE SURE SAFETY VALVES ARE OPERABLE.
3. See that all dampers are in good working order and so set on the shafts that their position is correctly indicated. All hot casing should be insulated and lagged.
4. Make sure that the gage glasses and other means of indicating the water level are in good working order and indicating the correct water level.
5. Make sure that the fuel-burning equipment, temporary or otherwise, is in such shape that it can be operated in strict accordance with all recognized rules of safety applying to the particular fuel to be used for the boiling-out process.
6. Make sure that the unit is filled with water and chemicals in accordance with the foregoing instructions. The normal feedwater pump, or equivalent, should be available to supply water to the boiler 50 psig above boil-out pressure.
7. Before lighting any fires, completely purge the setting for at least five minutes at the rate of at least 30 percent the requirements for maximum capacity of the unit.

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8. During the pressure raising period, the steam drum vent should be closed at 25 psig. Also, during cool-down at the completion of the boil-out process, the steam drum vent should be re-opened at 25 psig
9. After the fires have been lit and stable combustion is assured, the firing rate can be increased up to a point not exceeding the safe limits for pressure part protection and superheater tube metal temperatures. A rise in saturation temperature of 100°F per hour has been set as a safe practical limit on drum stress and to protect rolled tube joints against leakage. The firing should be regulated to limit the gas temperature entering the superheater to 900°F for protection of the tube metals. If the limits are reached, the fires should be extinguished by shutting off the fuel. After about 30 minutes, the fires can be relit, and the above procedure followed again noting the limits on temperature. This intermittent firing, if required, should be continued until the desired pressure is obtained. Once at this pressure, longer periods of time will be required between firing to allow for pressure decay, but the average intervals should be no greater than every four hours.

The above recommended procedure for boil-out insures that a good circulation of chemicals is taking place during the firing periods which facilitates the cleaning of the unit.

10. When gas firing is used, it is important to make sure that the burners are operated at gas pressures at which stable ignition will be maintained; furthermore, it is important to employ every precaution to ensure gas pressure regulation or control which will absolutely prevent even temporary lapses in this regulation. When regenerative type air heaters are used, they should not be started until the flue gas temperature at the air heater inlet reaches 400°F. This precaution prevents flue gas moisture from condensing and being entrained in the combustion air.
11. Occasionally, the firing during the drying and boiling-out periods is looked upon as a routine to be endured and completed in the most convenient and simplest manner, with the result that the handling of the new equipment is frequently entrusted to inexperienced operators or men pressed into service from the construction force. Aside from the importance of satisfactory performance of the equipment, the matter of safety of equipment and personnel must be considered of utmost seriousness and the operation of the firing equipment should be entrusted only to experienced operators who are fully familiar with the type of system being used.

Johnston Boiler Boil-out Procedure

D. Boiler Boil-out Procedure

It is recommended that your new Johnston Boiler be boiled-out before placing it into service. This may be done before or immediately following initial start-up. A proper boil-out will remove any grease or oil that may still be present in the waterside of the boiler as the result of boiler installation. A clean boiler waterside is one of the requirements of establishing and maintaining a stable waterside condition.

JOHNSTON BOILER COMPANY DOES NOT BOIL-OUT THE BOILER. IT IS RECOMMENDED THAT A QUALIFIED WATER TREATMENT CONSULTANT IN YOUR AREA BE CONTACTED FOR A RECOMMENDATION ON A BOIL-OUT COMPOUND, WHICH SHOULD INCLUDE ITS OWN USE PROCEDURE. IN THE ABSENCE OF A BOIL-OUT PROCEDURE, JOHNSTON BOILER RECOMMENDS THE FOLLOWING:

1. Isolate boiler from piping system (valve off).
2. Remove safety valves from the boiler. A boiler safety valve tapping on the top of the boiler pressure vessel is often used as the opening to introduce the boil-out compound into the boiler. It will also serve as a vent to fill the boiler and operate it during boil-out.
3. Fill the boiler with clean, ambient temperature water. Allow sufficient room for the boil-out compound solution (generally diluted) and expansion of the water. The boiler will be boiled out to atmosphere.
4. Start the boiler, following the appropriate start-up procedure included in this Manual. The boiler will be operated in the manual mode, low fire setting, for the duration of the boil-out. Observe the open safety valve tapping as the boiler is being warmed. Due to expansion, water will have to be drained from the boiler to prevent it from overflowing. Any number of blowdown valves can be used to drain the boiler during boil-out; however, follow the boil-out compound supplier's instructions on how to dispose of the chemically treated boiler water. You might not be permitted use of a normal floor drain by environmental regulations.

WARNING

ONLY QUALIFIED AND EXPERIENCED PERSONNEL SHOULD PERFORM A BOILER BOIL-OUT. STEPS MUST BE TAKEN TO BE PROPERLY PROTECTED AGAINST THE HAZARDS OF HANDLING AND USING BOIL-OUT COMPOUNDS.

5. Continue to observe the open safety valve tapping on the top of the boiler. As the boiler water begins to boil, and then develops into a steady discharge of steam coming out of the open safety valve tapping, turn the boiler off. Wait until the steady stream of steam reduces to only traces of radiant steam, and then restart the boiler. Repeat this process as often as necessary for the duration of the boil-out.

6. After the boiler has been allowed to cool down to normal hot water temperatures, drain the boiler completely. Follow the boil-out compound supplier's instructions on how to dispose of the chemically treated boiler water. Refill the boiler completely with clean, hot water. Drain the boiler again.

7. Remove all handhole and manway covers from the boiler pressure vessel. Inspect the waterside of the boiler for cleanliness. Reinstall the handhole and manway covers using new replacement gaskets.

8. Reinstall the boiler safety valves on the boiler, including the discharge piping. Fill the boiler with clean, chemically treated water to its normal operating level. The boiler is now ready for initial start-up or to be placed into service.

WARNING

Handhole, manway and fluebox door gaskets must be checked for leakage following initial operation of the boiler. These gaskets may begin to leak due to temperature and pressure changes and expansion or contraction.

7.7 Boil-out procedure (1/2)

NOTICE!

All new boilers must be boiled out or Superior Boiler Works will void the warranty! Before introducing the boil-out chemicals to any drain system, check local environmental regulations to ensure you are in compliance

It is necessary to clean the inside of the new boiler of oil and grease used as tube rolling lubricants. Failure to remove these materials will result in your unit foaming, priming, and pulling over. These contaminants must be removed to provide clean heat transfer surfaces. Before boil-out procedures may begin, the burner must be ready for firing and the operator must be familiar with the procedure outlined under burner operation. SBT-710 is the chemical recommended for the cleaning of boilers. Dosage is one (1) gallon per fifty (50) gallons of water in the boiler. The operator must become familiar with the information in the SBT-710 technical data sheet and the MSDS.

1. Close valve in steam line (for steam boilers), Close off supply and return water valves (for water boilers), and Remove safety relief valves.
2. An overflow pipe should be attached to either the vent connection or a safety valve connection located at the top center of the boiler and routed to a safe point of discharge, in compliance with local environmental regulations. Use care in removing and reinstalling these valves. All other openings shall be closed off.
3. All valves in the piping leading to and from the boiler must be closed to prevent cleaning solution from getting into the system.
4. Fill Pressure vessel with soft water* to the normal water line. Add the SBT-710 and then fill to the top.
5. The boiler should then be fired intermittently at a low rate sufficient to hold the solution just at the boiling point. Maintain this temperature for a minimum of twelve (12) to twenty-four (24) hours to allow sufficient time for the removal of all dirt, oil and grease from the internal boiler surfaces. Do not produce steam pressure.
6. Add a small amount of fresh water to the boiler to create a slight overflow that will carry off surface impurities.
7. Maintain temperature and overflow until water clears of impurities. Do not produce steam pressure.
8. Shut down the burner; permit the boiler to cool to 120°F then drain boiler. Use caution that the hot water is discharged with safety.
9. Remove manway cover and hand hole plates, wash the waterside surfaces thoroughly using a high-pressure water system.
10. Inspect internal surfaces and repeat steps four (4) through nine (9) if necessary.

Note: Tubes near the sidewalls are usually the last to boil out because the temperature of the flue gas passing over them is lower.



7.7 Boil-out procedure (2/2)

11. All hand holes, manway, and any other openings shall be closed except a vent line. Fill the boiler immediately to prevent flash corrosion. Fire boiler until water is heated to at least 180°F to drive off any dissolved gases that may corrode the metal.
12. On initial firing of the system, the condensate should be discarded until tests show the elimination of undesirable impurities. Proper Water Treatment must be maintained at all times to prevent scale and corrosion in the boiler and condensate return lines. See your water treatment professional for the program that best fits your needs.
13. Connect a vent pipe to the safety relief valve port on the boiler and run this vent to a drain.
14. Fire the boiler at a low rate for three (3) to four (4) hours allowing the steam to discharge through the vent pipe. (installed in place of the safety relief valve if necessary)
15. Drain the boiler while still warm. Remove manway cover, wash out hand holes. Wash interior of boiler with tap water at full pressure through a nozzle. Wash until all evidence of dirt, mud, and impurities are removed through the bottom hand hole opening. Clean any shell mounted probe holders.
16. When the boiler is so equipped, remove water level prove holder(s), and check for contamination that may have been caused by the boiler out chemicals. Clean the water side surfaces of the probe holder and the probe(s) to remove any contamination. Reinstall using appropriate pipe thread sealant to ensure a leak proof seal.
17. The boil-out procedure will be complete after replacing the safety valve and opening the outlet valve.
18. The above cleaning operation also serves to safely remove any moisture in the insulating refractory in your boiler.



Boil Out Procedure

- Technical Bulletin WDTBB-003
- Boiler Systems

PLACING A BOILER IN SERVICE

Before placing a new steam boiler in service, the internal surfaces must be cleaned and passivated. Cleaning helps remove the oil, grease, or mill scale that may be present. Failure to remove these coatings can result in problems such as priming and carryover on start up as well as reduced heat transfer efficiency. Passivation aids corrosion control by forming a protective iron phosphate film on metal surfaces. The waterside of every new boiler should be inspected **prior** to the boil out to verify that no significant corrosion has occurred before the unit is placed in service.

SAFETY PRECAUTIONS

Carefully read the Material Safety Data Sheets (MSDS) on all products involved **before** starting this procedure. Follow all safety precautions. Note that the products are highly alkaline and will cause burns and ruin clothing. When handling these products, wear protective clothing, face shield or splash proof goggles; and rubber gloves. An eye wash station and ready supply of potable water should be nearby. Do not use aluminum or galvanized containers for handling.

BOIL OUT PROCEDURE

- 1) Fill a fire tube boiler just over the top tubes with cold water. For a water tube boiler, fill to the normal water level (NWL) with cold water.
- 2) Add WD 100 or WD 133 at a rate of 1 gallon product per 50 gallons boiler volume. Alternatively, WD BOILOUT STICKS can be used at a rate of 1 stick per 50 gallons boiler volume.
- 3) Finish filling the boiler with water to the normal operating level, replace all manholes, and close steam header. Pipe a steel vent line from the steam space to a drain. Make sure this line is secured properly so that any boil out solution carried over to the vent line will not strike people or property. **Do not allow the boil out solution to contact painted surfaces - it will remove paint.**
- 4) If the manufacturer's specifications for boiling time or other details are available, they may be followed. Otherwise, heat on low fire for 6 hours at atmospheric pressure. Maintain normal water level in the boiler while heating.
- 5) During and upon completion of Step 5, blow down all valves and water columns thoroughly.
- 6) Allow boiler to cool and then drain completely. It may be necessary to neutralize the boil out solution prior to discharging. Do not neutralize the cleaning solution in the boiler.
- 7) Open all manholes and handholes. Wash out thoroughly using fresh water. To prevent thermal stress, avoid sudden temperature changes.
- 8) Inspect boiler, replace manholes and handholes, and refill with soft water.
- 9) If possible, fill and drain boiler one more time.
- 10) Add the recommended start up dosages of treatment chemicals directly to the boiler during the final fill. Open steam header before placing in operation.
- 11) If the boiler is not to be immediately used, follow the wet storage procedure outlined in Technical Bulletin WDTBB-002, "Wet & Dry Boiler Storage Procedures". Failure to follow these guidelines can result in significant corrosion damage.
- 12) If the water appears dirty after the boiler is placed on line, increase the blowdown rate until it clears up.
- 13) As new steam and condensate return piping is put on line, the boiler water may become dirty and/or foamy due to the grease, oils, etc., stripped from this piping being returned to the boiler(s). If possible, the condensate should be dumped when new piping is first used. Otherwise, blow down heavily until the boiler water is clear and not foamy.

Cleaver Brooks Firetube Boil-out Procedure

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed because they lower the heat transfer rate and could cause over-heating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

WARNING

Use of a suitable face mask, goggles, rubber gloves, and protective garments must be worn when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing. Failure to follow these instructions could result in serious personal injury or death

Your local Cleaver-Brooks authorized representative will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unscheduled, the following information may be of assistance.

There are several chemicals suitable for boil-out. One combination often used is soda ash (sodium carbonate) and caustic soda (sodium hydroxide) at the rate of 3 to 5 pounds each per 1,000 pounds of water, along with a small amount of laundry detergent added as a wetting agent.

The suggested general procedure for cleaning a boiler is as follows:

- (1) Refer to Figure 3-4 to determine water capacity. Have sufficient cleaning material on hand to complete the job.
- (2) When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.
- (3) An over-flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.
- (4) Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate the valves. Use care in removing and reinstalling the valves.

Refer to Chapter 8, Section M for valve installation instructions.

GENERATOR SIZES CB & CB-LE	WATER – GALLONS		WATER – WEIGHT	
	NORMAL	FLOODED	NORMAL	FLOODED
125 HP	689	920	5750	7670
150 HP	869	1115	7250	9295
200 HP	1034	1335	8625	11130

Figure: 3-4 Water Capacity and Weights

- (5) All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.
- (6) Fill the pressure vessel with clean water until the top of the tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in the initial fill should be at ambient temperature.
- (7) The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. Do not produce steam pressure.
- (8) Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
- (9) Continue the boil and overflow process until the water clears. Shut the burner down.
- (10) Let the boiler cool to 120°F or less.

WARNING

Be sure to drain the hot water to a safe point of discharge to avoid scalding. Failure to follow these instructions could result in serious personal injury or death

- (11) Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
- (12) Inspect the surfaces. If they are not clean, repeat the boil out.
- (13) After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180°F to drive off any dissolved gases, which might otherwise corrode the metal.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean. However, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, be sure make-up water is treated to prevent an accumulation of unwanted materials or corrosion.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

F. WASHING OUT

1. HOT WATER BOILER

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and water treated), and with no make-up water added, will require no further cleaning or treatment. However, since the system (new or old) can allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient. However, if there is any doubt, the pressure vessel waterside should be inspected no later than three months after initially placing the boiler into operation, and periodically thereafter as indicated by conditions observed during inspections.

2. STEAM BOILER

No later than three months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature. Handhole covers should be removed and waterside surfaces should be inspected for corrosion, pitting, or formation of deposits.

Flushing of Pressure Vessel Interior

Upon completion of the inspection, the pressure vessel interior should be flushed out, as required, with a high pressure hose. If deposits are not fully removed by flushing, a consultation may be required with your local Cleaver-Brooks authorized representative. In extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

The inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washouts. Contact your local Cleaver-Brooks authorized representative for more information.

Determine the actual fuel flow input based on specification provided data.

100% MCR Natural gas input: 35,737 mmBTU/hr.

100% MCR #2 oil input: 34,018 mmBTU/hr.

Natural Gas BTU/SCF = 1,025 BTU

#2 oil BTU/gallon = 139,000 BTU

Gas	(35,737,000/1025)
Oil	(34,018,000/139,000)

Input Required
34,865 SCFH
244.7 GPH

O2	Corr. Factor	O2	Corr. Factor	O2	Corr. Factor	O2	Corr. Factor	O2	Corr. Factor
1	0.899	3	1.000	5	1.126	7	1.288	9	1.504
1.1	0.904	3.1	1.006	5.1	1.133	7.1	1.297	9.1	1.517
1.2	0.909	3.2	1.011	5.2	1.140	7.2	1.307	9.2	1.530
1.3	0.913	3.3	1.017	5.3	1.147	7.3	1.316	9.3	1.543
1.4	0.918	3.4	1.023	5.4	1.155	7.4	1.326	9.4	1.557
1.5	0.923	3.5	1.029	5.5	1.162	7.5	1.336	9.5	1.570
1.6	0.927	3.6	1.035	5.6	1.170	7.6	1.346	9.6	1.584
1.7	0.932	3.7	1.041	5.7	1.178	7.7	1.356	9.7	1.598
1.8	0.937	3.8	1.047	5.8	1.185	7.8	1.366	9.8	1.613
1.9	0.942	3.9	1.053	5.9	1.193	7.9	1.377	9.9	1.627
2	0.947	4	1.059	6	1.201	8	1.388	10	1.642
2.1	0.952	4.1	1.065	6.1	1.209	8.1	1.398	10.1	1.657
2.2	0.957	4.2	1.072	6.2	1.218	8.2	1.409	10.2	1.673
2.3	0.962	4.3	1.078	6.3	1.226	8.3	1.421	10.3	1.689
2.4	0.968	4.4	1.085	6.4	1.234	8.4	1.432	10.4	1.705
2.5	0.973	4.5	1.091	6.5	1.243	8.5	1.444	10.5	1.721
2.6	0.978	4.6	1.098	6.6	1.252	8.6	1.455	10.6	1.738
2.7	0.984	4.7	1.105	6.7	1.261	8.7	1.467	10.7	1.755
2.8	0.989	4.8	1.112	6.8	1.270	8.8	1.479	10.8	1.772
2.9	0.994	4.9	1.119	6.9	1.279	8.9	1.492	10.9	1.790
3	1.000	5	1.126	7	1.288	9	1.504	11	1.808

Determine the correction factor to correct the raw NOx to 3.0% O2

$$CF = \frac{20.9 - 3.0}{20.9 - \text{actual O}_2}$$

Example $CF = \frac{20.9 - 3.0}{20.9 - 4.2}$ $CF = \frac{17.9}{16.7}$ $CF = 1.0719$

Raw NOx of 25 PPM = 26.798 corrected to 3.0% O2

Determine the #/mmBTU from the corrected NOx for Gas and Oil

		Corrected PPM	NOx #/mmBTU
Natural Gas-	(ppm)(.00104)(1.1676)	24.55	0.029811
Oil-	(ppm)(.0011)(1.1676)	117	0.15027

The above calculations are based on the below formulas provided by the State of New Jersey DEP.

Natural Gas

$$\frac{(\text{NOx PPM @ 3\%})(46)(8710)}{387,000,000} \quad \text{Equals \#/mmBTU}$$

Oil

$$\frac{(\text{NOx PPM @ 3\%})(46)(9190)}{387,000,000} \quad \text{Equals \#/mmBTU}$$

Calculate #/mmBTU Carbon Monoxide

(note: for NG 1,281 PPM CO = 1.0 #/mmBTU)

	CO PPM	CO #/mmBTU
Natural Gas-		
(ppm)/1,281 PPM	2	0.001561
#2 Oil-		
(ppm)/1,281 PPM	100	0.078064

Calculate the % FGR knowing the Windbox O2% and the stack O2%

WB O2	Stk O2	% FGR
18.5	4.0	16.0517

2.45 14.5 0.168966	Do not change these cells
--------------------------	------------------------------

$$\text{FGR \%} = \frac{20.9 - \text{WB O2}}{\text{WB O2} - \text{Stk O2}} \times (.95)(100)$$

Determine the Density of Natural Gas at various line pressures.

Calculation:

- 1 This calculation assumes that the natural Gas is 100% methane.
- 2 The natural Gas "R" constant used in this calculation is 79.1 from the Crane Engineering Guide. Some engineers argue that the "R" factor for 100% methane is 96.1.
- 3 Gas temperature in degrees Rankin at 60° F° is 520° R
- 4 Density is in pounds per cubic foot

The formula is as follows:

$$\text{Density} = \frac{144 \times (14.7 + P_g)}{R \times 520} \quad \text{for 18 PSIG} \quad \frac{144 \times (14.7 + 18)}{79.1 \times 520}$$

Density = .1145 lbs./cubic foot

Gas Line Pressure

18

	32.7
	4708.8
R factor	79.1
gas temp.	60
degrees Rankin	520
	41132

Density =

0.1145

Do not change the valves in the red cells

HEAT LOSSES from HORIZONTAL BARE STEEL PIPES

Expressed in BTU per hour per linear foot per degree Fahrenheit difference in temperature between the pipe and surrounding still air at 70° F.

Nominal Pipe Size (Inches)	Hot Water					Steam	
	120 F	150 F	180 F	210 F	227.1 F (5 Lb.)	297.7 F (50 Lb.)	337.9 F (100 Lb.)
	Temperature Difference						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
1/2	0.455	0.495	0.546	0.584	0.612	0.706	0.760
3/4	0.555	0.605	0.666	0.715	0.748	0.866	0.933
1	0.684	0.743	0.819	0.877	0.919	1.065	1.147
1 1/4	0.847	0.919	1.014	1.086	1.138	1.324	1.425
1 1/2	0.958	1.041	1.148	1.230	1.288	1.492	1.633
2	1.180	1.281	1.412	1.512	1.578	1.840	1.987
2 1/2	1.400	1.532	1.683	1.796	1.883	2.190	2.363
3	1.680	1.825	2.010	2.153	2.260	2.630	2.840
3 1/2	1.900	2.064	2.221	2.433	2.552	2.974	3.215
4	2.118	2.302	2.534	2.717	2.850	3.320	3.590
5	2.580	2.804	3.084	3.303	3.470	4.050	4.385
6	3.036	3.294	3.626	3.886	4.074	4.765	5.160
8	3.880	4.215	4.638	4.960	5.210	6.100	6.610
10	4.760	5.180	5.680	6.090	6.410	7.490	8.115
12	5.590	6.070	6.670	7.145	7.500	8.800	9.530

Volumetric Corrections for Fuel Oil

Petroleum products expand and contract as the temperature varies. For this reason, it is necessary to have a standard temperature in order to measure all oils on a uniform volume basis, regardless of temperature. The standard temperature of 60°F is used to correct all petroleum products to this temperature. Therefore, you can bring all quantities of oil at different temperatures to a constant volume.

The gravity and temperature of the oil must be known in order to make the proper temperature correction.

$$\text{Correction Factor} = 1 - (\Delta T \times \text{Multiplier})$$

<u>Oil API</u>	<u>Multiplier</u>
0° to 14.9° API	0.00035
15° to 34.9° API	0.0004
35° to 50.9° API	0.0005

Example: Oil having an API of 17° is clocked through a positive displacement meter at 565 GPH. The oil is 190° F at the meter. Find the corrected or actual volumetric flow.

$$190 - 60 = 130^\circ \Delta T$$

$$\text{Correction Factor} = 1 - (130 \times 0.0004) = .9480$$

$$\text{Corrected Volumetric Flow} = 565 \times .9480 = 535.62$$

Calculate the Energy Required to Heat #6 Oil

Electric

$$\text{Watts} = 1.25 \times \text{GPH} \times \Delta T (^\circ\text{F})$$

Example: To heat 600 GPH of #6 oil from 90°F to 150°F

$$\Delta T = 150 - 90 = 60^\circ\text{F}$$

$$\text{Watts} = 1.25 \times 600 \times 60 = 45,000$$

Steam

$$\text{Lbs/hr steam} = \frac{\text{Lbs/ hr oil} \times \Delta T}{1920} \quad (\#6 \text{ oil \& 5 psi steam})$$

Example: To heat 600 GPH of #6 oil from 90°F to 150°F

$$\text{Lbs/ hr steam} = \frac{600 \text{ GPH} \times 8 \text{ lbs/ gal.} \times 60}{1920} = 150$$

RATIO OF COMBUSTION

AIR and FLUE GAS

Air Required for Theoretical Combustion

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Tech File

VOL. VI, NO. 2

$$\begin{aligned} &\text{Computation of Lbs. of Air per Lb. of Oil} \\ &= 11.5 C + 34.3 H + 4.3 S - 4.3 O \end{aligned}$$

To compute Air required for complete theoretical combustion, add in the amount of excess air as determined by CO₂ Flue Gas Analysis.

Equation	C = % of Carbon in the Fuel, by weight
	O = % of Oxygen in the Fuel, by weight
	H = % of Hydrogen in the Fuel, by weight
	S = % of Sulphur in the Fuel, by weight

At 60°F and atmospheric pressure, one lb. of Air measures 13.1 cu. ft.

Computation for the Weight of the Flue Gases
per lb. of Fuel (No Excess Air) =

$$3.6 C = \text{Lbs. CO}_2 \text{ (Carbon Dioxide)}$$

$$9.0 H = \text{H}_2\text{O (Water Vapor)}$$

$$3.0 S = \text{Lbs. SO}_2 \text{ (Sulphur Dioxide)}$$

$$.7689 \text{ (Lbs. of Air)} + N = \text{Lbs. N (Nitrogen)}$$

and:

$$\begin{aligned} &3.6 C + 9.0 H + 3.0 S + (.7689 \text{ Lbs. Air} + N) \\ &= \text{Lbs. of Flue Gas per Lb. of Air required for} \\ &\text{complete theoretical combustion.} \end{aligned}$$

To find Weight of actual Flue Gases per lb. of Fuel consumed, take a Flue Gas Analysis. Then:

$$\begin{aligned} &\text{Weight of Dry Flue Gases} \\ &= \frac{11\text{CO}_2 + 7\text{CO} + 8\text{O}_2 + 7\text{N}_2}{3(\text{CO}_2 + \text{CO})} = \% \text{ Carbon in Fuel, by wt.} \end{aligned}$$

Equation	CO ₂ = % Carbon Dioxide, by volume
	CO = % Carbon Monoxide, by volume
	O ₂ = % Oxygen, by volume
	N ₂ = % Nitrogen, by volume

And, the amount of heat carried by the Flue Gases up the chimney
= .24 x Weight of Flue Gases x Difference in Temperatures of Flue
Gases and Air entering the Burner.

Average % of Carbon by Weight:

#3 Oil — 84%	#5 Oil — 85%	#6 Oil — 86%
--------------	--------------	--------------

Air required for Theoretical Combustion (No excess), expressed in CMF
per gal. of Oil:

#2 — 22.9 CMF
#5 — 25.0 CMF

#4 — 24.0 CMF
#6 — 25.7 CMF



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October 25, 2012

Energy Products Company
868 Sussex Blvd
Broomall, PA 19008

ATT: Kevin Collins

Ref: Boeing Site Visit

Project: Boeing Bldg. 4-14

Job Number: J12307E

Site Visit: 10/19/12

Purpose: Investigate report of an oil spill.

Attendees from Preferred Utilities:

Dennis Cosgrove – Project Manager

Jeff Bailey – District Sales Manager

Brent Geis – Service Technician

Aubrey Prime – Service Technician

System Back Ground:

The fuel supply system to the boilers consists of (2) fuel pumps, each rated for 1730 GPH of #2 oil at a discharge pressure of 346' TDH WG (150 PSI), with their respective relief valves factory set at 170 PSI. The pumps draw fuel from one of two 30,000 gallon vertical tanks as dictated by operator selection at the pump control panel. Each of the fuel storage tanks is equipped with a motorized ball valve for the suction and return lines. The valves are powered open when a call for fuel from the boilers is received. Upon removal of the call for oil, the fuel pumps are de-energized and the tank selection valves are powered closed.

The pumps operate in a lead/lag manner providing fuel to (3) 900 HP Cleaver Brooks boilers. Each boiler has a single fuel supply line to the boiler off of the common fuel supply header. The pressure in the header is controlled by a modulating pressure control valve (PCV), based on the pressure as sensed at the discharge from the pump set. There are two of these pressure control valves (PCV1 & PCV2) located in the fuel supply header, one for primary control with the second for redundancy. Both valves are driven to the fully open position when pumps are not in operation. Upon energizing of a pump, the backup PCV valve is driven closed with the primary valve used for pressure control. Located in the fuel header is a 3" bypass valve around the two pressure control valves.

Reported Problem:

a continual rise in pressure once the system was again isolated. The cause of this pressure build up is suspect to be due to thermal expansion, which will be addressed later in this report.

The system pressure needed to be manually relived as the cause of the pressure build up was down stream of the check valves located in the pump discharge piping. These check valves prevented the pressure from being felt at the pump safety relief valves.

2. Each boiler has a single fuel supply line coming from the common fuel supply header. This line has a single ball valve for isolation, then goes into the filter unit, then into control valves for the boiler oil supply. Part of the supply piping consists of two oil safety shutoff valves in series, with a relief valve tied in between them. The discharge of this relief valve goes back into the same supply line upstream of the first oil safety shutoff valve. It was explained that the purpose of the relief valve is to relieve hydraulic pressure created between the oil safety shut off valves. However, as the discharge of the relief valve is piped upstream of the first oil safety shut off valve, any pressure being relieved through the valve, will then be felt on the supply piping to the boiler and subsequently the inlet filter, possibly causing this filter to fail.

Conclusion:

As has been mentioned, the pumps were operated under varying conditions and nothing was shown to be out of the normal operating range of the pumps as designed per specification. The pumps were specified to be rated for 150 PSI discharge operating pressure since at the time of specifying the pumps, it is understood that the boiler manufacturer did not know what pressure would be required at the boiler front for proper operation. Based on the 150 PSI discharge pressure from the pumps, the relief valves were factory set at 170 PSI to prevent the pumps from over pressurizing the system. All inspection and operation of the system showed no signs or evidence of the pumps ever creating excessive pressure within the system as all valves were functioning correctly.

It was mentioned that at the time of the fuel leak, the system pressure was witnessed to be "going to a level of approximately 150 PSI", however this is the pressure that the pump and motor combination are rated for, so the 150 PSI should not be of concern. Furthermore, the strainer that ruptured the gasket has a rated pressure of 200 PSIG, again the 150 PSI should not be of concern.

The pumps and the operation there of did not cause this filter unit to fail.

Recommendations:

1. As the system is required to provide the boilers with 100 PSI fuel supply pressure, it is recommended that the relief valves setting on the fuel pumps be lowered to 125 PSI. This would not affect the operation of the system, and also will prevent the pumps from approaching the 200 PSIG rating of the boiler inlet fuel filters.
2. The Pressure Control Valves have been tuned as best as possible without actual boiler firing. It is recommended that once all parties are ready, the final tuning adjustments are made during boiler firing to ensure proper total system operation
3. The cause of the pressure buildup of the idle system is suspected to be due to thermal expansion of the oil or some sort of back feed from the boilers, however, it was stated

Preferred Utilities Manufacturing

CC: David Bohn (PUMC)

Harry Wells (PUMC)

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Jeff Bailey (PUMC)

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 and 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):

$$\text{lbs/hr steam} = \frac{600 \times 8 \times 60}{1920} = 150$$

Bulk Modulus and Fluid Elasticity

Gasoline	1.9	1.3
Glycerin	6.31	4.35
Kerosene	1.9	1.3
Mercury	41.4	28.5
Paraffin Oil	2.41	1.66
Petrol	1.55 - 2.16	1.07 - 1.49
SAE 30 Oil	2.2	1.5
Seawater	3.39	2.34
Sulfuric Acid	4.3	3.0
Water	3.12	2.15

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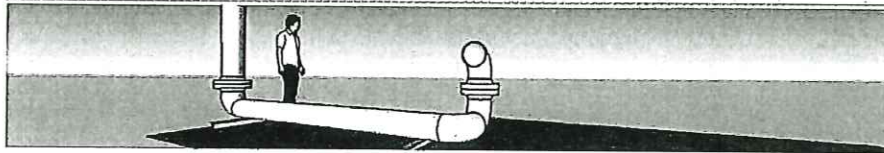
Related Topics

- **Fluid Mechanics** - The study of fluids - liquids and gases. Involves various properties of the fluid, such as velocity, pressure, density and temperature, as functions of space and time.
- **Material Properties** - Material properties - density, heat capacity, viscosity and more - for gases, fluids and solids

Related Documents

- **Cauchy Number** - An introduction and a definition of the Cauchy Number
- **Density of Fluids - Changing Pressure and Temperature** - Calculating density of fluids when changing pressure and temperature
- **Mach Number** - Introduction and definition of the Mach Number
- **Modulus of Rigidity** - Shear Modulus or Modulus of Rigidity is the coefficient of elasticity for a shearing or torsion force
- **Speed of Sound Formulas** - Calculation formulas for velocity of sound in gases, fluids or solids

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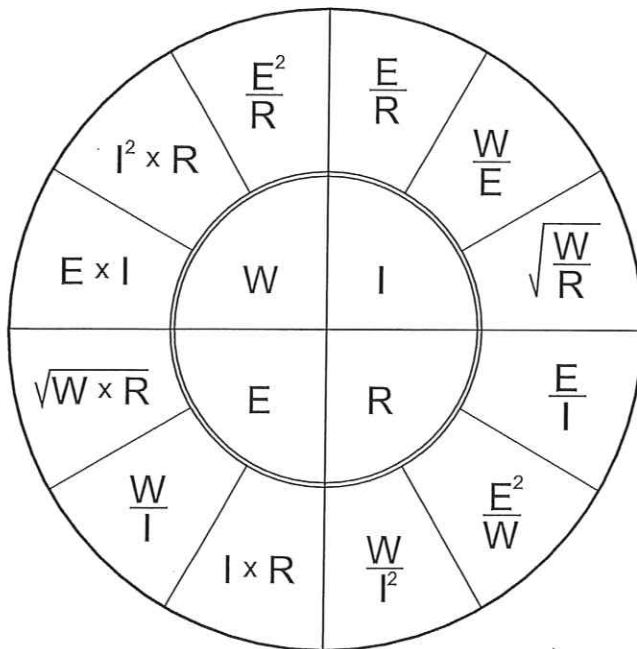
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GENERAL ENGINEERING DATA

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

Unit Conversion Tables

Pressure or Force Per Unit Area

Knowing	To Obtain						
	Atmospheres	PSI	lbs/ft ²	Kg/M ²	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 ²	.000473	.00694		4.882	.01414	.03591	.1922
Kg/M ²	.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 hr	.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.	
Multiply By										
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

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SUMMARY OF NATIONAL CODES

	UNDERWRITERS LABORATORIES 296 (OIL)	UNDERWRITERS LABORATORIES 795 (GAS)	FACTORY MUTUAL AUTO LIGHTED BOILERS	INDUSTRIAL RISK INSURERS* AUTOMATIC SINGLE BURNER	NATIONAL FIRE PROTECTION ASSOCIATION 85	IMPROVED RISK MUTUAL	AMERICAN SOCIETY OF MECHANICAL ENGINEERS ASME CSD-1	KEMPER
SCOPE	OVER 400,000	OVER 400,000	100 HP OIL 50 HP GAS	OVER 400,000	OVER 12.5 Mil. BTU/H	OVER 400,000	OVER 400,000 UNDER 12.5 MIL BTU/H	OVER 1,000,000 BTU UNDER 200,000 LBS P/H
PREPURGE	No Mention	4 air changes at 1/3 air flow minimum or 30 sec. @ hi fire air flow rate 90 sec. @ 1/3 hi fire air flow rate - atmospheric 90 sec. w/o automatic shutters; no PP req'd.	4 air changes @50% average air flow supervised - automatic dampers which close during down time on natural draft boiler must be opened 90 sec. prior to each start	4 air changes @ 60% minimum air flow supervised.	8 air changes reaching not less than 70% air flow supervised. <i>MUST have Purge Air JW - AP.</i>	4 air changes supervised.	- Power gas- above 400,000 to 2.5M 4 air changes in 90 sec. or at 60% max. air flow proven. - Above 2.5 mil. 4 air changes @ 60% max. air flow proven - Atmospheric gas- none if unrestricted air passage; if automatic damper, prove open for 90 sec. - Oil- 3 to 7 gal. 4 air changes in 90 seconds - Over 7 gal. 4 air changes @ 60% w/proven air flow.	4 air changes @ min. 50% of maximum air flow rate and supervised during purge period. 8 air changes suggested as more positive safety feature
PILOT PROVING	- Required over 20 GPH starting rate 15 sec.	- Under 2.5 Mil. 15 sec. - Over 2.5 Mil. 10 sec.	10 sec.	10 sec. max.	10 sec.	10 sec.	- Power & Atmospheric Gas- 400,000 to 2.5 Mil. 15 sec. 2.5 Mil. & over 10 sec. - Oil- interrupted 10 sec.	10 sec. - Over 7 gal. must have pilot
MAIN FLAME TRIAL FOR IGNITION (OIL)	- Spark or unproved pilot 3 G.P.H. max. 90 sec. 3 to 7 30 sec. 7 to 20 15 sec. - Over 3 GPH/w proved pilot Distillate 10 Residual 15	Not applicable	#2 & 4 10 sec. #5 & 6 15 sec.	#2 & 4 15 sec. #5 & 6 30 sec. - UL timings take precedence	#2 & 4 10 sec. #5 & 6 15 sec.	- Direct Spark 15 sec. - Pilot ignition oil, grades 1 through 6- 15 sec.	400,000 to 2.5 mil - 15 sec. - Over 2.5 mil #2 & 4 - 10 sec. #5 & 6 - 15 sec.	- Direct spark under 7 gal. 10 sec. max. - Oil- #1 thru 4 15 sec. max. Preheated oils #5 & 6 30 sec.
MAIN FLAME TRIAL FOR IGNITION (GAS)	Not Applicable	- Under 2.5 mil. 15 sec. - Over 2.5 mil. 10 sec. (if interrupted pilot is used)	10 sec.	15 sec. (published) UL takes precedence	10 sec.	10 sec.	400,000 to 2.5 mil. 15 sec. Over 2.5 mil. 10 sec.	15 sec.
FLAME FAILURE RESPONSE TIME	4 sec. max.	4 sec. max.	4 sec. max.	4 sec. max.	4 sec. max.	3 sec. max.	4 sec. max.	4 sec. max.
INTERLOCKS REQUIRED	Shutdown on loss of atomizing means	Over 2.5 mil. BTU non-recycling hi & lo gas pressure switches	- Over 12.5 mil. prove fuel valve closed prior & during purge - no fire start - lo oil temp. - hi & lo gas press. - NON-RECYCLING - min. comb. air - rotary burner pwr. outage to motor - lo oil pressure - atomizing medium	- hi & lo oil temp. - lo fire start - NON-RECYCLING - Supervised atomizing medium - hi & lo gas press. - min. comb. air - rotary burner pwr. outage to motor - lo oil pressure	- lo fire start - manual start from cold start - lo fire start - prove safety shutoff valve closed - NON-RECYCLING - loss of combustion control system activating energy - lo oil temp. & pressure - atomizing medium - min. air flow	- lo oil pressure on non-integral pumps. - lo oil temp. - lo fire start - damper position switch - min. air flow - hi & lo gas Pressure	- low fire start over 2.5 mil. - combustion air (gas & oil) - action on loss of combustion air - gas: 400,000 to 2.5 mil. recycle 2.5 mil. & over. safety shutdown - Oil: 3 to 16 gal. recycle once-16 Gal. & over safety shutdown - fuel pressure supervision - gas: 400,000 to 2.5 mil- not required 2.5 mil. & over- lo & hi press., non-recycle - oil: pre-heated oil lo & hi temp., non-recycle	- lo fire start - proof of closure over 10,000,000 BTU - NON-RECYCLING - lo water - loss of comb. air - hi & lo gas press. - lo oil press. - lo atomizing air or steam press. - lo oil temp. - lo & hi gas pressure switch on Pilot over 250,000 BTU. - motor starter interlock
FUEL VALVES (SSOV = SAFETY SHUTOFF VALVE)	Automatic shutoff valve close within 5 sec.	400,000 to 2.5 mil. 1 SSOV close within 5 sec. 2.5 to 5 mil. 2 SSOV in series or 1 SSOV incorporating a valve seal over travel interlock; closing time 1 sec. max. 5 to 12.5 mil. 2 SSOV in series 1 of which incorporates a valve seal over travel interlock; closing time 1 sec. max. - over 12.5 mil. 2 SSOV in series 1 of which incorporates a valve seal over travel interlock. When fuel gas has specific gravity of less than 1.0 include a NO 3/4" or larger electrically operated valve in a vent line between the 2 SSOV's.	- Approved SSOV - Over 250 HP or 12.5 mil Btu/H interlock main brnr shutoff valve to prove closed prior to & during prepurge period.	- Gas - Pilot- over 120,000 Btu/H 2 SSOV plus vent valve - Main- 1 motor driven and 1 shutoff valve plus vent valve. - Oil 1-SSOV	- Gas - Pilot & Main 2 SSOV plus vent valve. - Oil 1 SSOV	- Gas 400,000 to 1,000,000 Btu/H 1 UL SSOV 1,000,000 to 2,000,000 2 SSOV; 1 valve must be UL listed plus vent of closure interlock. 2,000,000 & over 2 UL listed SSOV's w/vent. SSOV's should have a spring force of 5 lbs. - Pilot Valves - Under 250,000 Btu/H 1 SSOV Over 250,000 2 SSOV with vent - All valves closing time: Over 400,000 to 2.5 mil. 5 sec. Over 2.5 mil. 1 sec. - Oil 1 SSOV, 2 SSOV when: - atomizing pressure over 125 PSI - when oil pump operates w/o main oil burner firing regardless of pressure - w/comb. oil/gas burners when oil pump operates during gas burner operation. - Valve closing times: 5 sec. max.	- Gas 400,000 to 2.5 mil- 1 SSOV w/5 sec. max. closing time 2.5 mil. to 5.0 mil. Btu/H 2 SSOV or one SSOV w/proof of closure interlock. 5.0 ml. to 12.5 ml. 2 SSOV's 1 w/proof of closure or 2 SSOV's w/vent valve. 12.5 & over- 2 SSOV's 1 w/proof of closure plus vent valve. - Main burner SSOV's must have min. 5 lbs. closing force. - Pilot 1 SSOV - Oil 1 SSOV 2 SSOV when: - atomizing press. greater than 125 PSI - oil pump operates w/o main burner firing. - Second SSOV may be replaced by 3-way valve or by-pass valve. - All valve closing times: Over 400,000 to 2.5 mil. gas and oil 3 to 16 gal.: 5 sec. Over 2.5 mil. & 16 gal.: 1 sec.	- Gas - Pilot & main over 250,000 BTU 2 SSOV's and 1 vent valve. - For burners over 10,000,000 BTU's per hour the safety-shutoff valves should be provided with interlocks proving that the valves are in the closed position before the preignition purging can be started. The interlock shall remain in the circuit for the entire purge period. - Oil 1-SSOV min. 2-SSOV's suggested - SSOV shall exert min. 5 Lbs. pressure against seat w/valve closed.
OTHER	- Flame detectors must be positioned to detect only flame, not spark. - Relight permitted up to 20 GPH w/ intermittent ignition and w/ interrupted direct spark providing spark is restored in .8 sec.	- Relight operation not permitted. - an ignition system shall ignite only a pilot.				- non-recycle over 20 GPH or 2,500,000 BTU/H gas - recycle OK (limited to 15 sec) under 20 GPH if direct spark or pilot ign. providing control has .8 sec. flame failure response time & re-establishment of ignition accomplished in .8 sec. - burners w/max. starting rate in excess of 20 GPH using intermittent pilot must prove main flame only after pilot trial for ignition period. - Interrupted pilot on firing rates over 2,500,000 BTU/H gas; under 2,500,000 Btu/H pre-purge before recycle		- Gas & oil fuels should not be fired simultaneously through a same burner - when interrupted pilots used, a single flame sensor may be used. When constant or intermittent pilots are used, a separate scanner required for pilot & main burner.

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ASME CSD-1-2009
(Revision of ASME CSD-1-2006)

Controls and Safety Devices for Automatically Fired Boilers

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FOREWORD

(09)

The major perils in operating automatically fired boilers are loss of water (low water), furnace explosion, overpressure, and overtemperature. Principal causes of accidents to automatically fired boilers are lack of proper controls and safety devices, lack of adequate maintenance, improperly trained operators, failure to test controls and safety devices, and complacency on the part of the operator due to long periods of trouble-free operation. It is believed that improved instrumentation, controls and safety devices, proper operating procedures, and a clearer understanding of installation requirements by the manufacturers, installers, and operators can greatly reduce the chances of personal injury, damage to property, and loss of equipment from accidents.

It should be pointed out that any governmental jurisdiction has authority over any particular installation. Inquiries dealing with problems of a local character should be directed to the proper authorities of such jurisdictions.

Safety codes and standards are intended to enhance public health and safety. Revisions result from the committee's consideration of factors such as technological advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

The first edition of this Standard, which was approved by The American Society of Mechanical Engineers' Committee on Controls and Safety Devices for Automatically Fired Boilers, was approved and designated as an ASME Standard by The American Society of Mechanical Engineers on April 29, 1977.

The second edition, which was approved by the American National Standards Institute (ANSI) on October 4, 1982, was issued on December 31, 1982. An addenda to the edition, CSD-1a-1984, was approved on August 17, 1984 and issued on November 15, 1984.

The third edition, which was approved by ANSI on November 17, 1988, was issued on February 15, 1989. The CSD-1a-1989 Addenda was approved on October 3, 1989 and issued on February 15, 1990. The CSD-1b-1990 Addenda was approved on June 21, 1990 and issued on December 1, 1990.

The fourth edition, which was approved by ANSI on February 28, 1992, was issued on June 15, 1992. The CSD-1a-1993 Addenda was approved on August 18, 1993 and issued on November 30, 1993. The CSD-1b-1994 Addenda was approved on June 20, 1994 and issued on September 30, 1994.

The fifth edition, which was approved by ANSI on February 6, 1995, was issued on June 30, 1995. The CSD-1a-1996 Addenda was approved on February 5, 1996 and issued on July 31, 1996. The CSD-1b-1996 Addenda was approved on July 16, 1996 and issued on December 20, 1996.

The sixth edition, which was approved by ANSI on January 30, 1998, was issued on April 14, 1998. The CSD-1a-1999 Addenda was approved on November 2, 1999 and issued on March 10, 2000. The CSD-1b-2001 Addenda was approved on July 30, 2001 and issued on November 30, 2001.

The seventh edition, which was approved by ANSI on January 17, 2002, was issued on April 15, 2002.

The eighth edition, which was approved by ANSI on August 9, 2004, was issued on April 15, 2005.

The ninth edition, which was approved by ANSI on September 13, 2006, was issued on December 29, 2006.

This tenth edition of CSD-1 was approved by ANSI on February 24, 2009.



COMMITTEE ON CONTROLS AND SAFETY DEVICES FOR AUTOMATICALLY FIRED BOILERS

(The following is the roster of the Committee at the time of approval of this Standard.)

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J. P. Chicoine , Mestek, Inc.	M. R. Poulin , State of Idaho, Division of Building Safety
M. H. Diehl, Jr. , CNA Insurance	J. Safarz , CEC Combustion Services Group, Inc.
P. K. Fanning , U.S. Naval Facilities Engineering Command	J. R. Puskar , <i>Alternate</i> , CEC Combustion Services Group, Inc.
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L. J. Ashton , <i>Alternate</i> , Raypak, Inc.	J. C. Smelcer , Lochinvar Corp.
J. P. Gorman , CSA International	J. D. Spuller , ITT Industries, Inc.
G. M. Halley , American Boiler Manufacturers Association	J. C. Stoeger , Industrial Combustion
M. W. Hilton , The Fulton Companies	M. W. Valentino , <i>Alternate</i> , Industrial Combustion
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J. C. Merwin , Potter Electric Signal Co.	K. J. Carlisle , <i>Alternate</i> , Karl Dungs, Inc.
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G. Moino , The American Society of Mechanical Engineers	T. F. Hardin , <i>Alternate</i> , Underwriters Laboratories, Inc.
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General. ASME Codes and Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

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Three Park Avenue
New York, NY 10016-5990

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The committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Interpretations. Upon request, the CSDAFB Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the CSDAFB Standards Committee.

The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s), and provide a concise description.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain any proprietary names or information.

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ASME CSD-1-2009

SUMMARY OF CHANGES

Following approval by the ASME CSDAFB Standards Committee, and after public review, ASME CSD-1-2009 was approved by the American National Standards Institute on February 24, 2009.

The 2009 edition of ASME CSD-1 includes editorial changes, revisions, and corrections introduced in ASME CSD-1-2006, as well as the following changes identified by (09).

<i>Page</i>	<i>Location</i>	<i>Change</i>
v	Foreword	Updated
1	CG-110	Revised
	CG-120	Revised
	CG-130	Revised
	CG-140(a)(2)	Revised
	CG-150	Added
	CG-160	Added
2	CG-300	(1) CG-310 revised (2) CG-320 deleted
	CG-420	Revised
3-7	CG-510(b)	Revised
	CG-700	(1) Section moved from front of book (2) Definitions of <i>ANSI</i> and <i>ASME</i> deleted (3) Term <i>drip leg</i> revised to read <i>drip</i> (4) Definitions of <i>ignition system</i> , <i>hot surface</i> and <i>valve shaft</i> added
9	CE-110(a)	Third paragraph revised
10	CE-140(a)	Revised
12	CW-140(c)	Revised
16, 19	CF-110(a)	Revised
	CF-110(c)	Revised
	CF-140	(1) Subparagraph (a) revised (2) Subparagraph (b) added
	CF-150	(1) Subparagraphs (a) through (d) revised in their entirety (2) Subparagraphs (e) through (g) added
17	Table CF-1	(1) Last column added (2) Last row added (3) General Note added
18	Table CF-2	(1) Last column added (2) Last row added (3) General Note added



<i>Page</i>	<i>Location</i>	<i>Change</i>
19	CF-160(a)	Last sentence added
	CF-162	Revised
20	Table CF-3	(1) Last lines in third entries of second and third columns added (2) Last entry in second column revised (3) General Note revised
21	Table CF-4	(1) Last lines in third entries of second and third columns added (2) Last entry in second column revised (3) General Note revised
22	CF-180	(1) Subparagraphs (a) through (f) revised (2) Subparagraph (g) added
23	CF-210(a)	(1) Revised (2) Subparagraph (a)(1) consolidated into (a) (3) Subparagraph (a)(2) deleted
	CF-310(c)	Revised
24, 25	CF-320	Revised
	CF-330(e)	Revised
	CF-410	Revised
25	CF-470	Revised
26	Table CF-5	General Note revised
27, 28	CF-510(c)	Revised
	CF-610	Revised
	CF-710	Revised
	CF-910	First sentence revised
	CF-920	First sentence revised
	CF-930	Revised
36	Manufacturer's/Installing Contractor's Report for ASME CSD-1	"ASME" line revised
44	Nonmandatory Appendix F	Added
47	Index	Updated

SPECIAL NOTE

The interpretations to ASME CSD-1 are included in this edition as a separate section for the user's convenience.



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CONTROLS AND SAFETY DEVICES FOR AUTOMATICALLY FIRED BOILERS

Part CG General

CG-100 GENERAL REQUIREMENTS

(09) CG-110 Scope

The rules of this Standard cover requirements for the assembly, installation, maintenance, and operation of controls and safety devices on automatically operated boilers directly fired with gas, oil, gas-oil, or electricity, subject to the service limitations, exclusions, and acceptance to other listings in CG-120, CG-130, and CG-140, respectively. Burner or burner assemblies installed on boilers or as a replacement burner shall comply with the requirements of CF-110 and CF-410 for gas and oil firing, respectively. The use of a gaseous or oil fuel not listed in the definitions has not been evaluated, and special considerations may be required.

(09) CG-120 Service Limitations

The rules of this Standard are applicable to the following service:

(a) all automatically fired boilers and burner assemblies, regardless of fuel input ratings subject to the exclusions and acceptance to other listings of CG-130 and CG-140, respectively

(b) burners field-installed in automatically fired boilers

(09) CG-130 Exclusions

(a) boilers with fuel input ratings greater than or equal to 12,500,000 Btu/hr (3 663 389 W), falling within the scope of NFPA 85, Boiler and Combustion Systems Hazard Code

(b) water heaters (see CG-700)

(c) direct gas-fired swimming pool heaters that are labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with ANSI Z21.56/CSA 4.7, Standard for Gas-Fired Pool Heaters

CG-140 Acceptance by Other Listings

(a) automatically operated boilers fired with gas having inputs of 400,000 Btu/hr (117 228 W) or less that

(1) comply with Part CW, CE-110(a) and (i)

(2) are labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with ANSI Z21.13/CSA 4.9, Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers, and meet the remaining requirements of this Standard

(b) automatically operated boilers fired with oil having inputs of 3 gph (11.4 L/h) or less that

(1) comply with Part CW, CE-110(a) and (i)

(2) are labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with UL 726, Standard for Oil-Fired Boiler Assemblies, and meet the remaining requirements of this Standard

(c) automatically operated, electrically heated boilers having inputs of 115 kW or less that

(1) comply with Part CW and CE-110(a)

(2) are labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with UL 834, Standard for Heating, Water Supply, and Power Boilers – Electric, and meet the remaining requirements of this Standard

CG-150 Jurisdictional Adoption of CSD-1

Adoption of CSD-1 by a jurisdiction shall not preclude the jurisdiction adopting and accepting boilers listed or certified to other safety standards or codes acceptable to the jurisdiction beyond the limitations contained in CG-140. Where other such safety codes and/or standards are adopted/accepted and overlap with the scope of CSD-1, it shall be the responsibility of the jurisdiction to define the application of this Standard and those other codes and/or standards.

CG-160 Metric (SI) Units

This edition of the Standard uses U.S. Customary Units. The acceptable equivalent SI units are shown in parentheses for information only and have been directly (soft) converted from the U.S. Customary Units.



CG-200 GENERAL PROVISIONS

CG-210 General Provisions

Installation requirements shall apply to controls, safety devices, and burners on automatically fired boilers covered by this Standard.

For information regarding boiler and/or burner installations, refer to local codes. In the absence of local codes, see NFPA 54/ANSI Z223.1 for gas-fired boilers and NFPA 31 for oil-fired boilers.

For boilers firing liquefied-petroleum gas or LP-gas air mixtures, the requirements pertaining to the storage container, the first and second stage LP-gas pressure regulators, and all components upstream of the point of gas delivery (see CG-700) are covered by NFPA 58, Liquefied-Petroleum Gas Code.

CG-220 Installation

(a) Installation of controls, safety devices, and burners shall be in accordance with the manufacturer's instructions and the applicable requirements of this Standard. Diagrams detailing the wiring and piping connections for the controls and safety devices installed shall be furnished by the unit manufacturer [see CG-510(c)].

(b) Installations shall provide accessibility for removing burners; adjusting, cleaning, and lubricating working parts; and replacing controls, safety devices, and other control components.

(c) For information concerning the location and installation of LP-gas air mixture boilers, refer to local building codes.

(d) When one or more modules of a modular boiler (see CG-700) are replaced, compatibility of all controls and systems shall be ensured. The replacement modules shall comply with the initial listing and shall meet the requirements of this Standard.

CG-230 Observation Ports

Observation ports shall be provided to permit direct visual inspection of the pilot, main burner flame, and boiler furnace.

CG-240 Guarding

Guards shall be provided to protect personnel and protect against damage to control equipment. Guarding shall conform to applicable regulations.

CG-250 Annunciator Systems

Where used, annunciator systems, and their associated test and acknowledgement circuits, shall have all contacts, switches, relays, and lights arranged so that safety control functions are not bypassed.

CG-260 Combustion Air

(a) The requirements of combustion air shall be in accordance with NFPA 54/ANSI Z223.1, National Fuel Gas Code, for gas-fired boilers and with NFPA 31,

Standard for the Installation of Oil-Burning Equipment, for oil-fired boilers.

(b) Louvers and grilles shall be fixed in the open position or interlocked with the equipment so that they are opened automatically during equipment operation. The interlock shall be placed on the driven member.

(c) Fans supplying air to the boiler room for combustion shall be interlocked with the burner so that air flow is proven during equipment operation.

CG-300 MATERIAL REQUIREMENTS

(09)

CG-310 Components

Each control and safety device covered by this Standard shall be accepted for the intended service by a nationally recognized testing agency such as, but not limited to, UL, FM, or CSA.

CG-400 TESTING AND MAINTENANCE

CG-410 Cleaning

Manufacturers of controls and safety devices requiring periodic service shall furnish detailed instructions covering the procedures and frequency of cleaning [see CG-510(c)].

CG-420 Testing

(09)

Manufacturers of boilers and burners covered by this Standard shall furnish detailed instructions for testing controls and safety devices, both when the boiler is operating and when it is out of service [see CG-510(c)].

CG-430 Maintenance

Boiler, boiler unit, and burner manufacturers shall furnish detailed instructions on maintenance and service procedures for the fuel burning system or electrically heated units, including controls and safety devices installed with the unit.

These instructions shall include requirements specifying that cover plates, enclosures, and guards shall be maintained in place at all times, except during maintenance (see CG-510 and Part CM).

Boiler, boiler unit, burner, and control manufacturers' operation and maintenance instructions furnished with the equipment shall be retained and made available to the boiler operator (see CG-510).

CG-440 Operational Testing

The operation of control systems and safety devices installed in accordance with this Standard shall be tested by the installing contractor prior to release to the owner/user.

(a) Control systems and safety devices installed in accordance with this Standard by the boiler manufacturer on shop-assembled boiler units shall be operationally tested as close to specified field conditions as



practicable prior to shipment from the manufacturer's facility.

(b) For boiler units with inputs less than or equal to 400,000 Btu/hr (117 228 W) for gas, or less than or equal to 3 gph for oil, where production makes it impractical to check each boiler unit individually, the manufacturer will prepare and follow an inspection and quality control procedure by which the requirements of this paragraph will be met.

CG-500 CERTIFICATION AND REPORTING

CG-510 Certification and Reporting

(a) Manufacturers of shop-assembled boiler units covered by this Standard shall maintain a report for each boiler unit or on each category (type, size, or model) for boiler units. For boiler units less than or equal to 400,000 Btu/hr (117 228 W) for gas, or less than or equal to 3 gph for oil, a report shall be maintained on each category (type, size, or model).

This report shall list

(1) each control and safety device installed in accordance with this Standard

(2) name of the manufacturer and model number of each control and safety device

(3) operational test performed (see CG-440)

CG-510(a)(1) through (3) shall be verified by the signature of an authorized representative of the manufacturer on this report. An example of an acceptable data report form is contained in Nonmandatory Appendix C.

This report shall be made available to the authorized inspection agency or the inspector for action as required by the local jurisdiction.

(09) (b) Installing contractors shall maintain or obtain from the manufacturer a report for each installation completed. The report shall list

(1) each control and safety device installed in accordance with this Standard

(2) name of the manufacturer and model number of each control and safety device

(3) operational test performed (see CG-440)

CG-510(b)(1) through (3) shall be verified by the signature of an authorized representative of the installing contractor on this report. An example of an acceptable report form is contained in Nonmandatory Appendix C.

This report shall be made available to the authorized inspection agency or the inspector for action as required by the local jurisdiction.

(c) Installing contractors shall obtain from the boiler manufacturer pertinent operating, testing, servicing, and cleaning instructions for the controls and safety devices (see CG-410, CG-420, and CG-430). It is the responsibility of the installing contractor to deliver these instructions, together with complete wiring and piping diagrams, and a written precaution that the operating, testing, and servicing only be performed by a qualified

individual (see CG-700) to the owner/user and to obtain a receipt for the instructions. The receipt shall be filed with the installation report.

CG-600 OPERATION

CG-610 Lockout

The manual procedure required for effecting the restart of the equipment subsequent to a lockout shall be accomplished from a location where the cause of the lockout may be determined so that the necessary corrective action may be performed to ensure that safe operating conditions prevail before restarting the boiler.

Safety control(s) that can electronically reset without local manual intervention, such as when power or control input to the device is interrupted and then restored, shall not be permitted.

CG-700 DEFINITIONS

(09)

accepted: a boiler unit, equipment, or device is accepted when listed, labeled, or otherwise determined to be suitable and safe by a nationally recognized testing agency. Field installations are accepted when approved by the authority having jurisdiction.

air change: the quantity of air necessary to completely replace the air contained in the combustion chamber and associated flue passages.

air shutter: an adjustable device for varying the flow of air.

alarm: an audible or visible signal indicating an off-standard or abnormal condition.

alarm circuit: a circuit that includes an alarm.

annunciator: a device that indicates a condition, either normal or abnormal, by visual signals, audible signals, or both.

approved: acceptable to the authority having jurisdiction.

atomizing media: a supplementary medium, such as steam or air, that assists in breaking the fuel oil into a fine spray.

authorized inspection agency: the inspection agency approved by the appropriate authority of a state or municipality of the United States or a province of Canada that has adopted this Standard.

AWG: American Wire Gauge.

bleed line: a line used to relieve pressure to the atmosphere, either manually or automatically.

boiler: a closed vessel in which water is heated, steam is generated, steam is superheated, or any combination thereof, under pressure or vacuum by the direct application of heat. The term *boiler* shall include fired units for heating or vaporizing liquids other than water where these systems are complete within themselves.



boiler, automatically fired: a boiler that cycles automatically in response to a control system.

boiler, high-pressure: a boiler in which steam or vapor is generated at a pressure greater than 15 psig (103.4 kPa gage).

boiler, hot-water heating: a boiler in which no steam is generated and from which hot water is circulated for heating purposes, then returned to the boiler.

boiler, hot-water supply: a boiler that furnishes hot water to be used externally to itself at a pressure less than or equal to 160 psig (1 100 kPa gage) or a temperature less than or equal to 250°F (120°C) at or near the boiler outlet.

boiler, low-pressure: a boiler in which steam or vapor is generated at a pressure less than or equal to 15 psig (103.4 kPa gage).

boiler, miniature: a boiler that does not exceed any of the following limits:

- (a) 16 in. (406.4 mm) inside diameter of shell
- (b) 20 ft² (1.86 m²) heating surface
- (c) 5 ft³ (0.142 m³) gross volume,¹ exclusive of casing and insulation
- (d) 100 psig (689.5 kPa gage) maximum allowable working pressure.

boiler, modular: a steam or hot water heating assembly consisting of a grouping of individual boilers called modules intended to be installed as a unit with no intervening stop valves. Modules may be under one jacket or individually jacketed. The individual modules shall be limited to a maximum input of 400,000 Btu/hr (117 228 W) (gas), 3 gph (11.4 L/h) (oil), or 115 kW (electric).

boiler manufacturer: an organization that manufactures pressure parts for boilers or that shop-assembles parts into completed boilers.

boiler system: a system comprised of the boiler(s); its controls, safety devices, and interconnected piping; vessels; valves; fittings; and pumps.

boiler unit: a complete assembly comprised of the boiler, the apparatus used to produce heat, and associated controls and safety devices.

branch circuit: that portion of the wiring system between the final overcurrent device protecting the circuit and utilization equipment.

Btu (British thermal unit): a quantity of heat required to raise the temperature of 1 lb (0.45 kg) of water 1°F (0.56°C).

¹ The gross volume is intended to include such gas passages as are integral with the assembled pressure parts. Gross volume is defined as the volume of a rectangular or cylindrical enclosure into which all the pressure parts of the boiler in their final assembled positions could be fitted. Projecting nozzles or fittings need not be considered in the volume.

Btu/hr: a unit of power equal to one British thermal unit/hr.

building code: an ordinance that sets forth requirements for building design and construction, and equipment installation, or, where such an ordinance has not been enacted, one of the following model codes:

- (a) National Building Code
- (b) Standard Building Code
- (c) Uniform Building Code

burner: a device for the introduction of fuel and air into the combustion zone at the desired velocities, turbulence, and concentration to establish and maintain ignition and combustion of the fuel (see also *burner assembly*).

burner, atmospheric: a gas burner in which air for combustion is supplied by natural draft, the inspirating force being created by gas velocity through the orifices.

burner, mechanical draft, atmospheric: an atmospheric gas burner including a mechanical draft device, such as a forced draft or induced draft fan to provide sufficient air for completing the combustion process.

burner, natural draft type: a burner that depends primarily on the natural draft created in the flue to induce the air required for combustion into the burner.

burner, power: a burner in which all air for combustion is supplied by a power-driven fan that overcomes the resistance through the burner.

burner assembly: a burner that is factory-built as a single assembly or as two or more subassemblies that include all essential parts necessary for its normal function when installed as intended.

combined feeder/cutoff: a device that regulates makeup water to a boiler in combination with a low-water fuel cutoff.

combustion: the rapid oxidation of fuel, producing heat or heat and light.

combustion air: the air required for combustion of the fuel. This does not include the air used for atomization.

conductor: a body that may be used to conduct electric current.

continuous duty: the design feature of an electrical device, such as a motor, enabling the device to operate at the rated load for an indefinite period.

control: a device designated to regulate the fuel, air, water, steam, or electrical supply to the controlled equipment. It may be automatic, semiautomatic, or manual.

control, operating: an automatic control, other than a safety control, to start or regulate input according to demand and to stop or regulate input on satisfaction of demand.

control, primary safety: a control directly responsive to flame properties, sensing the presence of flame and, in



event of ignition failure or loss of flame, causing safety shutdown.

control, safety (also known as *limit*): a control responsive to changes in liquid level, pressure, or temperature and set beyond the operating range to prevent the operation beyond designed limits.

control manufacturer: an organization that manufactures operating and safety controls for use on boilers.

CSA: CSA International.

damper: a valve or plate for regulating combustion air or flue gases.

draft: the difference in pressure between atmospheric and some other pressure in the furnace or gas passages.

draft, mechanical: the draft caused by a mechanical device, such as a forced draft or induced draft fan.

draft, natural: the draft caused by the difference in the temperature of the hot flue gases and the outside atmosphere.

drip: the container placed at a low point in a system of piping to collect condensate and from which condensate may be removed.

fan, forced draft: a fan used to supply air, under pressure, to the fuel-burning equipment of the boiler.

fan, induced draft: a fan used to exhaust gases, under suction, from the boiler.

firing rate: the rate at which air, fuel, or an air-fuel mixture is supplied to a burner, expressed in volume or heat units supplied per unit of time.

flame failure response time: the time interval between the loss of flame and deenergizing the safety shutoff valve.

FM: Factory Mutual system.

fuel train: a series of valves, regulators, and controls, between the burner and the source of fuel, that regulates and controls the flow of fuel to the burner.

gas: one of the following fuel gases: natural gas, liquefied petroleum (LP) gas, LP-air mixture, manufactured gas, or mixed gas.

gas-pressure regulator, main: a device for controlling and maintaining a predetermined gas pressure for the main burner.

gas-pressure regulator, pilot: a device for controlling and maintaining a predetermined gas pressure for the pilot burner.

ground: a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and either the earth or a conducting body that serves in place of the earth.

grounded: connected to earth or to some conducting body that serves in place of the earth.

grounded conductor: a system or circuit conductor that is intentionally grounded.

grounding conductor, equipment: the conductor used to connect noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system-grounded conductor at the service and/or the grounding electrode conductor.

guarded: covered, shielded, fenced, enclosed, or otherwise protected by means of covers, casings, barriers, rails, screens, mats, or platforms to prevent contact by persons or objects.

high fire: the rate of a burner at or near design maximum fuel input.

ignition system, direct: an automatic ignition system that uses an electrically energized device to ignite fuel at a main burner.

ignition system, hot surface: an automatic, direct ignition system that uses a hot surface igniter to ignite fuel at a main burner.

input rating: the fuel-burning capacity of a burner at sea level in Btu/hr (W) as specified by the manufacturer.

installing contractor: an organization that installs a boiler, combustion controls, burners, and protective equipment in the field.

labeled: equipment or materials to which has been attached a label of a nationally recognized testing agency that maintains periodic inspection of production of labeled equipment or materials. Labeling indicates compliance with nationally recognized standards.

liquefied-petroleum gas: fuel gases, including commercial propane; predominantly propane, propylene, or commercial butane; predominantly butane; isobutane; and/or butylene.

listed: equipment or materials included in a list published by a nationally recognized testing agency that maintains periodic inspection of production of listed equipment or materials. Listing indicates compliance with nationally recognized standards.

local: within physical sight and sound of the affected equipment (see also *lockout*).

lockout: a safety shutdown that requires a local, manual procedure to restart the equipment (see also *shutdown, safety*).

low fire start: the lightoff ignition of a burner with the fuel controls in a low fire position. In a system with guaranteed low fire start, interlocks are used to prevent startup if the burner is not in the low fire position.

low-water fuel cutoff: a device that shuts off the fuel when the boiler water falls to an unsafe level.

LP-gas air mixture: liquefied-petroleum gases distributed at relatively low pressures and normal atmospheric temperatures that have been diluted with air to produce a desired heating value and utilization characteristic.



main burner flame-establishing period: the interval of time the main burner fuel safety shutoff valves are permitted to be open before the primary safety control is required to prove the presence of the main burner flame.

main manifold gas pressure: the gas pressure measured at a location that is specified by the burner/boiler unit manufacturer and is taken downstream of the main gas pressure regulator.

manifold, gas: the conduit of an appliance that supplies gas to the individual burners.

manual reset device: a component of a control that requires resetting by hand to restart the burner after safe operating conditions have been restored.

maximum fixed stop limit: on a temperature or pressure control having an adjustable set point, the maximum fixed stop limit is the maximum setting to which the control can be adjusted and still perform its intended function (i.e., safety shutdown) but not be exceeded due to a mechanical or electrical stop device.

NEMA: National Electric Manufacturers Association.

NFPA: National Fire Protection Association.

oil: any commercial grade fuel oil as defined by ASTM D 396.

pilot: a small burner that is used to lightoff (ignite) the main burner.

pilot, continuous: also known as a constant burning pilot, a pilot that burns without turndown throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

pilot, intermittent: a pilot that is automatically lighted each time there is a call for heat. It burns during the entire period the main burner is firing.

pilot, interrupted: a pilot that is automatically lighted each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.

pilot, proved: a pilot flame supervised by a primary safety control.

pilot flame-establishing period: the interval of time that fuel is permitted to be delivered to a pilot burner before the primary safety control is required to prove the pilot flame.

pilot manifold gas pressure: the gas pressure measured at a location that is specified by the burner/boiler unit manufacturer and is taken downstream of the pilot gas-pressure regulator.

point of gas delivery: for other than undiluted liquefied-petroleum gas systems, the point of gas delivery shall be considered the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve when no meter is provided. For undiluted, liquefied-petroleum gas systems, the point of gas delivery

shall be considered the outlet of the first stage LP-gas-pressure regulator.

pool heater: an appliance designed for heating nonpotable water stored at atmospheric pressure, such as water in swimming pools, spas, hot tubs, and similar applications.

postpurge period: a period of time after the fuel valves close, during which the burner motor or fan continues to run to supply air to the combustion chamber.

prepurge period: a period of time on each startup during which air is introduced into the combustion chamber and associated flue passages in volume and manner as to completely replace the air or fuel-air mixture contained therein prior to initiating ignition.

pressure regulator, LP-gas, first stage: on undiluted LP-gas systems, a pressure regulator designed to reduce pressure from the container to 10.0 psi (69 kPa) or less.

pressure regulator, LP-gas, second stage: a pressure regulator for service on undiluted LP-gas systems designed to reduce first stage regulator outlet pressure to 14.0 in. W.C. (4.0 kPa) or less.

pressure regulator, service: a pressure regulator installed by the serving gas supplier to reduce and limit the service line gas pressure to delivery pressure.

proven prepurge: a provision of the control system for preventing burner operation until prescribed air flow is proven to be established during prepurge.

qualified individual: a boiler service technician who is engaged in and responsible for installation, replacement, repair, or service of the boiler, fuel-burning system controls, and safety devices and is experienced in such work.

readily accessible: having direct unimpeded access without the need of a ladder or removing or moving any panel, door, or similar covering of the item described.

recycle: the process of sequencing a normal burner start following safety shutdown before the establishment of lockout.

relay: a device that is operative by a variation in the conditions of one electric circuit to start the operation of other devices in the same or another electric circuit, such as pressure or temperature relay.

relight: the action upon loss of main flame to reestablish the ignition source without recycle.

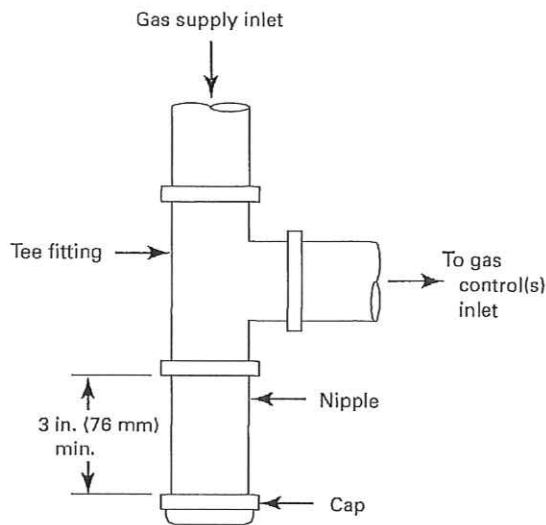
sediment trap: a device in a gas line that collects and prevents solid debris (such as pipe dope, slag, dirt, etc.) from traveling downstream into the gas controls (see Fig. 1).

shutdown, normal: shutting off fuel and ignition energy to the burner by means of an operating control.

shutdown, safety: shutting off all fuel and ignition energy to the burner by means of a safety control or primary safety control (see also *lockout*).



Fig. 1 Sediment Trap



switch, air flow: a device used to prove the flow of air.

switch, high oil temperature: a temperature-actuated device arranged to stop the flow of fuel to a preheated oil burner or to prevent it from starting when the fuel oil temperature rises above a set point, which shall be the upper end of the viscosity range recommended by the burner manufacturer.

switch, high-pressure: a pressure-actuated device to monitor liquid, steam, or gas pressure and arranged to stop the flow of fuel to the burner at a preset high pressure.

switch, low oil temperature: a temperature-actuated device arranged to stop the flow of fuel to a preheated oil burner or to prevent it from starting when the fuel oil temperature falls below a set point, which shall be the lower end of the viscosity range recommended by the burner manufacturer.

switch, low-pressure: a pressure-actuated device to monitor liquid, steam, or gas pressure and arranged to stop the flow of fluid to the burner at a preset low pressure.

switch, pressure: a pressure-responsive device that makes or breaks an electrical circuit and may be automatically or manually reset.

time delay: a deliberate delay of a predetermined time in the action of a safety device or control.

UL: Underwriters Laboratories, Inc.

upper set point limit: on a temperature or pressure control having an adjustable range of set points, the upper set point limit is the maximum pressure or temperature set point in the range of the control, to which the control can be adjusted and still perform its intended function (i.e., safety shutdown).

valve, automatic: an automatic device consisting essentially of a valve and operator that controls the fuel supply to the burner(s) during normal operation of a boiler. It may be actuated by application of electrical, mechanical, or other means.

valve, lubricated plug type: a valve of the plug and barrel type designed for maintaining a lubricant between the bearing surfaces.

valve, modulating control: a valve designed to regulate fuel input to the burner in response to demand.

valve, proof of closure: a safety shutoff valve equipped with an interlock switch that will be actuated only after the valve has fully closed.

valve, safety shutoff: a fast-closing valve that automatically and completely shuts off the fuel supply in response to a normal or safety shutdown signal.

valve shaft: the movable part of the sealing mechanism of a safety shutoff valve. The valve shaft may also be referred to as the valve stem.

vent limiter: a means that limits the flow of gas from the atmospheric diaphragm chamber to the atmosphere in the event of diaphragm rupture. This may be either a limiting orifice or device.

vent line: a line used to convey leakage gases to a safe point of discharge.

vent valve: a normally open, power-closed valve piped between the two safety shutoff valves and vented to a safe point of discharge.

water heater: a vessel, which is closed except for openings through which water can flow, that includes the apparatus by which heat is generated and on which all controls and safety devices necessary to prevent pressures greater than 160 psig (1 100 kPa gage) and water temperatures greater than 210°F (99°C) are provided, in which potable water is heated by the combustion of fuels, electricity, or any other heat source and withdrawn for external use.

Part CM

Testing and Maintenance

CM-100 PERIODIC TESTING AND MAINTENANCE

CM-110 General

Since the effective operation of all safety devices depends upon their ability to respond to their activating impulses, a systematic and thorough maintenance program shall be established and performed.

(a) An inspection and maintenance schedule shall be established and performed on a periodic basis. The periodic basis shall be at least that required by the equipment manufacturer.

(b) Operability and set points on all devices, where applicable, shall be verified by periodic testing, and the results shall be recorded in the boiler log, maintenance record, service invoice, or other written record.

(c) Any defects found shall be brought to the attention of the boiler owner and shall be corrected immediately.

(d) Frequent inspection, adjustment, and cleaning shall be performed during initial start-up operation to ensure all safety controls and devices are functioning as intended and are in a reliable operating condition (see CM-120).

CM-120 Familiarity With Equipment and Procedures

The qualified individual performing inspections and tests shall be trained and familiar with all operating procedures and equipment functions and shall be capable of determining the equipment is in an as-designed operating condition. The individual shall be familiar with all precautions and shall have complied with the requirements of the authority having jurisdiction.

CM-130 Periodic Maintenance and Testing

The owner or user of an automatic boiler system shall develop and maintain a formal system of periodic preventive maintenance and testing. Tests shall be conducted on a regular basis, and the results shall be recorded in the boiler log or in the maintenance record or service invoice. The manufacturer's instructions shall be followed. Additional information is contained in a recommended checklist found in Nonmandatory Appendix D.

Because of the variety of equipment and modes of operation, owners and users shall provide a detailed checklist for operator's use in accordance with the boiler, boiler unit, burner, and control device assembly manufacturer's instructions.



Part CE Electrical

CE-100 ELECTRICAL REQUIREMENTS

CE-110 General

Installation requirements shall apply to controls, safety devices, and burners on automatically fired boilers covered by this Standard.

For information regarding boiler and/or burner installations, refer to local codes. In the absence of local codes, see NFPA 70, National Electrical Code.

- (09) (a) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the boiler so that the boiler can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the boiler or adjacent to it.

A manually operated remote shutdown switch or circuit breaker shall be located just outside the boiler room door and marked for easy identification. Consideration should be given to the type and location of the switch to safeguard against tampering. If the boiler room door is on the building exterior, the switch should be located just inside the door. If there is more than one door to the boiler room, there should be a switch located at each door.

Activation of the emergency shutdown switch or circuit breaker shall immediately shut off the fuel or energy supply.

(b) All uninsulated live metal parts and all rotating or moving parts that may cause injury shall be guarded to avoid accidental contact.

(c) The electrical equipment shall be arranged so that failure of this equipment will cause the fuel supply to be shut off.

(d) The power supply to the electrical control system shall be from a two-wire branch circuit that has a grounded conductor; otherwise, an isolation transformer with a two-wire secondary shall be provided. When an isolation transformer is provided, one side of the secondary winding shall be grounded. Control voltage shall not exceed 150 nominal volts, line to line.

(1) One side of all coils shall be electrically located in the grounded side of the circuit. All switches, contacts, and overcurrent devices shall be electrically located in the ungrounded or "hot" side of the circuit.

(2) All electrical contacts of every safety device installed in the same control circuit shall be electrically connected in series.

(e) All electrical components and devices shall have a voltage rating commensurate with the supply voltage of the control system.

(f) All electrical components and devices shall be provided with an electrical enclosure that is at least NEMA Type 1 (General Purpose). Where electrical devices will be subject to dripping moisture, the enclosures shall be at least NEMA Type 2 (Driptight).

(g) All electrical control devices shall be of a type tested and accepted by a nationally recognized testing agency.

(h) The design of the control circuits shall be such that limit and primary safety controls shall directly open a circuit that functions to interrupt the supply of fuel to combustion units.

(i) Automatic resetting devices, controls, or switches shall be installed in accordance with the instructions of the combustion safeguard control manufacturer. No automatic resetting device, control, or switch shall be installed in the wiring between the load side (terminal) of the primary or programming control and the main or ignition fuel valve or valves. This does not preclude the installation of manually operated test switches for the purposes of testing tight closure of individual fuel valves.

CE-120 Overcurrent Protection

(a) Conductors for interconnecting wiring that is smaller than the supply conductors shall be provided with overcurrent protection based on the size of the smallest interconnecting conductors external to any control box.

(b) Overcurrent protection for interconnecting wiring shall be located at the point where the smaller conductors connect to the larger conductors. However, overall overcurrent protection is acceptable if it is sized on the basis of the smallest conductors of the interconnecting wiring.

(c) Overcurrent protection devices shall be accessible, and their function shall be identified.

CE-130 Motors

(a) Motors exposed to dripping or spraying oil or water shall be of drip-proof construction. All motors shall be fully guarded as installed.

(b) Motors shall be provided with a corrosion-resistant nameplate.



(c) Motors shall be provided with running protection by means of integral thermal protection, overcurrent devices, or a combination of both in accordance with manufacturer's instructions that shall be based on the requirements of NFPA 70, National Electrical Code.

(d) Motors shall be rated for continuous duty and shall be designed for an ambient temperature of 104°F (40°C) or higher.

(e) All motors shall be provided with terminal leads or terminal screws in terminal boxes integral with, or secured to, the motor frames.

CE-140 Ignition System

(09) (a) When automatic electric ignition is provided, it shall be accomplished by means of a high-voltage electric spark, a high-energy electric spark, or a hot surface igniter.

(b) Ignition transformers shall conform to requirements of UL 506, Standard for Specialty Transformers.

(c) Ignition cable shall conform to the requirements of UL 814, Gas-Tube-Sign Cable.

CE-150 Wiring

(a) All wiring for boilers shall be rated for the maximum operating temperature to which it may be exposed.

Such wiring shall be in accordance with NFPA 70, National Electrical Code. All wiring between components shall have copper conductors not less than size No. 18 AWG and constructed in accordance with NFPA 70, National Electrical Code.

(b) All electrical wiring shall have a voltage rating commensurate with the voltage of the power supply.

(c) Conductors shall be protected from physical damage.

(d) Conductors shall be sized on the basis of the rated current of the load they supply.

CE-160 Bonding and Grounding

(a) Means shall be provided for grounding the major metallic frame or assembly of the boiler.

(b) Noncurrent-carrying enclosures, frames, and similar parts of all electrical components and devices shall be bonded to the main frame or assembly of the boiler. Electrical components that are bonded by their installation do not require a separate bonding conductor.

(c) When an insulated conductor is used to bond electrical components and devices, it shall show a continuous green color, with or without a yellow stripe.



Part CW

Steam and Waterside Control

CW-100 AUTOMATIC LOW-WATER FUEL CUTOFF AND/OR COMBINED WATER FEEDING DEVICE

CW-110 General Requirements for Water Level Controls for All Boilers

(a) Each low-water fuel cutoff or combined feeder/cut-off device shall conform to UL 353, Standard for Limit Controls, and shall be accepted by a nationally recognized testing agency.

(b) Installation diagrams and instructions shall be furnished by the manufacturer.

(c) Low-water fuel cutoffs or combined feeder/cut-off devices shall be located to provide access for servicing, repairing, testing, and inspection.

(d) The low-water fuel cutoff shall have a pressure rating at least equal to the maximum allowable working pressure of the boiler.

(e) In probe-type, low-water fuel cutoffs, an open circuit failure, break, or disconnection of the electrical components or conductors in the safety circuit shall prevent continued operation of the firing mechanism.

(f) Alarms, when used, shall be distinctly audible above the ambient noise level and may be used in conjunction with indicating lights. They shall be located to alert the operator or an individual trained as to what action to take when an alarm indicates a potentially dangerous situation is developing.

(g) Low-water fuel cutoffs of the automatic or manual reset type shall be electrically connected in accordance with CE-110(i).

CW-120 Requirements for Water Level Controls for Low-Pressure Steam or Vapor System Boilers

(a) Each automatically fired, low-pressure steam or vapor system boiler shall have at least two automatic low-water fuel cutoffs, one of which may be a combined feeder/cut-off device. When installed external to the boiler, each device shall be installed in individual chambers (water columns), which shall be attached to the boiler by separate pipe connections below the waterline. A common steam connection is permissible. Each cut-off device shall be installed to prevent startup and to cut off the boiler fuel or energy supply automatically, prior to the fall of the surface of the water below the level of the lowest visible part of the gage glass (see also CW-210).

EXCEPTION: Only one low-water cutoff is required on gravity return units installed in residences, as defined by the authority having jurisdiction.

A water feeding device, when used, shall be constructed and installed so that the water inlet valve cannot feed water into the boiler through the float chamber or its connections to the boiler. The water feeding device shall be located to maintain the operating water level.

(b) The electrical circuit shall be connected in such a manner that either low-water fuel cut-off control will shut off the fuel or energy supply to the boiler when a low-water condition develops. One cut-off control shall be set to function ahead of the other.

(1) With a pumped condensate return, functioning of the lower of the two cut-off controls shall cause safety shutdown and lockout. The manual reset may be incorporated in the lower cut-off control. Where a reset device is separate from the low-water fuel cutoff, a means shall be provided to indicate actuation of the low-water fuel cutoff. The manual reset device may be the instantaneous type or may include a time delay of not more than 3 min after the fuel has been cut off.

(2) With gravity condensate return, the lower of the two cut-off controls shall be electrically connected with the upper cutoff to cause a safety shutdown requiring manual reset only when the upper cutoff has failed to function.

(c) The fuel cut-off device may be inserted internally or attached externally to the boiler. An external cut-off device may be attached to piping connecting a water column to the boiler or combined with a water column. Water column piping and connections shall be at least NPS 1. If the lower water fuel cutoff is connected to the boiler by pipe or fittings, no shutoff valves of any type shall be placed in such piping. A cross, or equivalent fitting, shall be placed in the water piping connection at every right angle to facilitate cleaning and inspection. Fuel cut-off devices embodying a separate chamber shall have a vertical drainpipe and blowoff valve, not less than NPS $\frac{3}{4}$, located at the lowest point of the chamber or water-equalizing pipe connections so that the chamber and equalizing pipe can be flushed and the device tested.

(d) A low-water fuel cutoff or combined feeder/cut-off device may also be installed in the tapped openings available for attaching a water gage glass directly to a boiler, provided the connections are made to the boiler with nonferrous tees or wyes not less than NPS $\frac{1}{2}$



between the boiler and water gage glass so that the water gage glass is attached directly and as close as possible to the boiler; the run of the tee or wye shall take the water gage fitting, and the side outlet or branch of the tee or wye shall take the low-water fuel cutoff or combined feeder/cut-off device. The ends of all nipples shall be hollowed to full-size diameter.

(e) A system may incorporate a time delay component with the low-water fuel cut-off device to prevent short cycling. This component shall not constrict any connecting piping, and the time delay shall not exceed the boiler manufacturer's recommended timing or 90 sec, whichever is less. The device shall cut off the fuel or energy supply when the water falls to the lowest visible part of the gage glass.

CW-130 Requirements for Water Level Controls for Hot-Water Heating Boilers

(a) Each automatically fired, hot-water heating boiler, except those installed in residences (as defined by the authority having jurisdiction), shall be protected by a low-water fuel cutoff intended for hot-water service (see also CW-210).

(b) Since there is no normal waterline to be maintained in a hot-water boiler, the low-water fuel cutoff can be located any place above the lowest safe permissible water level established by the boiler manufacturer.

(c) If the low-water fuel cutoff is located in the system piping, it must be ensured that the float chamber will drain properly under a low-water condition, and the installation must be arranged to ensure that if flow occurs in the float chamber, it will be in the upward direction. The low-water fuel cut-off device may be inserted internally or attached externally to the boiler. An external low-water fuel cut-off device attached to the boiler by piping and connections shall be at least NPS 1. If the low-water fuel cutoff is connected to the boiler by pipe or fittings, no shutoff valves of any type shall be placed in such piping. A cross, or equivalent fitting, shall be placed in the water piping connection at every right angle to facilitate cleaning and inspection. Low-water fuel cut-off devices embodying a separate chamber shall have a vertical drainpipe and a blow-off valve not less than NPS $\frac{3}{4}$, located at the lowest point of the chamber of water equalizing pipe connections so that the chamber and equalizing pipe can be flushed and the device tested.

(d) Functioning of the low-water fuel cutoff due to a low-water condition shall cause safety shutdown and lockout. Where a reset device is separate from the low-water fuel cutoff, a means shall be provided to indicate actuation of the low-water fuel cutoff. The manual reset device may be the instantaneous type or may include a time delay of not more than 3 min after the fuel has been cut off.

(e) A means shall be provided for testing the operation of the low-water fuel cutoff without resorting to draining the entire system. Such means shall not render the device inoperable. If the means temporarily isolates the device from the boiler during this testing, it shall automatically return to its normal position.

CW-140 Requirements for Water Level Controls for High-Pressure Steam Boilers

(a) Each automatically fired, high-pressure steam boiler, except miniature boilers, shall have at least two automatic low-water fuel cut-off devices. When installed external to the boiler, each device shall be installed in individual chambers (water columns), which shall be attached to the boiler by separate pipe connections below the waterline. A common steam connection is permissible. Each cut-off device shall be installed to prevent startup and cut off the boiler fuel or energy supply automatically when the surface of the water falls to a level not lower than the lowest visible part of the gage glass. One control shall be set to function ahead of the other. Each miniature boiler shall have at least one low-water fuel cut-off device (see also CW-210).

(b) Functioning of the lower of the two controls shall cause safety shutdown and lockout. The manual reset may be incorporated in the lower cut-off control. Where a reset device is separate from the low-water fuel cutoff, a means shall be provided to indicate actuation of the low-water fuel cutoff. The manual reset device may be of the instantaneous type or may include a time delay of not more than 3 min after the fuel has been cut off.

(c) The fuel cut-off device may be inserted internally or attached externally to the boiler. An external cut-off device may be attached on piping connecting a water column to the boiler or combined with a water column. Water column piping and connections shall be at least NPS 1. If the low-water fuel cutoff is connected to the boiler by pipe or fittings, no shutoff valves of any type shall be placed in such piping. The steam and water connections to a water column shall be readily accessible for internal inspection and cleaning. Some acceptable methods of meeting this requirement are by providing a cross-fitting with a back outlet at each right-angle turn to permit inspection and cleaning in both directions or by using pipe bends or fittings of a type that does not leave an internal shoulder or pocket in the pipe connection and with a radius of curvature that will permit the passage of a rotary cleaner. Fuel cut-off devices embodying a separate chamber shall have a vertical drainpipe and blowoff valve, not less than NPS $\frac{3}{4}$, located at the lowest point of the chamber or water-equalizing pipe connections, so that the chamber and the equalizing pipe can be flushed and the device tested.

(d) A system may incorporate a time delay component with the low-water fuel cut-off device to prevent short cycling. This component shall not constrict any

(09)



connecting piping, and the time delay shall not exceed the boiler manufacturer's recommended timing, or 90 sec, whichever is less. The device shall cut off the fuel or energy supply when the water falls to the lowest visible part of the gage glass.

CW-150 Requirements for Operating and Safety Controls for Electrically Heated Boilers

Electric resistance and electrode boilers shall have a boiler feed control system that shall maintain the operating level in steam boilers and operating water pressure on hot-water boilers. Where uncovering of the electrical element can lead to an unsafe condition, the boiler shall be provided with low-water fuel cutoff(s) in accordance with Part CW. Boiler feed control and low-water fuel cutoff may be common to one control. In the case of electrode-type boilers, where the reduction in water level provides a self-limiting control on input, low-water fuel cut-off controls are not required.

CW-200 AUTOMATIC FUEL CUTOFF FOR FORCED CIRCULATION BOILERS

CW-210 Requirements for Flow or Temperature-Sensing Devices for Forced Circulation Boilers

(a) In lieu of the requirements for low-water fuel cutoffs in CW-100, a water tube or coil-type boiler, requiring forced circulation to prevent overheating and failure of the tubes or coils, shall have an accepted safety control to prevent burner operation at a flow rate inadequate to protect the boiler unit against overheating, at all allowable firing rates. This safety control shall shut down the burner and prevent restarting until an adequate flow is restored. Positive means shall be provided to determine during testing that the accepted safety control has functioned upon an inadequate flow condition. The positive means shall enable the accepted safety control to remain in the running safety lock circuitry during testing. The safety control must be automatically restored to service after completion of system testing.

(b) When there is a definitive waterline, a low-water fuel cutoff complying with the applicable portions of CW-100 shall be provided in addition to the sensing device required in (a) above. Functioning of the low-water fuel cutoff shall cause a safety shutdown and lockout.

CW-300 PRESSURE CONTROLS

CW-310 Requirements for Pressure Controls for Steam Boilers

(a) Each boiler pressure control shall conform to UL 353, Standard for Limit Controls, and shall be accepted by a nationally recognized testing agency.

(b) Each automatically fired steam boiler or system of commonly connected steam boilers shall have at least one steam pressure control device that will shut off the fuel supply to each boiler or system of commonly connected boilers when the steam pressure reaches a preset maximum operating pressure. This requirement does not preclude the use of additional operating control devices where required.

(c) In addition to the pressure control required in (b) above, each individual automatically fired steam boiler shall have a high steam pressure limit control that will prevent generation of steam pressure greater than the maximum allowable working pressure. Functioning of this control shall cause safety shutdown and lockout. The manual reset may be incorporated in the pressure limit control. Where the reset device is separate from the pressure limit control, a means shall be provided to indicate actuation of the pressure limit control. Each limit and operating control shall have its own sensing element and operating switch.

EXCEPTION: Lockout is not required for boiler units installed in residences, as defined by the authority having jurisdiction.

(d) A pressure limit control of the automatic or manual reset type shall be electrically connected in accordance with CE-110(i).

(e) No shutoff valve of any type shall be placed in the steam pressure connection between the boiler and the high-pressure limit control device and steam pressure control device or between the boiler and steam pressure control device.

(f) Each pressure control device shall be protected with a siphon, or equivalent means of maintaining a water seal, that will prevent steam from entering the control. The minimum size of a siphon shall be NPS $\frac{1}{4}$. Tubing suitable for the temperatures and pressures involved, with an inside diameter at least equal to standard pipe sizes, may be substituted for pipe. When a control incorporating a mercury switch is mounted on the siphon, the loop of the siphon shall be in a plane that is 90 deg (1.57 rad) from the plane of the mercury switch.

(g) Steam pressure supply connections to a single pressure control using pipe of nonferrous material shall not be less than NPS $\frac{1}{4}$ for lengths up to and including 5 ft (1.5 m) and not less than NPS $\frac{1}{2}$ for lengths over 5 ft (1.5 m). Tubing suitable for the temperatures and pressures involved, having an inside diameter at least equal to that of standard pipe, may be substituted for pipe.

(h) Steam pressure supply connections to a single pressure control using pipe of ferrous material shall not be less than NPS $\frac{1}{2}$ for lengths up to and including 5 ft (1.5 m) and not less than NPS 1 for lengths over 5 ft (1.5 m). Tubing suitable for the temperatures and pressures involved, having an inside diameter at least equal to that of standard pipe, may be substituted for pipe.



(i) Pressure controls should have separate pressure connections; however, manifolding is permitted. When multiple controls are fed from a manifold, the manifold and common source connection to the boiler, for pipe of nonferrous material, shall not be less than NPS $\frac{1}{2}$ for lengths up to and including 5 ft (1.5 m) and not less than NPS $\frac{3}{4}$ for lengths over 5 ft (1.5 m). For manifolds using ferrous material, the manifold and common source connection to the boiler shall not be less than NPS $\frac{3}{4}$ for lengths up to and including 5 ft (1.5 m) and not less than NPS $1\frac{1}{4}$ for lengths over 5 ft (1.5 m). Individual controls are to be piped from the manifold according to the provisions of CW-310(g) and (h).

(j) The upper set point limit or maximum fixed stop limit of the pressure control selected shall not exceed the maximum allowable working pressure of the boiler.

CW-400 TEMPERATURE CONTROLS

CW-410 Requirements for Temperature Controls for Hot-Water Heating and Supply Boilers

(a) Each temperature control device shall conform to UL 353, Standard for Limit Controls, and shall be accepted by a nationally recognized testing agency.

(b) Each automatically fired, hot-water boiler or each system of commonly connected hot-water boilers shall have at least one temperature-actuated control to shut off the fuel supply when the system water reaches a preset operating temperature. This requirement does not preclude the use of additional operating control devices where required.

(c) In addition to the temperature control required in CW-410(b), each individual automatically fired hot-water boiler unit shall have a high temperature limit control that will prevent the water temperature from exceeding the maximum allowable temperature. The upper set point limit or the maximum fixed stop limit of the selected control shall not exceed the maximum allowable temperature. Functioning of this control shall cause safety shutdown and lockout. The manual reset may be incorporated in the temperature limit control. Where a reset device is separate from the temperature limit control, a means shall be provided to indicate actuation of the temperature limit control. Each limit and operating control shall have its own sensing element and operating switch.

EXCEPTION: Lockout is not required for boiler units installed in residences, as defined by the authority having jurisdiction.

(d) A temperature limit control of the automatic or manual reset type shall be electrically connected in accordance with CE-110(i).

CW-500 SAFETY AND SAFETY RELIEF VALVES

CW-510 Requirements for Steam and Hot-Water Heating Boilers

The safety and safety relief valves of all steam and hot-water heating boilers shall conform to the ASME Boiler and Pressure Vessel Code, Section I or IV, as applicable.

CW-520 Requirements of Hot-Water Supply Boilers

(a) Each hot-water supply boiler shall have at least one officially rated safety relief valve mounted directly on the boiler and set to relieve at or below the maximum allowable working pressure of the boiler. The required steam-relieving capacity in Btu/hr (W) shall equal or exceed the maximum Btu/hr (W) output rating of the boiler.

(b) Each hot-water system consisting of a hot-water supply boiler and hot-water storage tank served by a hot-water supply boiler that is designed to operate at or below 210°F (99°C) shall have a temperature relief valve installed and set to relieve at or below 210°F (99°C). This valve shall be installed either in combination with that required in (a) above or within the top 6 in. (150 mm) of the system's hot-water storage tank.

(c) Safety relief valves shall be installed and tested in accordance with the ASME Boiler and Pressure Vessel Code. Temperature relief valves shall be rated, tested, and installed in accordance with ANSI Z21.22/CSA 4.4 and combination pressure-temperature relief valves in accordance with ANSI Z21.22/CSA 4.4 for temperature and the ASME Boiler and Pressure Vessel Code for pressure.

CW-600 MODULAR BOILERS

CW-610 Water Level Controls for Modular Steam Heating Boilers

Modular steam heating boilers shall comply with CW-120, with the following differences:

(a) Each module shall be equipped with an automatic low-water fuel cutoff.

(b) The assembled modular steam boiler shall have a second low-water fuel cutoff mounted on a water column attached to the manifolds, or may be mounted on one of the modules, where the return piping is below the lowest safe waterline and all modules will drain equally. Operation of this low-water fuel cutoff shall shut off the fuel or energy supply to all modules.

CW-620 Pressure Controls for Modular Steam Heating Boilers

Modular steam heating boilers shall comply with CW-310, with the following differences:

(a) The assembled modular boiler shall have a pressure control that complies with CW-310(c). Operation



of this control shall shut off the fuel or energy supply to all modules.

(b) Each module shall have a pressure control that complies with CW-310(b).

CW-630 Water Level Controls for Modular Hot-Water Boilers

Modular hot-water boilers shall comply with CW-130, with the following differences:

(a) The assembled modular boiler shall be protected by a low-water fuel cutoff located in the system piping such that it will detect a low-water condition before the level falls below the lowest safe waterline in any module.

(b) Operation of the low-water fuel cutoff shall shut off the fuel or energy supply to all modules.

CW-640 Temperature Controls for Modular Hot-Water Heating Boilers

Modular hot-water boilers shall comply with CW-410, with the following differences:

(a) The assembled modular boiler shall have a temperature control that complies with CW-410(c). Operation of this control shall shut off the fuel or energy supply to all modules.

(b) Each module shall have a temperature control that complies with CW-410(b).



Part CF

Combustion Side Control

CF-100 GAS-FIRED BOILER UNITS, EQUIPMENT

CF-110 Burner Assemblies and Boiler Units

- (09) (a) Burner assemblies for boiler units having inputs in excess of 400,000 Btu/hr (117 228 W) shall comply with the provisions of this Part. Burner assemblies, as part of a boiler unit or separately, shall be labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with the standards referenced below. For a burner provided as an integral part of a boiler unit, the label on the boiler unit may serve as evidence that the burner is in compliance.

(1) UL 795, Standard for Commercial-Industrial Gas Heating Equipment

(2) ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers or

(3) ANSI Z21.56/CSA 4.7, Gas-Fired Pool Heaters

(b) Boiler units having inputs of 400,000 Btu/hr (117 228 W) or less, with field-installed gas burner assemblies, and boiler units that do not comply with ANSI Z21.13/CSA 4.9 shall comply with the provisions for purging, safety control timing, action on flame failure, loss of combustion air, combustion air proving, and fuel supervision given in Table CF-1 or CF-2, as applicable.

- (09) (c) Field-installed, oil-fired assemblies having inputs of 400,000 Btu/hr (117 228 W) or less shall be labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complies with ANSI Z21.17/CSA 2.7, Standard for Domestic Gas Conversion Burners. The units on which they are installed shall comply with the provisions of this Standard.

(d) Boilers firing liquefied-petroleum gases or LP-gas air mixtures that do not comply with ANSI Z21.13/CSA 4.9, which are installed indoors, shall be equipped with safety shutoff devices of the complete shutoff type. A safety shutoff device of the complete shutoff type is one that will shut off the gas flow to both the main and pilot burner(s) in the event of main flame, pilot flame, or ignition failure.

(e) The provisions of this Part are intended to apply to equipment supplied with gas pressures not in excess of the following:

(1) 10 psig (69 kPa gage) for boilers firing gas-air mixtures within the flammable range (i.e., 5% to 15% by

volume natural gas in air and 2.15% to 9.6% by volume propane in air)

(2) 20 psig (140 kPa gage) for boilers firing liquefied-petroleum gas

(3) 60 psig (414 kPa gage) for all other boilers

CF-120 Fuel Train

(a) See Nonmandatory Appendix B for typical fuel train diagrams. Fuel train designs, other than those pictured in Nonmandatory Appendix B, but meeting the requirements of this Standard, shall be permitted.

(b) Thread sealing compounds used on threaded joints of gas piping shall be resistant to the action of liquefied-petroleum gases.

CF-130 Filters or Strainers

Fuel cleaning equipment such as filters or strainers are recommended for use in the main gas supply line to the unit.

CF-140 Sediment Traps and Drips

(09)

(a) A sediment trap shall be installed upstream of the gas control(s). When a vertical section of piping supplied by the manufacturer is on the upstream side of the gas control(s), a sediment trap shall be installed. When a vertical section of piping is not supplied, installation instructions supplied by the manufacturer shall specify that a sediment trap be installed as close to the gas control(s) as practical at the time of the boiler's installation.

(b) For other than dry gas conditions, a drip shall be provided at any point in the line of pipe where condensate could collect.

CF-150 Manually Operated Gas Shutoff Valves

(09)

(a) Manually operated main shutoff and pilot shutoff valves shall be ball or lubricated plug type, with stops.

(b) All manually operated valves shall be of the T-handle or lever-handled type with the handle parallel to the gas flow only when in the open position and perpendicular to the gas flow only when in the closed position. The valve shall be accessible, and the handle position shall clearly indicate the "open" and "closed" positions. The handle shall be of adequate size to permit opening and closing the valve without the use of tools. All manually operated shutoff valves shall be maintained and exercised in accordance with the manufacturer's instructions to ensure the valve remains operable without the use of tools.



(09)

Table CF-1 400,000 Btu/hr (117 228 W) and Smaller (Gas — Natural Draft)

Safety Control	Pilot Ignition Gas				
	Continuous Pilot	Intermittent Pilot	Interrupted Pilot	Direct Ignition System	Hot Surface Ignition
Purge requirements [Note (1)]	None	None	None	None	None
Pilot flame-establishing period	None	15-sec maximum	15-sec maximum	15-sec maximum	15-sec maximum
Main burner flame-establishing period	None	None	15-sec maximum	15-sec maximum	15-sec maximum
Flame failure response time [Note (2)]					
Pilot	180-sec maximum	4-sec maximum	4-sec maximum	Not applicable	Not applicable
Main burner	Not applicable	Not applicable	4-sec maximum	4-sec maximum	4-sec maximum
Valve closing time	Not applicable	5-sec maximum after de-energization	5-sec maximum after de-energization	5-sec maximum after de-energization	5-sec maximum after de-energization
Action on pilot flame failure [Note (1)]	Safety shutdown	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Not applicable	Not applicable
Action on main burner flame failure [Note (1)]	Not applicable	Not applicable	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Safety shutdown
Fuel pressure supervision	Not required	Not required	Not required	Not required	Not required

GENERAL NOTE: Timings shown above represent the maximum primary safety control timings permitted by this Standard. The model designation of the installed primary safety control together with the timings shall be provided in the documentation of the burner/boiler.

NOTES:

- (1) After safety shutdown, wait a minimum 5-min time delay before resetting ignition system (instructional requirement).
- (2) If the ignition system includes a relight feature, one relight attempt shall be initiated within 0.8 sec upon loss of flame.

(09)

Table CF-2 400,000 Btu/hr (117 228 W) and Smaller (Power Gas Burners and Mechanical Draft Atmospheric Gas Burners), 3 gph (11.4 L/h) and Smaller (Oil)

Safety Control	Pilot Ignition Gas			Direct Ignition System		Hot Surface Ignition
	Continuous Pilot	Intermittent Pilot	Interrupted Pilot	Gas	Oil	Gas Only
Purge requirements [Note (1)]	None	None	None	None	None	None
Pilot flame-establishing period	None	15-sec maximum	15-sec maximum	Not applicable	Not applicable	Not applicable
Main burner flame-establishing period	None	None	15-sec maximum	15-sec maximum	30-sec maximum	15-sec maximum
Flame failure response time [Note (2)]						
Pilot	180-sec maximum	4-sec maximum	4-sec maximum	Not applicable	Not applicable	Not applicable
Main burner	Not applicable	Not applicable	4-sec maximum	4-sec maximum	30-sec maximum	4-sec maximum
Valve closing time	None	5-sec maximum after de-energization	5-sec maximum after de-energization	5-sec maximum after de-energization	Not applicable	5-sec maximum after de-energization
Action on pilot flame failure	Safety shutdown	Safety shutdown [Note (1)]	Safety shutdown [Note (2)]	Not applicable	Not applicable	Not applicable
Action on main burner flame failure	None	None	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Safety shutdown
Fuel pressure supervision	Not required	Not required	Not required	Not required	Not required	Not required

GENERAL NOTE: Timings shown above represent the maximum primary safety control timings permitted by this Standard. The model designation of the installed primary safety control together with the timings shall be provided in the documentation of the burner/boiler.

NOTES:

- (1) After safety shutdown, wait a minimum 5-min time delay before resetting ignition system (instructional requirement).
 (2) If ignition system includes a relight feature, one relight attempt shall be initiated within 0.8 sec upon loss of flame.

(c) Except as allowed in (d) below, the handle for all manually operated shutoff valves shall be permanently attached.

(d) Where permanently attached handles are not available or where the handle of a manual shutoff valve creates a personnel obstruction or hazard when the valve is in the closed position, a removable handle shall be permitted provided all the following requirements are satisfied:

(1) The handle shall remain installed on the valve at all times when the valve is open.

(2) Following removal, reattachment shall only be possible such that the handle is perpendicular to the gas flow with the valve in the closed position.

(3) Valve position shall be clearly indicated whether the handle is attached or detached.

(4) Upon removal, the valve handle shall be reoriented (turned 180 deg) and reattached to eliminate the personnel obstruction or hazard, or if remaining detached, the valve handle shall be tethered to the gas main no more than 3 ft from the valve in a manner that does not cause personnel safety issues and allows trouble-free reattachment of the handle and operation of the valve without untethering the handle.

(5) A handle tethered in accordance with (4) above shall only be permitted when the line in which the valve is located is tagged/locked out to prevent operation.

(e) A manually operated shutoff valve, as described in (a) through (d) above, shall be provided upstream from all other main gas line controls to isolate the boiler fuel train from the fuel supply. The valve shall be located within 6 ft of the boiler and must be readily accessible from the boiler room floor.

(f) When the pilot gas supply is obtained independently from the main burner fuel supply or upstream of the manual shutoff valve required in (e) above, a manually operated shutoff valve, as described in (a) through (d) above, shall be located in the gas supply line to the pilot burner(s). When the pilot gas supply is obtained downstream of the manual shutoff valve required in (e) above, one or more manual shutoff valves or other means shall be provided as required to permit pilot turndown tests and/or pressurization of the pilot fuel train without pressurizing the main fuel train.

(g) A manually operated shutoff valve, as described in (a) through (d) above, shall be provided after the downstream safety shutoff valve for each fuel train.

CF-160 Gas-Pressure Regulators

- (09) (a) Individual gas-pressure regulators or gas-pressure regulators that are part of a combination valve shall be furnished for both pilot fuel lines (if a pilot is used) and main fuel lines of gas-fired boiler units in accordance with ANSI Z21.78/CSA 6.20, Combination Controls for Gas Appliances. The gas pressure at the outlet of the regulator shall be within $\pm 10\%$ of the regulation set point

at all firing rates. A pressure test port shall be provided to permit measuring the gas pressure to confirm compliance with the requirements of this paragraph.

(b) Gas-pressure regulators incorporating integral vent limiters shall comply with the applicable provisions of ANSI Z21.18/CSA 6.3, Gas Appliance Pressure Regulators.

(c) Second stage gas-pressure regulators on boilers firing liquefied-petroleum gas or LP-gas air mixtures shall comply with UL 144, Standard for LP-Gas Regulating, and shall be installed in accordance with the NFPA 58, Liquefied-Petroleum Gas Code.

CF-161 Overpressure Protection

(a) When the maximum allowable working pressure of any component is less than the gas pressure entering a building, so that failure of a gas system pressure regulator would produce downstream pressures greater than that rating, the downstream piping system shall be provided with overpressure protection.

(b) Gas overpressure protection devices, if required, shall be located upstream of all operating and safety controls and in both the main burner and, if applicable, the pilot burner gas supply system. The gas overpressure protection devices shall be vented to a safe point of discharge, if required.

(c) Refer to CG-210 for additional requirements.

(d) Overpressure protection, if required, may be provided by any of the devices listed in the latest edition of NFPA 54/ANSI Z223.1, National Fuel Gas Code.

CF-162 Pressure Switches

(09)

(a) Gas-pressure supervision shall be provided on gas trains, as specified in Table CF-3 or CF-4, by pressure switches interlocked to accomplish a safety shutdown and lockout in the event of either high or low gas pressure. The pressure switch monitoring high gas pressure shall function to cause safety shutdown and lockout before the manifold gas pressure exceeds 150% of the boiler/burner's main manifold gas pressure. The pressure switch monitoring low gas pressure shall function to cause safety shutdown and lockout before the manifold gas pressure is less than 50% of the boiler/burner's main manifold gas pressure. Pressure test port(s) shall be provided to permit measuring the gas pressure(s) to confirm compliance with the requirements of this paragraph.

(b) Gas-pressure switches shall be labeled and listed by a nationally recognized testing agency.

(c) The low gas-pressure switch shall be located upstream of the safety shutoff valve(s). The high gas-pressure switch shall be located downstream of the gas-pressure regulator and may be located downstream of all main burner gas supply controls. When the low gas-pressure switch is located upstream of the main gas-pressure regulator, the burner shall be labeled and



(09) Table CF-3 Safety Controls for Automatically Fired Units: Power Gas Burners and Mechanical Draft Atmospheric Gas Burners

Safety Control	Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)	Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)	Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)
Purge requirements	Four air changes in 90 sec, or at 60% damper opening, with both damper opening and air flow proven [Note (1)] Air changes to include fire box and boiler passes Instructional requirement: minimum 5-min shutoff before lighting constant pilot	Four air changes at 60% damper opening with both damper opening and air flow proven [Note (1)]	Four air changes at 60% damper opening with both damper opening and air flow proven
Pilot flame type and establishing period			
Continuous	15 sec (initial start only)	Not permitted	Not permitted
Interrupted	15 sec	10 sec	10 sec
Intermittent	15 sec	Not permitted	Not permitted
Main burner ignition type and establishing period	Pilot only: 15-sec maximum if interrupted pilot used Direct ignition system: 4-sec maximum Hot surface ignition system: 4-sec maximum	Interrupted pilot only, 10-sec maximum Direct ignition system: 4-sec maximum [Note (2)] Hot surface ignition system: 4-sec maximum [Note (2)]	Interrupted pilot only, 10-sec maximum
Flame failure response time	4-sec maximum	4-sec maximum	4-sec maximum
Valve closing time	5-sec maximum after de-energization	1-sec maximum	1-sec maximum
Action on flame failure	Safety shutdown and lockout or recycle once	Safety shutdown and lockout	Safety shutdown and lockout
Action on power or control input interruption after safety shutdown and lockout	Manual reset required in accordance with para. CG-610	Manual reset required in accordance with para. CG-610	Manual reset required in accordance with para. CG-610
Proven low fire start	Not required	See para. CF-610	See para. CF-610
Combustion air proving — action on loss of combustion air	Required: safety shutdown and lockout or recycle	Required: safety shutdown and lockout	Required: safety shutdown and lockout
Fuel pressure supervision	Not required for ignition systems with pilots. Required for direct ignition and hot surface ignition systems: high and low gas pressure arranged to cause safety shutdown and lockout.	Required: high and low gas pressure arranged to cause safety shutdown and lockout	Required: high and low gas pressure arranged to cause safety shutdown and lockout

GENERAL NOTE: Timings shown above represent the maximum primary safety control timings permitted by this Standard. The model designation of the installed primary safety control together with the timings shall be provided in the documentation of the burner/boiler.

NOTES:

- (1) For dampers with a fixed mechanical stop, see paras. CF-210(a)(1) and (a)(2).
 (2) Maximum input at light off shall be less than or equal to 2,500,000 Btu/hr (732 678 W).

(09)

Table CF-4 Safety Controls for Automatically Fired Units: Atmospheric Gas Burners — Natural Draft

Safety Control	Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)	Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)	Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)
Purge Requirements	None, if unrestricted air passages; if automatic burner dampers are used, prove open 90-sec Instructional requirement: minimum 5-min complete fuel shutoff period before lighting constant pilot		
Pilot flame type and establishing period			
Continuous	15 sec (initial start only)	10 sec (initial start only)	10 sec (initial start only)
Interrupted	15 sec	10 sec	10 sec
Intermittent	15 sec	10 sec	10 sec
Main burner ignition type and establishing period	Pilot only; 15-sec maximum if interrupted pilot used, Direct ignition system: 4-sec maximum Hot surface ignition system: 4-sec maximum	Interrupted pilot only, 10-sec maximum Direct ignition system: 4-sec maximum [Note (2)] Hot surface ignition system: 4-sec maximum [Note (2)]	Interrupted pilot only; 10-sec maximum
Flame failure response time	4-sec maximum	4-sec maximum	4-sec maximum
Valve closing time	5-sec maximum after de-energization	1-sec maximum	1-sec maximum
Action on flame failure	Safety shutdown and lockout or recycle once	Safety shutdown and lockout	Safety shutdown and lockout
Action on power or control input interruption after safety shutdown and lockout	Manual reset required in accordance with para. CG-610	Manual reset required in accordance with para. CG-610	Manual reset required in accordance with para. CG-610
Proven low fire start	Not required	See para. CF-610	See para. CF-610
Combustion air proving — action on loss of combustion air	Required: safety shutdown and lockout or recycle	Required: safety shutdown and lockout	Required: safety shutdown and lockout
Fuel pressure supervision	Not required for ignition systems with pilots. Required for direct ignition and hot surface ignition systems: high and low gas pressure arranged to cause safety shutdown and lockout.	Required: high and low gas pressure arranged to cause safety shutdown and lockout	Required: high and low gas pressure arranged to cause safety shutdown and lockout

GENERAL NOTE: Timings shown above represent the maximum primary safety control timings permitted by this Standard. The model designation of the installed primary safety control together with the timings shall be provided in the documentation of the burner/boiler.

NOTES:

(1) For dampers with a fixed mechanical stop, see paras. CF-210(a)(1) and (a)(2).

(2) Maximum input at light off shall be less than or equal to 2,500,000 Btu/hr (732 678 W).

listed by a nationally recognized testing agency for this arrangement.

(d) Gas-pressure switches shall be capable of withstanding without damage a pressure of not less than 10% above the relieving pressure of the nearest upstream relief device. Where no relief device is provided, the gas-pressure switches shall be capable of withstanding without damage a pressure of not less than the maximum inlet pressure of the nearest upstream gas-pressure regulator. When the high gas-pressure switch is located downstream of the safety shutoff valve(s), the high gas-pressure switch shall be capable of withstanding without damage a pressure of not less than 50% above its upper set point limit or 5 psig, whichever is greater.

(e) Gas-pressure switches of the automatic or manual reset type shall be electrically connected in accordance with CE-110(i).

CF-170 Control Valves

(a) An automatic input, complete closure, control valve may be combined with a safety shutoff valve.

(b) A bypass to provide for a minimum flame may be installed around a valve used to control input only. A bypass shall not be installed around a safety shutoff valve or a combination input control and safety shutoff valve.

(09) CF-180 Safety Shutoff Valves

(a) Each main burner supply line shall be equipped with a safety shutoff valve(s) that shall comply with the applicable provisions of ANSI Z21.21/CSA 6.5, Automatic Valves for Gas Appliances, ANSI Z21.78/CSA 6.20, Combination Gas Controls for Gas Appliances, or UL 429, Standard for Electrically Operated Valves.

(b) The burner supply line shall be equipped as indicated below for the applicable input classification or any greater input classifications:

(1) For boiler units having inputs less than or equal to 5,000,000 Btu/hr (1 465 356 W), the main burner supply line shall be equipped with at least two safety shutoff valves in series that may be in a single valve body or one safety shutoff valve with a valve seal overtravel (proof of closure) interlock function. If the two safety shutoff valves are in a single valve body, the two safety shutoff valve seats shall be in series and shall have independently operated valve shafts.

(2) For boiler units having inputs greater than 5,000,000 Btu/hr (1 465 356 W) and less than 12,500,000 Btu/hr (3 663 389 W), the main burner supply line shall be equipped with at least two safety shutoff valves in series that may be in a single valve body. At least one of the two safety shutoff valves shall incorporate a valve seal overtravel (proof of closure) interlock function. If the two safety shutoff valves are in a single valve body, the two safety shutoff valve seats shall be in series and shall have independently operated valve shafts. When

the input of a branch gas supply is greater than 2,500,000 Btu/hr (732 678 W), the branch valve requirements are determined by the branch input.

(c) The pilot gas supply line shall be equipped with a safety shutoff valve that shall comply with the applicable provisions of ANSI Z21.21/CSA 6.5, Automatic Gas Valves for Gas Appliances; ANSI Z21.78/CSA 6.20, Combination Gas Controls for Gas Appliances; or UL 429, Standard for Electrically Operated Valves.

(d) Safety shutoff valves shall be labeled and listed by a nationally recognized testing agency.

(e) Safety shutoff valves shall have a shutoff time not to exceed that specified in Table CF-1, CF-2, CF-3, or CF-4.

(f) Safety shutoff valves shall be capable of withstanding, without damage, a pressure of not less than 10% above the set point of the nearest upstream overpressure protection device. In case no overpressure protection device is provided, the safety shutoff valves shall be capable of withstanding, without damage, a pressure of not less than the maximum inlet pressure to the nearest upstream gas-pressure regulator.

(g) A means shall be provided to independently leak test each main burner safety shutoff valve. Where a separate leakage test valve(s) is required to perform the test, the leakage test valve(s) shall be NPS $\frac{1}{8}$ or larger and shall be in accordance with the requirements of CF-150(a) through (d). The outlet of all leak test connections shall be plugged or capped, except when used during testing (see Nonmandatory Appendix B and Part CM).

CF-190 Atmospheric Vents and Gas Vent, Bleed, or Relief Lines

(a) Gas-pressure regulators, including second stage LP-gas-pressure regulators, not incorporating integral vent limiters, pressure interlock switches, and all other valve train components requiring atmospheric air pressure to balance a diaphragm or other similar device, shall be provided with a pipe-threaded connection for the vent line. These lines shall be sized in accordance with the component manufacturer's instructions. For second stage LP-gas-pressure regulators, the relief line shall be at least the same size as the outlet of the pressure-relieving device. Vent and relief lines shall be piped by the installer to the outdoors at a safe point of discharge as determined by the authority having jurisdiction. A means shall be provided at the terminating point to prevent blockage of the line by foreign material, moisture, or insects. Where there is more than one gas-pressure regulator at a location, each gas-pressure regulator shall have a separate vent to the outdoors at a safe point of discharge as determined by the authority having jurisdiction. If approved by the authority having jurisdiction, the vent lines may be manifolded in accordance with accepted engineering practices [see (b) and (c)]



below] to minimize back pressure in the event of diaphragm failure.

(b) Atmospheric vent lines, when manifolded, shall be connected into a common atmospheric vent line having a cross-sectional area not less than the area of the largest vent line plus 50% of the areas of the additional vent lines.

(c) Atmospheric vent lines shall not be connected to any common or manifolded gas vent, bleed, or relief lines.

(d) Gas vent, bleed, or relief lines shall have provisions to be piped by the installer to the outdoors at a safe point of discharge as determined by the authority having jurisdiction. A means shall be provided at the terminal point to prevent stoppage of the lines by foreign material, moisture, or insects. However, a gas bleed line from a diaphragm control valve and vent line from a pressure regulator may be vented to a constant burning pilot. An internal (within the valve) gas bleed line from a diaphragm control valve or combination valve/regulator is allowed, with or without a continuous pilot, if the construction of the valve is such that when a valve is in the closed position, a damaged main diaphragm will not allow gas to flow through the bleed line to the main burner. At locations where gas-pressure regulators might be submerged during floods, a special antiflood-type breather vent fitting shall be installed, or the vent line shall be extended above the height of the expected flood waters.

(e) The bleed line from a diaphragm control valve or a vent line from a pressure regulator to a constant burning pilot shall terminate in burner tips made of metal having a melting point greater than 1,450°F (788°C). These tips shall be located so that the escaping gas will be readily ignited by the pilot flame. Bleed line burners shall be securely held so that the ports are in a fixed position in relation to the pilot flame. A gas-pressure regulator shall not be vented into the boiler flue or exhaust system.

(f) Gas-pressure relief valves may discharge into common manifolding only with other gas vent, bleed, or relief lines. When manifolded, the common vent line shall have a cross-sectional area not less than the area of the largest vent line plus 50% of the areas of the additional vent lines.

CF-200 GAS-FIRED BOILER UNITS, PURGING

CF-210 Preignition Purging (See Table CF-3 or CF-4)

- (09) (a) Power gas burners and mechanical draft atmospheric gas burners shall provide for preignition purging of the combustion chamber and flue passages. The purge shall provide no fewer than either

(1) four air changes, within 90 sec or

(2) four air changes at not less than 60% damper opening with both damper opening and air flow proven

Boiler units less than or equal to 5,000,000 Btu/hr (1 145 356 W) input utilizing burners labeled and listed by a nationally recognized testing agency and designed with a fixed mechanical stop to prevent the damper from going below an air flow rate at least equivalent to that provided for combustion at 60% of the rated high-fire input are exempt from proving damper opening.

(b) Lightoff instructions for boiler units equipped with manually lighted, constant burning pilots shall specify a minimum 5-min complete shutoff period before the pilot is lighted.

(c) Natural draft atmospheric gas burners equipped with an automatically operated air shutter or damper that is closed or positioned to restrict the passage of air when the burner is not firing shall provide means to open such air shutters or dampers to the high-fire position for a period of at least 90 sec immediately before each lightoff cycle is initiated. Compliance with ANSI Z21.13/CSA 4.9 satisfies the intent of this provision.

CF-220 Control

Boiler units having power gas burners or mechanical draft atmospheric gas burners shall comply with one of the following for safety shutdown and lockout, or recycle, as applicable:

(a) recycle is permitted following loss of combustion air for boiler units having inputs greater than 400,000 Btu/hr (117 228 W) and less than or equal to 2,500,000 Btu/hr (732 678 W) or

(b) loss of combustion air shall result in safety shutdown and lockout for boiler units having inputs greater than 2,500,000 Btu/hr (732 678 W)

CF-300 GAS-FIRED BOILER UNITS, SAFETY CONTROLS

CF-310 Primary Safety Control

(a) Each main burner assembly shall be provided with a primary safety control that will deenergize the main gas shutoff valve(s) and shut off pilot fuel upon loss of flame at the point of supervision as specified in CF-330.

(b) The response time of the primary safety control to deenergize or activate the gas shutoff device shall not exceed the values shown in Tables CF-1 through CF-4.

(c) Primary safety controls shall be labeled and listed by a nationally recognized testing agency. (09)

(d) Primary safety controls shall require local manual intervention by an operator or service technician to reset. Devices that can electronically reset without local manual intervention, such as when power or control input to the device is interrupted and then restored, shall not be permitted.

(e) Supervision of the main burner flame alone shall begin at the end of the main burner flame-establishing period for



(1) power gas burners and mechanical draft atmospheric gas burners having inputs greater than 2,500,000 Btu/hr (732 678 W)

(2) all types of burners with modulating or high-low firing having inputs greater than 2,500,000 Btu/hr (732 678 W)

(3) all types of burners with an interrupted pilot(s)

(4) natural draft atmospheric gas burners having inputs greater than 5,000,000 Btu/hr (1 465 356 W)

(f) The main burner flame-establishing period shall not exceed the values shown in Tables CF-1 through CF-4.

(09) CF-320 Automatic Ignition Devices

(a) Automatic ignition devices using pilots shall comply with the following:

(1) Gas to pilots shall be automatically shut off if the pilot is not proved.

(2) The pilot type and flame-establishing period shall meet the provisions shown in Tables CF-1 through CF-4.

(3) The flame failure response time for additional pilots used for smooth lightoff shall not exceed 90 sec.

(b) A single direct ignition or hot surface ignition system may be used on a boiler unit that has a natural draft atmospheric gas burner with a total input less than or equal to 400,000 Btu/hr (117 228 W). This direct ignition or hot surface ignition system shall meet the provisions shown in Table CF-1.

(c) Multiple direct ignition or hot surface ignition systems may be used on a boiler unit that has a natural draft atmospheric gas burner with a total input less than or equal to 2,500,000 Btu/hr (732 678 W) and an input less than or equal to 400,000 Btu/hr (117 228 W) per ignition system. There shall be no interconnection between combustion zones served by separate ignition systems at any point below the draft hood or, if no draft hood is used, below the flue outlet.

Each direct ignition or hot surface ignition system shall meet the provisions shown in Table CF-1.

(d) A direct ignition or hot surface ignition system may be used on a boiler unit that has a power gas burner or mechanical draft atmospheric gas burner with a total input less than or equal to 5,000,000 Btu/hr (1 465 356 W) and a maximum input at ignition less than or equal to 2,500,000 Btu/hr (732 678 W). This direct ignition or hot surface ignition system shall meet the provisions shown in Table CF-3 if the total input is greater than 400,000 Btu/hr (117 228 W). This direct ignition or hot surface ignition system shall meet the provisions shown in Table CF-2 if the total input is less than or equal to 400,000 Btu/hr (117 228 W).

CF-330 Action on Flame Failure (Refer to Tables CF-1 Through CF-4)

Gas-fired boiler units shall comply with one of the following for safety shutdown, lockout, recycle, or relight upon loss of flame as applicable:

(a) Loss of flame for power gas burners and mechanical draft atmospheric gas burners having inputs greater than 400,000 Btu/hr (117 228 W) and less than or equal to 2,500,000 Btu/hr (732 678 W) shall result in a safety shutdown and lockout or recycle.

(b) Loss of flame for power gas burners and mechanical draft atmospheric gas burners having inputs greater than 2,500,000 Btu/hr (732 678 W) shall result in safety shutdown and lockout.

(c) Loss of flame for atmospheric gas burners using natural draft having inputs greater than 400,000 Btu/hr (117 228 W) and less than or equal to 12,500,000 Btu/hr (3 663 389 W) shall result in safety shutdown and lockout, or recycle, after a minimum 5-min time delay.

(d) Loss of pilot flame for gas-fired boilers using natural draft burners and power gas burners with inputs less than or equal to 400,000 Btu/hr (117 228 W) shall result in safety shutdown for a continuous, intermittent, or interrupted pilot. Relight may be applied to the intermittent or interrupted pilot if initiated within 0.8 sec upon loss of pilot flame.

(e) Loss of main flame for gas-fired boilers using natural draft burners and power gas burners with inputs less than or equal to 400,000 Btu/hr (117 228 W) shall result in safety shutdown for interrupted pilot direct ignition or hot surface ignition systems. Relight may be applied to the interrupted pilot or direct ignition system if initiated within 0.8 sec upon loss of flame. (09)

CF-400 OIL-FIRED BOILER UNITS, EQUIPMENT

CF-410 Burner Assemblies

(09)

(a) Burner assemblies that have a maximum nameplate fuel input rating greater than 3 gph (11.4 L/h) shall comply with the provisions of this section. Burner assemblies, as part of a boiler unit or separately, shall be labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction as complying with the standards referenced below. For a burner provided as an integral part of a boiler unit, the label on the boiler unit may serve as evidence that the burner is in compliance.

(1) UL 296, Standard for Oil Burners

(2) UL 726, Standard for Oil-Fired Boiler Assemblies or

(3) UL 2096, Commercial Industrial Gas and/or Oil Burning Assemblies With Emission Reduction Equipment

(b) Boiler units that have fuel input ratings less than or equal to 3 gph (11.4 L/h), with field-installed oil burner assemblies and boiler units that do not comply with UL 726, shall comply with the provisions for purging, safety control timing, action on flame failure, loss of combustion air, combustion air proving, and fuel supervision given in Table CF-2.



(c) Field-installed burner assemblies having inputs of 3 gph (11.4 L/h) or less shall be labeled and listed by a nationally recognized testing agency or other organization that is acceptable to the authority having jurisdiction, as complies with UL 296. The units on which they are installed shall comply with the provisions of this Standard.

CF-420 Fuel Train

See Nonmandatory Appendix B for typical fuel train diagrams.

CF-430 Filters or Strainers

Filters and strainers shall be installed upstream from the safety shutoff valve(s).

CF-440 Relief Valves

(a) A pressure relief valve shall be connected to a fuel line in which pressure greater than system design pressure may build up from the closing of any valve in the burner assembly or from oil heated by a preheater.

(b) The relief line from the relief valve shall discharge into the return line, oil tank, or pump suction line.

CF-450 Pressure and Temperature Switches

(a) All oil supplied to the main burner shall be supervised by a low oil pressure interlock switch for systems greater than 20 gph (75.7 L/h) (except for rotary cup burners), unless the oil pump is integral with the burner's motor shaft, to cause a safety shutdown and lockout if oil pressure falls below the manufacturer's design pressure.

(b) Atomizing media (air or steam) shall be supervised by a low-pressure interlock switch to cause safety shutdown and lockout if atomizing media pressure falls below the manufacturer's design pressure.

(c) A high oil temperature supervisory interlock switch shall be provided for all preheated oil systems to cause a safety shutdown and lockout when the oil temperature exceeds preset limits.

(d) For low oil temperature supervision, an interlock switch shall be provided to cause safety shutdown and allow circulation to reestablish preset oil temperature.

CF-460 Safety Shutoff Valves

(a) Two approved safety shutoff valves or one safety shutoff valve and a nozzle cutoff valve integral to the fuel unit shall be provided. The safety shutoff valves shall conform to UL 429, Standard for Electrically Operated Valves. A nozzle cutoff valve integral to the fuel unit shall conform to UL 343, Standard for Pumps for Oil Burning Appliances.

It is recommended that whenever shutoff valves can trap oil between two valves or between a check valve and safety shutoff valve, a relief valve be used to prevent hydraulic pressure increases in the line, as trapped oil absorbs heat.

(b) A safety shutoff valve responding to pressure variations in a hydraulic or pneumatic remote control system shall close upon failure of pressure in the control system.

(c) The pressure rating of the safety shutoff valve shall not be less than the maximum pump pressure.

(d) Safety shutoff valves shall have a shutoff time not to exceed that shown in Table CF-5.

CF-470 Oil-Fired Boiler Units, Purging (See Table CF-5)

(09)

Oil burners shall provide for purging the firebox and boiler passes as indicated below for the applicable input classification.

(a) for boiler units that have a maximum nameplate fuel input rating greater than 7 gph (26.5 L/h) and less than or equal to 20 gph (75.7 L/h), and where the oil pump is driven independently of the burner fan motor, a preignition purge of no fewer than four air changes — either in 90 sec or at 60% damper opening with both damper opening and air flow proven

Boiler units less than or equal to 5,000,000 Btu/hr input utilizing burners labeled and listed by a nationally recognized testing agency and designed with a fixed mechanical stop to prevent the damper from going below an air flow rate at least equivalent to that provided for combustion at 60% of the rated high-fire input are exempt from proving damper opening.

(b) for boiler units that have a maximum nameplate fuel input rating greater than 20 gph (75.7 L/h)

(1) a preignition purge of no fewer than four air changes at 60% damper opening with both damper opening and air flow proven

(2) a postpurge of 15 sec

Boiler units less than or equal to 5,000,000 Btu/hr input utilizing burners labeled and listed by a nationally recognized testing agency and designed with a fixed mechanical stop to prevent the damper from going below an air flow rate at least equivalent to that provided for combustion at 60% of the rated high-fire input are exempt from proving damper opening.

CF-480 Combustion Air Proving (Refer to Table CF-5)

Oil-fired boiler units having forced or induced draft fans, or both, shall comply with one of the following for safety shutdown and lockout, or recycle, as applicable:

(a) Combustion air proving shall be provided for units having inputs greater than 3 gph (11.4 L/h) [approximately 400,000 Btu/hr (117 228 W)] and less than or equal to 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)], if the fan is not integral with the burner motor shaft.

(b) Loss of combustion air shall result in safety shutdown and lockout, or recycle, for units having inputs greater than 3 gph (11.4 L/h) [approximately 400,000 Btu/hr (117 228 W)] and less than or equal to 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)].



(09)

Table CF-5 Safety Controls for Automatically Fired Units: Oil-Fired Burners

Safety Control	Greater Than 3 gph (11.4 L/h) [approximately 400,000 Btu/hr (117 228 W)] and Less Than or Equal to 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)]	Greater Than 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)]
Purge requirements	When oil pump operates independently of the burner, four air changes in 90 sec or at 60% damper opening, with damper opening and air flow proven if total input is in excess of 7 gph (26.5 L/h) [approximately 1,000,000 Btu/hr (293 071 W)] [Note (1)]	Four air changes at 60% damper opening with both damper opening and air flow proven [Note (1)]
Postpurge	Not required	15-sec minimum
Pilot type and establishing period		
Continuous	Not permitted	Not permitted
Intermittent	Not permitted	Not permitted
Interrupted	10-sec maximum if pilot is used	Required: 10-sec maximum Exception: see Note (2)
Main burner ignition type and establishing period	Interrupted pilot, 15-sec maximum Intermittent direct ignition system, 15-sec maximum Interrupted direct ignition system, 15-sec maximum	Interrupted pilot only Exception: see Note (2) Nos. 2 and 4 oil — 10-sec maximum Nos. 5 and 6 oil — 15-sec maximum
Flame failure response time	Intermittent direct ignition system, greater than 3 and less than or equal to 7 gph (11.4 L/h to 26.5 L/h), 15-sec maximum Intermittent direct ignition system, greater than 7 and less than or equal to 20 gph (26.5 L/h to 75.7 L/h), 4-sec maximum Interrupted pilot or direct ignition system, greater than 3 and less than or equal to 20 gph (11.4 L/h to 75.7 L/h), 4-sec maximum	4-sec maximum
Valve closing time	5-sec maximum after de-energization	1-sec maximum
Action of flame failure	Safety shutdown and lockout or recycle once [Note (3)]	Safety shutdown and lockout
Proven low fire start	Not required	See para. CF-610
Combustion air proving — action on loss of combustion air	Required if fans not integral with burner motor shaft; safety shutdown and lockout or recycle	Required: safety shutdown and lockout
Fuel pressure supervision	Not required	Required if oil pump not integral with burner motor shaft (see para. CF-450)
Low atomizing media supervision	Required unless atomization by air pump integral with burner motor shaft [see para. CF-450(b)]	Required [see para. CF-450(b)]
Oil temperature supervision	High and low temperature supervision required on preheated oil. Excess temperature shall cause safety shutdown and lockout.	High and low temperature supervision required on preheated oil. Excess temperature shall cause safety shutdown and lockout.

GENERAL NOTE: Timings shown above represent the maximum primary safety control timings permitted by this Standard. The model designation of the installed primary safety control together with the timings shall be provided in the documentation of the burner/boiler.

NOTES:

- (1) For dampers with a fixed mechanical stop, see paras. CF-470(a) and (b)(1).
- (2) With proven low fire start at a low fire input rate of not more than 20 gph (75.7 L/h), interrupted pilot or direct ignition system allowed. Main burner establishing period: 15-sec maximum
- (3) Recycle permitted when a maximum 4-sec flame failure response time is used.

(c) Loss of combustion air shall result in safety shutdown and lockout for units having inputs greater than 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)].

CF-500 OIL-FIRED BOILER UNITS, SAFETY CONTROLS

CF-510 Primary Safety Control

(a) Each main burner assembly shall be equipped with a primary safety control that will deenergize the shutoff means upon loss of flame at the point of supervision.

(b) The response time of the primary safety control to deenergize or deactivate the shutoff device shall not exceed the values shown in Table CF-5.

(09) (c) Primary safety controls shall be labeled and listed by a nationally recognized testing agency.

(d) The main burner flame-establishing period shall not exceed the values shown in Table CF-5.

(e) Primary safety controls shall require local manual intervention by an operator or service technician to reset. Devices that can electrically reset without local manual intervention, such as when power or control input to the device is interrupted and then restored, shall not be permitted.

CF-520 Automatic Ignition Devices

(a) Where automatically ignited pilots are used, the pilot flame shall be proved prior to energizing the main fuel supply means. Fuel to pilots shall be automatically shut off if the pilot is not proved.

(b) The pilot type and flame-establishing period shall meet the provisions shown in Table CF-5.

(c) The application of direct spark ignition systems is limited to boiler units having initial inputs less than or equal to 20 gph (75.7 L/h).

(d) The fuel train to pilots shall meet the applicable provisions of this Standard.

CF-530 Action on Flame Failure (Refer to Tables CF-2 and CF-5)

Loss of main flame shall result in safety shutdown for all oil-fired boiler units. In addition, oil-fired boiler units shall also comply with one of the following for relight, recycle, or lockout as applicable:

(a) Relight, if initiated within 0.8 sec upon loss of flame, is permitted for units having inputs less than or equal to 3 gph (11.4 L/h) [approximately 400,000 Btu/hr (117 228 W)] and using an interrupted pilot or direct ignition system.

(b) Lockout is required for units having inputs greater than 3 gph (11.4 L/h) [approximately 400,000 Btu/hr (117 228 W)] and less than or equal to 20 gph (75.7 L/h). However, recycle is permitted, if a maximum 4-sec flame failure response time is used.

(c) Lockout is required for units having inputs greater than 20 gph (75.7 L/h) [approximately 2,800,000 Btu/hr (820 599 W)].

CF-600 LOW FIRE START, GAS- OR OIL-FIRED BOILER UNITS

CF-610 Low Fire Start

(09)

Boiler units having inputs greater than 2,500,000 Btu/hr (732 678 W) (gas-fired) or a maximum nameplate fuel input rating greater than 20 gph (75.7 L/h) (oil-fired) shall be equipped with an interlocked damper to provide for low fire starts. However, boiler units that are labeled and listed by a nationally recognized testing agency shall be accepted without such interlocking controls.

CF-700 COMBINATION GAS- AND OIL-FIRED UNITS

CF-710 Burner Assemblies

(09)

Burner assemblies having gas inputs greater than 400,000 Btu/hr (117 228 W) and oil inputs that have a maximum nameplate fuel input rating greater than 3 gph (11.4 L/h) shall comply with the provisions of Part CF. Burner assemblies, as part of a boiler unit or separately, shall be labeled and listed by a nationally recognized testing agency or other certifying organization that is acceptable to the authority having jurisdiction as complying with

(a) UL 795, Standard for Commercial-Industrial Gas Heating Equipment

(b) UL 296, Standard for Oil Burners or UL 726, Standard for Oil-Fired Boiler Assemblies

CF-800 ELECTRICALLY HEATED BOILERS

CF-810 General

Electrically heated boilers for steam or hot-water service in sizes greater than 115 kW (approximately 400,000 Btu/hr) shall comply with the following provisions:

(a) Electric resistance-type boilers shall be listed by a nationally recognized testing agency as complying with UL 834, Standard for Heating, Water Supply, and Power Boilers — Electric.

(b) Electrode-type boilers shall be designed for single-phase, three-wire or three-phase, four-wire operation and shall conform to the requirements of NFPA 70, National Electrical Code.

CF-900 COMBUSTION SIDE CONTROLS FOR MODULAR BOILERS

CF-910 Gas Modular Boilers

(09)

The modules of gas modular boilers shall comply with CG-140(a).

Boiler units with field-installed gas burner assemblies and boiler units that do not comply with ANSI Z21.13/



CSA 4.9 shall comply with the provisions for purging, safety control timing, action on flame failure, loss of combustion air, combustion air proving, and fuel supervision given in Table CF-1 or CF-2, as applicable.

(09) CF-920 Oil Modular Boilers

The modules of oil modular boilers shall comply with CG-140(b).

Boiler units with field-installed oil burner assemblies and boiler units that do not comply with UL 726 shall comply with the provisions for purging, safety control timing, action on flame failure, loss of combustion air, combustion air proving, and fuel supervision given in Table CF-5.

CF-930 Electric Modular Boilers

(09)

The modules of electric modular boilers shall comply with CG-140(c).



NONMANDATORY APPENDIX A

COMPARISON OF THIS STANDARD AND ANSI Z21.13/CSA 4.9

Where permitted in CSD-1, boilers listed and labeled as in compliance with ANSI Z21.13/CSA 4.9 meet the requirements of this Standard when additional trim equipment is installed.

ANSI Z21.13/CSA 4.9 is a performance-based standard for gas-fired, low-pressure steam and hot water boilers that requires testing and design certification of boiler burner units by an approved testing laboratory. One of the major differences between the two standards is the automatic ignition, maximum safety control timing table. The ignition timing table as shown in Z21.13/CSA 4.9 reflects a wide range of ignition controls and timing sequences. This permits the greatest flexibility in design parameters; however, all boiler burner units must comply with the performance tests to obtain certification. These performance tests include testing under normal and abnormal operating conditions (e.g., delayed ignition, temperature ranges, voltage variations, etc.). As a result, most boiler burner units listed as in compliance with Z21.13/CSA 4.9 generally have shorter ignition timings than the maximum times allowed by Z21.13/CSA 4.9. All boiler burner units listed and

labeled under Z21.13/CSA 4.9 must be accompanied with installation instructions referring the installer to CSD-1 where jurisdictions require that the installation conform to this Standard. The instructional requirements of Z21.13/CSA 4.9 are a mandatory part of the standard.

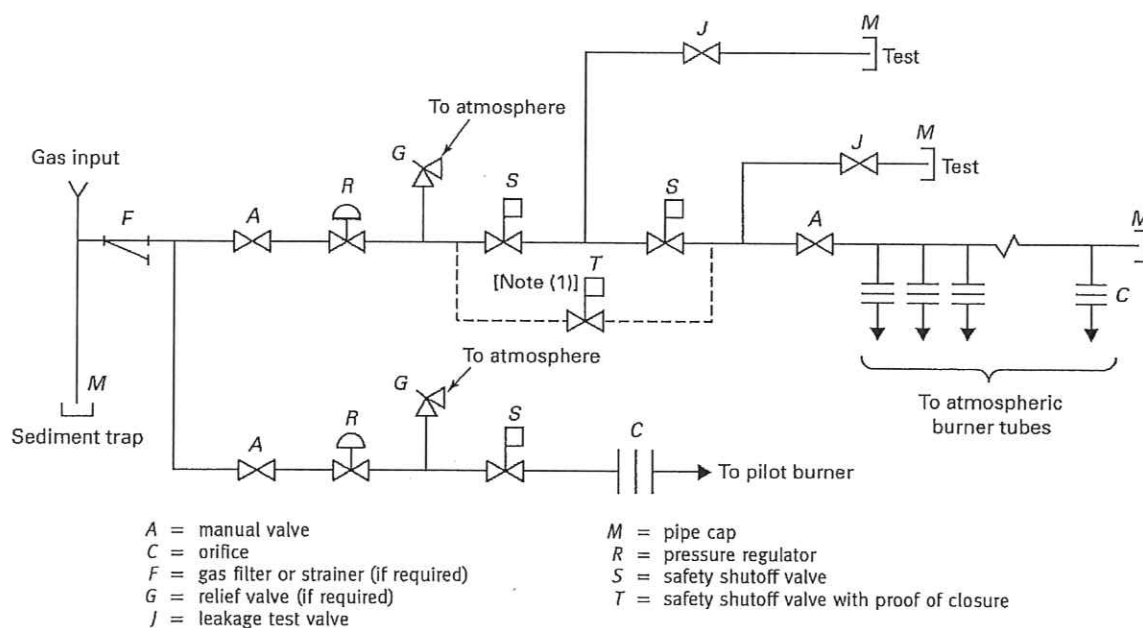
CSD-1 is a design-based standard for controls and safety devices for automatically fired boilers, which includes high- and low-pressure boilers that are gas, oil, or electrically fired. The automatic ignition, maximum safety control timings are generally shorter, as no laboratory certification testing of the boiler unit is required. CSD-1 requires the manufacturers of controls and safety devices to provide detailed instructions for testing, maintenance, and service procedures of controls and safety devices installed on boiler units covered by this Standard. CSD-1 requires the operation of control systems and safety devices be tested by the installing contractor prior to release to the owner/user. All controls and safety devices covered by CSD-1 must be accepted and listed for the intended service by a nationally recognized testing agency, such as, but not limited to, CSA, FM, or UL.



NONMANDATORY APPENDIX B

TYPICAL FUEL TRAINS

Fig. B-1 Typical Atmospheric Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)]



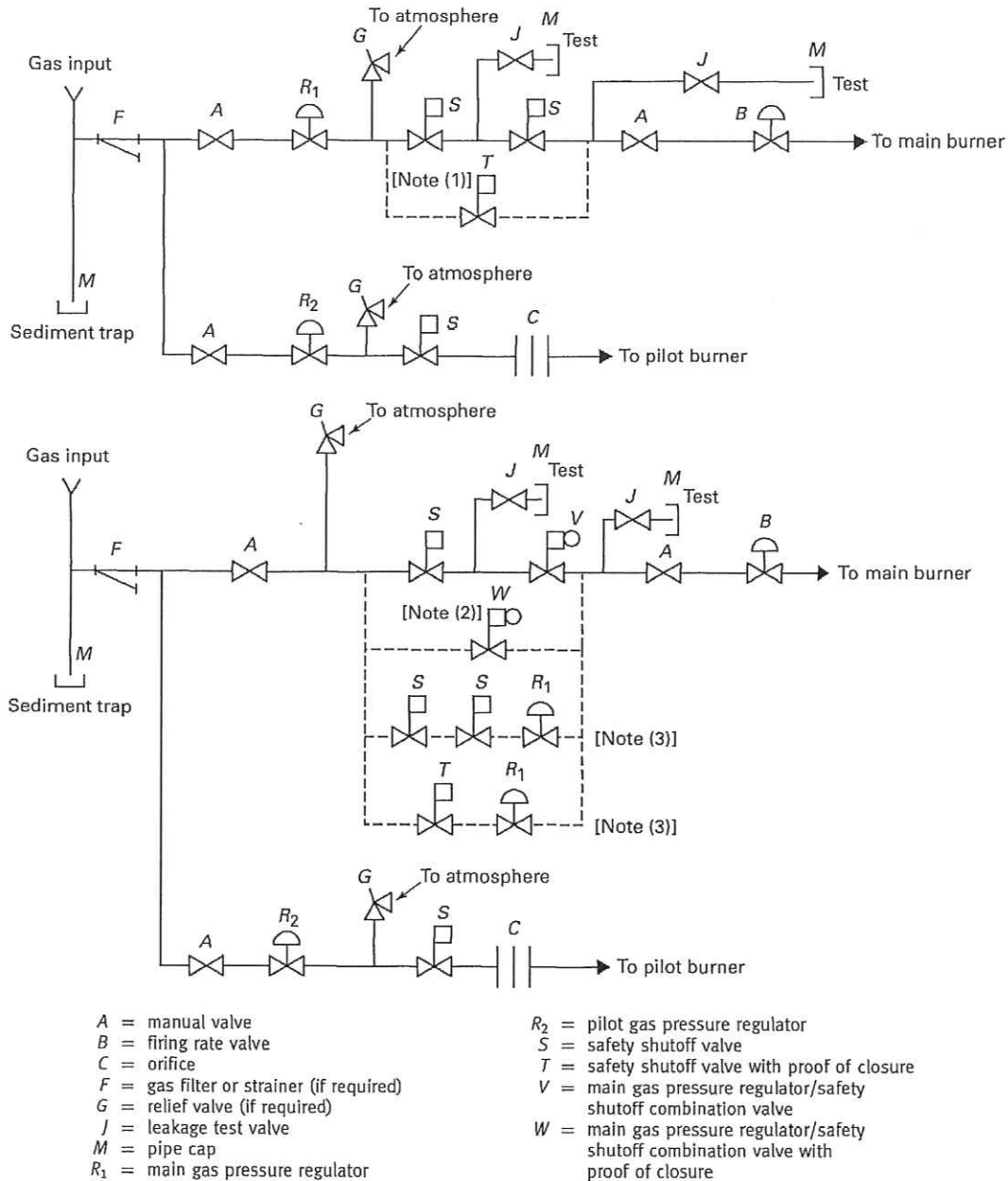
GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired, Low-Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished. This Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTE:

(1) Alternate arrangement — T may be used in place of two S-type valves.



Fig. B-2 Typical Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)]



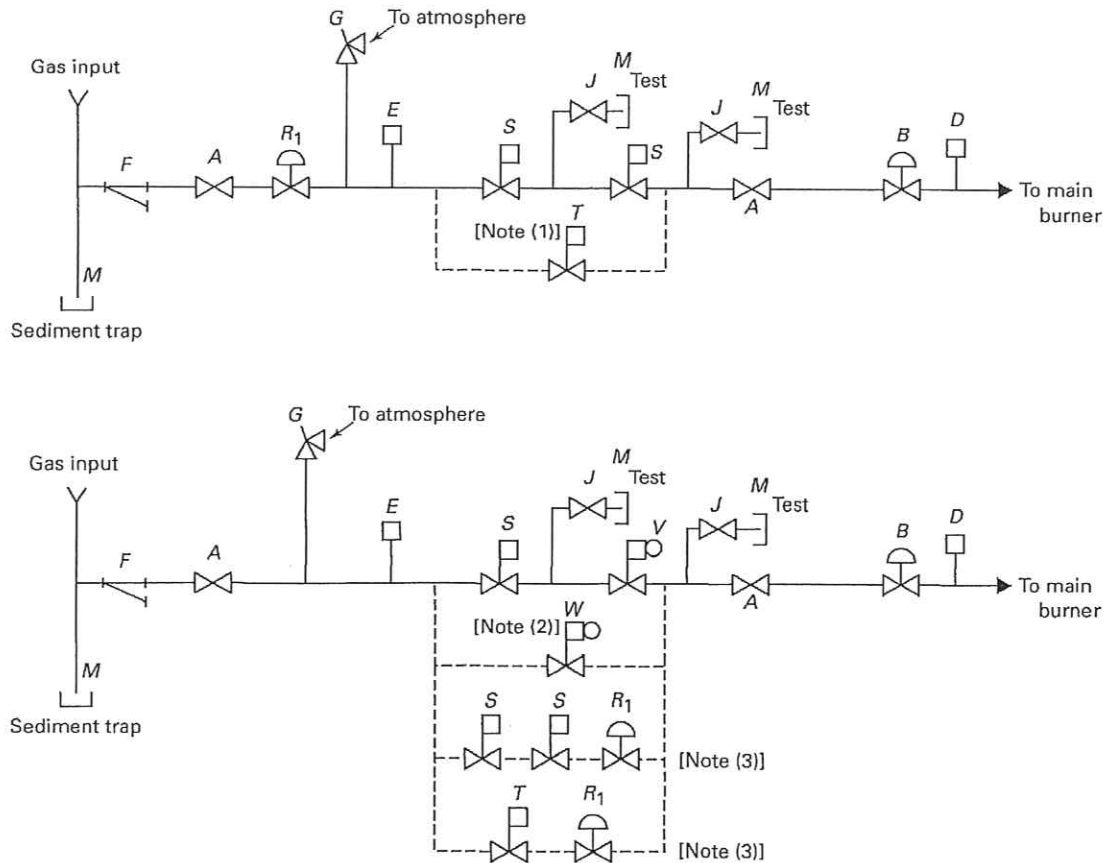
GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired, Low-Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished. This Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:

- (1) Alternate arrangement — T may be used in place of two S-type valves.
- (2) Alternate arrangement — W may be used in place of an S- and V-type valve.
- (3) Alternate arrangement — R₁ may be downstream of two S-type valves or a T-type valve.



Fig. B-3 Typical Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)] Direct Ignition System



- | | |
|--|--|
| A = manual valve | R ₁ = main gas pressure regulator |
| B = firing rate valve | R ₂ = pilot gas pressure regulator |
| C = orifice | S = safety shutoff valve |
| D = high gas pressure switch | T = safety shutoff valve with proof of closure |
| E = low gas pressure switch | V = main gas pressure regulator/safety shutoff combination valve |
| F = gas filter or strainer (if required) | W = main gas pressure regulator/safety shutoff combination valve with proof of closure |
| G = relief valve (if required) | |
| J = leakage test valve | |
| M = pipe cap | |

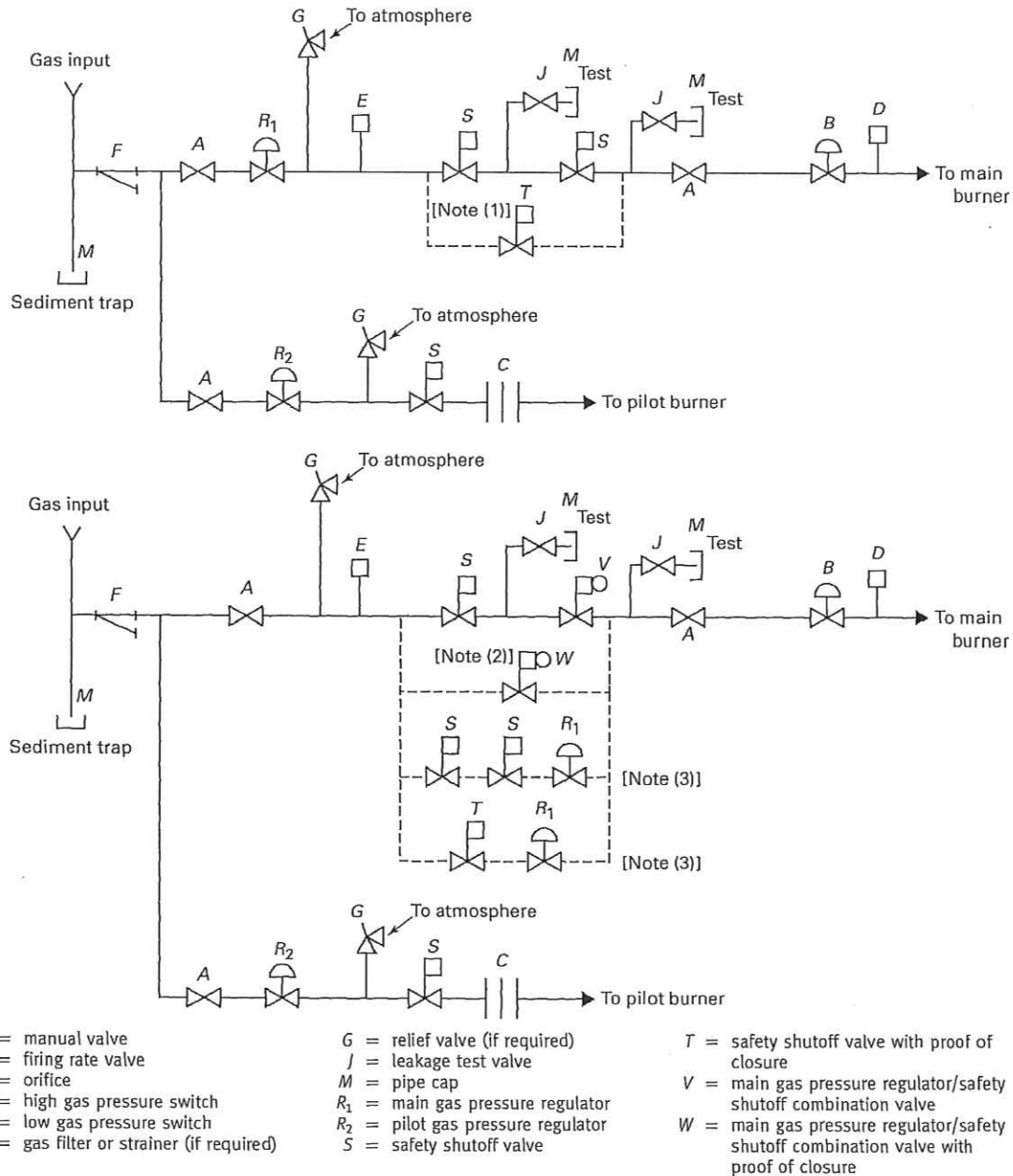
GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired, Low-Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished. This Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:

- (1) Alternate arrangement — T may be used in place of two S-type valves.
- (2) Alternate arrangement — W may be used in place of an S- and V-type valve.
- (3) Alternate arrangement — R₁ may be downstream of two S-type valves or a T-type valve.



Fig. B-4 Typical Gas Fuel Train [Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)]



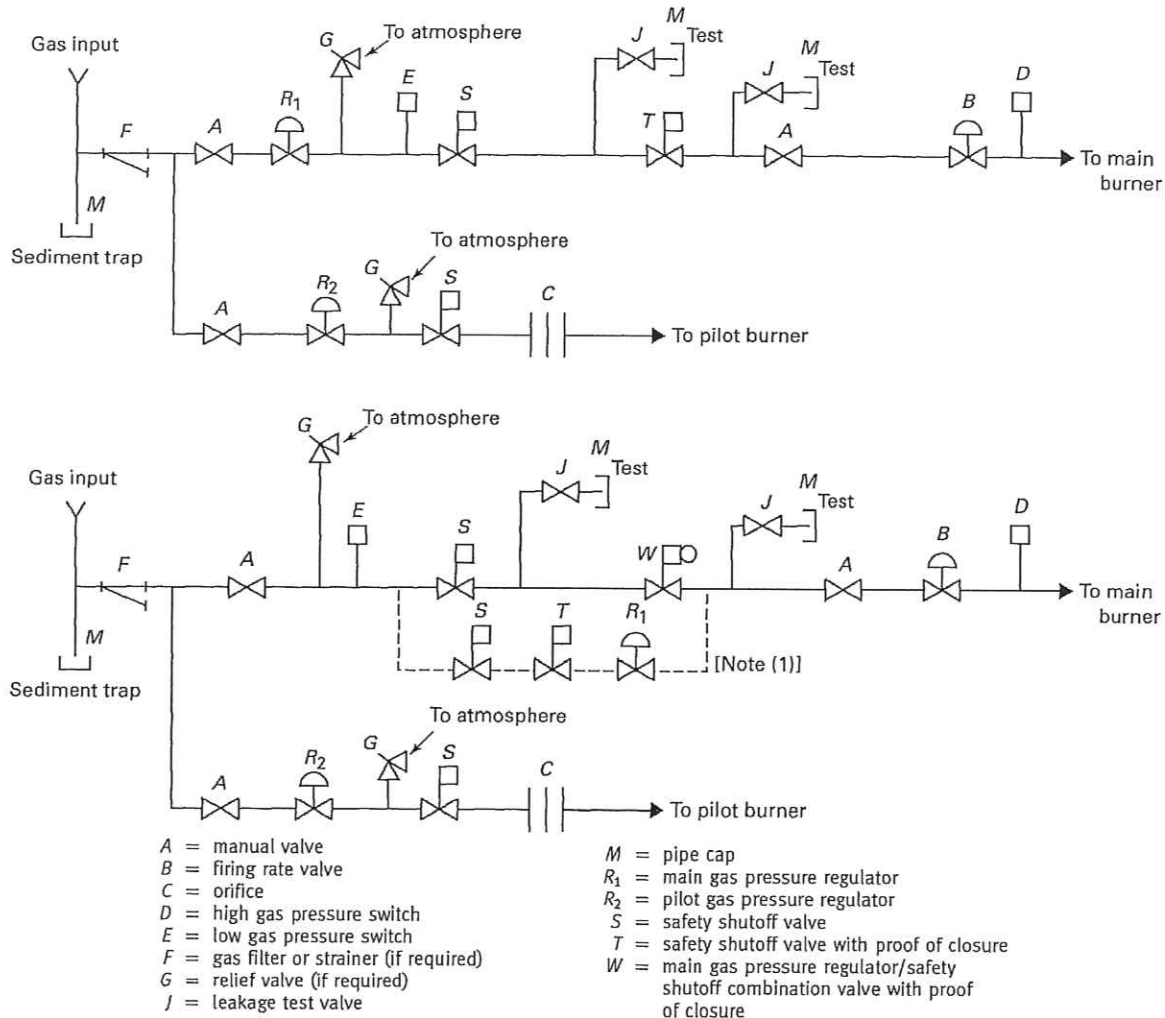
GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired, Low-Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished. This Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:

- (1) Alternate arrangement — T may be used in place of two S-type valves.
- (2) Alternate arrangement — W may be used in place of an S- and V-type valve.
- (3) Alternate arrangement — R₁ may be downstream of two S-type valves or a T-type valve.



Fig. B-5 Typical Gas Fuel Train [Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)]

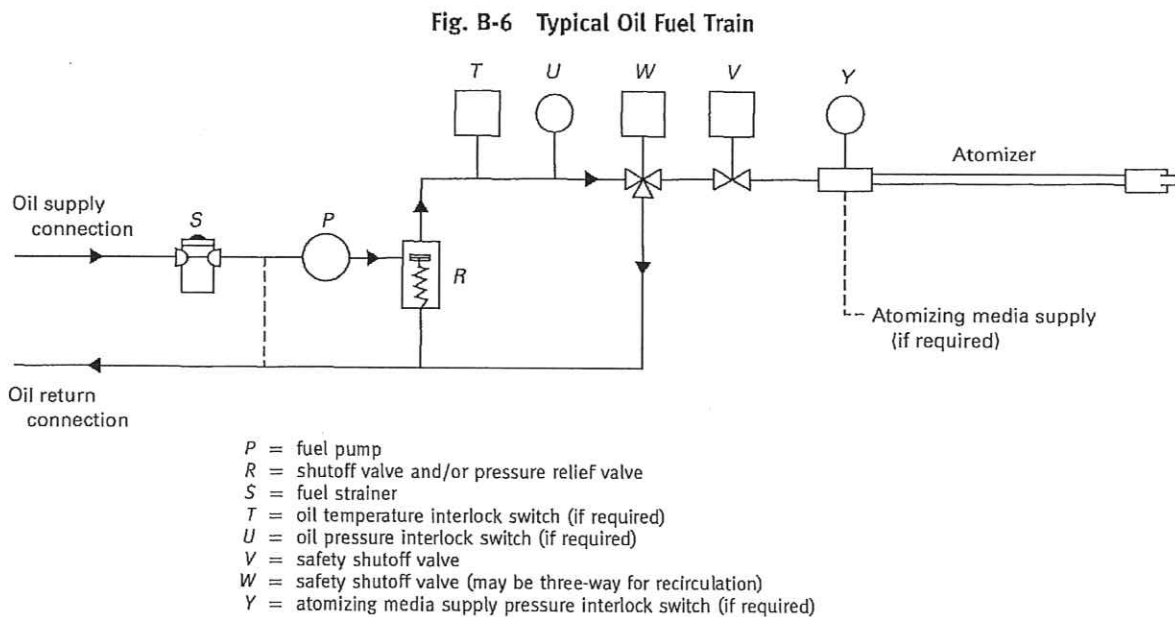


GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired, Low-Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished. This Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTE:

(1) Alternate arrangement — R₁ may be downstream of an S- and T-type valve.





NONMANDATORY APPENDIX C

MANUFACTURER'S/INSTALLING CONTRACTOR'S REPORT FOR ASME CSD-1

(09)

Certification and Reporting (CG-500) for Controls and Safety Devices

(This Form is a guideline and not part of ASME CSD-1-2009.)

Unit Manufacturer

Name _____

Address _____

Zip _____

Telephone _____

Fax _____

Unit Identification (Boiler)

Manufacturer's Model # _____

Year Built _____

ASME Section I _____

Section IV _____

Nat. Bd. # _____

UL # _____

CSA # _____

Jurisdiction _____

Steam

Hot Water

Maximum W.P. _____

psig

Maximum W.P. _____

psig

Minimum Safety Valve Cap. _____

PPH

Maximum Temp. _____

°F

Minimum Safety Relief Valve Cap. _____

PPH or Btu

Boiler Unit Description (type) _____

If Modular (no. of modules) _____

Boiler Unit Capacity (output) _____

Burner

Manufacturer _____

Model _____

UL or CSA # _____

Serial # _____

Fuels (as shipped) _____

Indicate Units (where not applicable, indicate "N/A")

Gas Manifold Pressure _____

Oil Nozzle/Delivery Pressure (at maximum input) _____

High Gas Pressure Switch Setting _____

Low Oil Pressure Switch Setting _____

Installation Location (if known)

Customer Name _____

Address _____

City _____

State _____

Zip _____

Telephone _____

Fax _____



Certification and Reporting (CG-500) for Controls and Safety Devices (Cont'd)

(This Form is a guideline and not part of ASME CSD-1-2009.)

Control/Device	Manufacturer	Model #	Operational Test Performed, Date
Operating Controls			
Low-Water Fuel Cutoff CW-120(a), CW-140			
Forced Circulation CW-210(a)			
Steam Pressure CW-310(b)			
Water Temperature CW-410(b)			
Safety Controls			
Low-Water Fuel Cutoff CW-120(a), CW-120(b) CW-130, CW-140			
Forced Circulation CW-210(b)			
High Steam Pressure Limit CW-310(c)			
High Water Temperature Limit CW-410(b)			
Fuel Safety Shutoff Valve, Main CF-180(b)(2), CF-180(b)(3)			
Pilot Safety Shutoff Valve CF-180(c)			
Atomizing Medium Switch CF-450(b)			
Combustion Air Switch CF-220			
High Gas Pressure CF-162			
Low Gas Pressure CF-162			
Low Oil Pressure CF-450(a)			
High Oil Temperature CF-450(c)			
Low Oil Temperature CF-450(d)			
Purge Air Flow CF-210			
Flame Safeguard (Primary) CF-310, CF-320			
Flame Detector CF-310, CF-320			
Low Fire Start			
Low-Fire Start Switch CF-610			
Safety or Safety Relief Valve(s)			
CW-510, CW-520			



Certification and Reporting (CG-500) for Controls and Safety Devices (Cont'd)
(This Form is a guideline and not part of ASME CSD-1-2009.)

Manufacturer _____ Operational Test Performed, Date _____ / _____ / _____

Model _____

Size _____

Capacity _____ PPH/Btu/hr

Representing Equipment Manufacturer, Name _____

Signature _____ Date _____

Representing Installing Contractor, Name _____

Signature _____ Date _____



NONMANDATORY APPENDIX D

RECOMMENDED PREVENTIVE MAINTENANCE SCHEDULE

(Operation and maintenance instructions in this safety standard are intended for general applications. For specific operating and maintenance instructions, consult the equipment manufacturer.)

D-1 DAILY

- (a) Check gages, monitors, and indicators.
- (b) Check instrument and equipment settings.
- (c) For high-pressure boilers, test low-water fuel cut-off device and alarm.
- (d) Check burner flame.

D-2 WEEKLY

- (a) For low-pressure boilers, test low-water fuel cut-off device and alarm.
- (b) Check igniter.
- (c) Check flame signal strength.
- (d) Check flame failure detection system.
- (e) Check firing rate control.
- (f) Make aural and visual check of pilot and main fuel valves.

D-3 MONTHLY

- (a) Check flue, vent, stack, or outlet dampers.
- (b) Test low draft, fan air pressure, and damper position interlocks.
- (c) Check low-fire start interlock.
- (d) Test high and low oil pressure and temperature interlocks.
- (e) Test high and low gas pressure interlocks.

D-4 SEMI-ANNUALLY

- (a) Recalibrate all indicating and recording gages.
- (b) For steam boilers, perform a slow drain test of the low-water fuel cut-off device.
- (c) Check flame failure detection system components.
- (d) Check firing rate control.
- (e) Check piping and wiring of all interlocks and shut-off valves.
- (f) Inspect burner components.

D-5 ANNUALLY

- (a) Flame failure detection system, pilot turndown test.

(b) Flame failure detection system, test for hot refractory hold in.

(c) Check dual fuel change over control.

(d) Test high-limit and operating temperature or steam pressure controls.

(e) Replace vacuum tubes, scanners, or flame rods in accordance with manufacturer's instructions.

(f) Conduct a combustion test.

(g) Check all coils and diaphragms; test other operating parts of all safety shutoff and control valves.

(h) Test fuel valve interlock switch in accordance with manufacturer's instructions.

(i) Perform leakage test on pilot and main gas and/or oil fuel valves.

(j) Test purge air switch in accordance with manufacturer's instructions.

(k) Test air/steam interlock in accordance with manufacturer's instructions.

(l) Test burner position interlock in accordance with manufacturer's instructions.

(m) Test rotary cup interlock in accordance with manufacturer's instructions.

(n) Test low-fire start interlock in accordance with manufacturer's instructions.

D-6 AS REQUIRED

(a) Recondition or replace low-water fuel cut-off device.

(b) For oil-fired burners, clean atomizers and oil strainers.

(c) For gas-fired burners, check sediment trap and gas strainers.

(d) Flame failure detection system, pilot turndown test.

(e) Flame failure detection system, test for hot refractory hold in.

(f) Test safety/safety relief valves in accordance with ASME Boiler and Pressure Vessel Code, Sections VI and VII.



Table D-1 Periodic Testing Recommended Checklist (See Manufacturer's Instructions)

Frequency [Note (1)]						Component/Item	Recommended Test	Accomplished By	
D	W	M	S/A	A	A/R			Boiler Operator	Service Technician
X	...	...	...	...	...	Gages, monitors, and indicators	Make visual inspection and record readings in boiler log.	X	...
...	...	...	X	...	...	Gages, monitors, and indicators	Recalibrate all indicating and recording gages.	...	X
X	...	...	...	...	...	Instrument and equipment settings	Make visual check against factory-recommended specifications.	X	...
X	...	...	...	...	...	Low-water fuel cut-off device (high-pressure boilers)	Test low-water fuel cut-off device according to manufacturer's instructions.	X	...
...	X	...	...	...	...	Low-water fuel cut-off device (low-pressure boilers)	Test low-water fuel cut-off device according to manufacturer's instructions.	X	...
...	...	...	X	...	...	Low-water fuel cut-off device (steam boilers)	For steam boilers, perform a slow drain test in accordance with ASME Boiler and Pressure Vessel Code, Section VI.	...	X
...	...	...	...	...	X	Low-water fuel cut-off device	Recondition or replace low-water fuel cut-off device.	...	X
...	...	...	...	X	...	Operating and/or limit controls	Test high-limit and operating temperature or steam pressure controls.	...	X
...	...	...	...	...	X	Safety/safety relief valves	Test safety/safety relief valves in accordance with ASME Boiler and Pressure Vessel Code, Sections VI and VII.	...	X
...	...	X	...	...	...	Flue, vent, stack, or outlet dampers	Make visual inspection of linkage, and check for proper operation.	X	...
X	...	...	...	...	...	Burner flame	Make visual inspection of burner flame [Note (2)].	X	...
...	X	...	...	...	...	Igniter	Make visual inspection, and check flame signal strength if meter-fitted.	X	...
...	X	...	...	...	...	Flame signal strength	If flame signal meter is installed, read and log. For both pilot and main flames, notify service organization if readings are very high, very low, or fluctuating (refer to manufacturer's instructions).	X	...
...	X	...	...	...	...	Flame failure detection system	Close manual fuel supply for (1) pilot, (2) main fuel cock, and/or (3) valve(s). Check safety shutdown timing, and log.	X	...

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Table D-1 Periodic Testing Recommended Checklist (Cont'd)

Frequency [Note (1)]						Component/Item	Recommended Test	Accomplished By	
D	W	M	S/A	A	A/R			Boiler Operator	Service Technician
...	...	...	X	...	...	Flame failure detection system	Check flame failure detection system components, such as vacuum tubes, amplifier, and relays.	...	X
...	...	...	...	X	...	Flame failure detection system	Replace vacuum tubes, scanners, or flame rods in accordance with manufacturer's instructions.	...	X
...	...	...	...	X	X	Flame failure detection system (pilot turndown test)	Conduct pilot turndown test according to manufacturer's instructions. This test is required annually and after any adjustments to flame scanner mount or pilot burner.	...	X
...	...	...	...	X	X	Flame failure detection system (hot refractory hold in test)	Test for hot refractory hold in. This test is required annually and after any adjustments to the flame scanner mount or pilot burner.	...	X
...	X	...	...	...	...	Firing rate control	Check firing rate control, and verify factory settings (refer to manufacturer's instructions).	X	...
...	...	...	X	...	...	Firing rate control	Check firing rate control, and verify factory settings (refer to manufacturer's instructions).	...	X
...	...	...	...	X	...	Firing rate control	Conduct a combustion test, and verify settings are in accordance with manufacturer's instructions.	...	X
...	X	...	...	...	...	Pilot and/or main fuel valves	Open limit switch, and make aural and visual check. Check valve position indicators, and check fuel meters if so fitted.	X	...
...	...	...	...	X	...	Pilot and/or main fuel valves	Check all coils and diaphragms. Test other operating parts of all safety shutoff and control valves.	...	X
...	...	...	...	X	...	Pilot and/or main fuel valves	Test fuel valve interlock switch in accordance with manufacturer's instructions.	...	X
...	...	...	...	X	...	Pilot and/or main fuel valves	Perform leakage test on pilot and main gas and/or oil fuel valves, in accordance with manufacturer's instructions.	...	X
...	...	X	...	...	...	Low draft, fan, air pressure, and damper position interlocks	Test low draft, fan, air pressure, and damper position interlocks according to manufacturer's instructions.	X	...
...	...	...	...	X	...	Low draft, fan, air pressure, and damper position interlocks	Test purge switch in accordance with manufacturer's instructions.	...	X

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Table D-1 Periodic Testing Recommended Checklist (Cont'd)

Frequency [Note (1)]						Component/Item	Recommended Test	Accomplished By	
D	W	M	S/A	A	A/R			Boiler Operator	Service Technician
...	...	X	...	...	...	Low-fire start interlock	Check low-fire start interlock according to manufacturer's instructions.	X	...
...	...	...	...	X	...	Low-fire start interlock	Test low-fire start interlock in accordance with manufacturer's instructions.	...	X
...	...	X	...	...	...	Oil pressure and temperature interlocks	Test high and low oil pressure and temperature interlocks according to manufacturer's instructions.	X	...
...	...	X	...	...	...	Gas pressure interlocks	Test high and low gas pressure interlocks according to manufacturer's instructions.	X	...
...	...	...	X	...	...	Interlocks and valves	Check piping and wiring of all interlocks, and shutoff valves.	...	X
...	...	...	...	X	...	Atomizing air/steam interlock	Test air/steam interlock in accordance with manufacturer's instructions.	...	X
...	...	...	...	X	...	Burner position interlock	Test burner position interlock in accordance with manufacturer's instructions.	...	X
...	...	...	...	X	...	Rotary cup burner interlock	Test rotary cup interlock in accordance with manufacturer's instructions.	...	X
...	...	...	X	...	...	Burner components	Inspect burner components according to manufacturer's instructions.	...	X
...	...	...	...	X	X	Burner components	Check dual fuel change over control. If automatically controlled by gas utility, perform test under the supervision of gas utility.	...	X
...	...	...	...	...	X	Burner components	For oil-fired burners, clean atomizers and oil strainers.	...	X
...	...	...	...	...	X	Burner components	For gas-fired burners, check sediment trap and gas strainer.	...	X

NOTES:

(1) D, daily; W, weekly; M, monthly; S/A, semi-annually; A, annually; A/R, as-required.

(2) Caution should be used when viewing burner flame. Personal protective equipment, such as filtered eyewear, may be necessary.

NONMANDATORY APPENDIX E REFERENCES

The following is a list of standards referenced in this Standard.

ANSI Z21.13-2005/CSA 4.9-2005, Gas-Fired, Low-Pressure Steam and Hot Water Boilers¹

ANSI Z21.17-1998/CSA 2.7-M98, Domestic Gas Conversion Burners¹

ANSI Z21.18-2000/CSA 6.3-2000, Gas Appliance Pressure Regulators (including all addenda issued)¹

ANSI Z21.21-2005/CSA 6.5-2005, Automatic Valves for Gas Appliances¹

ANSI Z21.22-1999 (R2004)/CSA 4.4-M99, Relief Valves for Hot Water Supply Systems¹

ANSI Z21.56-2001/CSA 4.7-2001, Gas-Fired Pool Heaters (including all addenda issued)¹

ANSI Z21.78-2005/CSA 6.20-2005, Combination Gas Controls for Gas Appliances¹

Publisher: CSA International, 8501 East Pleasant Valley Road, Cleveland, OH 44131

2007 ASME Boiler and Pressure Vessel Code (including all addenda issued)

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300

ASTM D 396-02, Standard Specification for Fuel Oils

¹ May also be obtained from the American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036.

Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959

NFPA 31-2001, Standard for the Installation of Oil-Burning Equipment

NFPA 54/ANSI Z223.1-2006, National Fuel Gas Code¹

NFPA 58-2004, Liquefied Petroleum Gas Code

NFPA 70-2005, National Electrical Code

NFPA 85-2004, Boiler and Combustion Systems Hazards Code

Publisher: National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471

UL 144-1999, Standard for LP-Gas Regulators

UL 296-2003, Standard for Oil Burners

UL 343-1997, Standard for Pumps for Oil-Burning Appliances

UL 353-1994, Standard for Limit Controls

UL 429-1999, Standard for Electrically Operated Valves

UL 506-2000, Standard for Specialty Transformers

UL 726-1995, Standard for Oil-Fired Boiler Assemblies

UL 795-1999, Standard for Commercial-Industrial Gas Heating Equipment

UL 814-2004, Gas-Tube-Sign Cable

UL 834-2004, Standard for Heating, Water Supply, and Power Boilers — Electric

Publisher: Underwriters Laboratories, Inc. (UL), 333 Pfingsten Road, Northbrook, IL 60062-2096



(09)

NONMANDATORY APPENDIX F

GUIDANCE FOR THE USE OF U.S. CUSTOMARY AND SI UNITS IN CSD-1

F-1 USE OF UNITS IN EQUATIONS

It is the responsibility of the individual and organization performing calculations to ensure that appropriate units are used. Either U.S. Customary or SI¹ units may be used as a consistent set. When necessary to convert from one system of units to another, the units shall be converted to at least three significant figures for use in calculations and other aspects of construction.

F-2 GUIDELINES USED TO DEVELOP SI EQUIVALENTS

The following guidelines were used to develop SI equivalents:

(a) SI units are placed in parentheses after the U.S. Customary units in the text.

(b) In general, separate SI tables are provided if interpolation is expected. The table designation (e.g., table number) is the same for both the U.S. Customary and SI tables, with the addition of suffix "M" to the designator for the SI table, if a separate table is provided. In the text, references to a table use only the primary table number (i.e., without the "M"). For some small tables, where interpolation is not required, SI units are placed in parentheses after the U.S. Customary unit.

(c) Separate SI versions of graphical information (charts) are provided, except that if both axes are dimensionless, a single figure (chart) is used.

(d) In most cases, conversions of units in the text were done using hard SI conversion practices, with some soft conversions on a case-by-case basis, as appropriate. This was implemented by rounding the SI values to the number of significant figures of implied precision in the existing U.S. Customary units. For example, 3,000 psi has an implied precision of one significant figure. Therefore, the conversion to SI units would typically be to 20 000 kPa. This is a difference of about 3% from the "exact" or soft conversion of 20 684.27 kPa. However,

the precision of the conversion was determined by the committee on a case-by-case basis. More significant digits were included in the SI equivalent if there was any question.

(e) Minimum thickness and radius values that are expressed in fractions of an inch were generally converted according to the following table:

Fraction, in.	Proposed SI Conversion, mm	Difference, %
$\frac{1}{32}$	0.8	-0.8
$\frac{3}{64}$	1.2	-0.8
$\frac{1}{16}$	1.5	5.5
$\frac{3}{32}$	2.5	-5.0
$\frac{1}{8}$	3	5.5
$\frac{5}{32}$	4	-0.8
$\frac{3}{16}$	5	-5.0
$\frac{7}{32}$	5.5	1.0
$\frac{1}{4}$	6	5.5
$\frac{5}{16}$	8	-0.8
$\frac{3}{8}$	10	-5.0
$\frac{7}{16}$	11	1.0
$\frac{1}{2}$	13	-2.4
$\frac{9}{16}$	14	2.0
$\frac{5}{8}$	16	-0.8
$\frac{11}{16}$	17	2.6
$\frac{3}{4}$	19	0.3
$\frac{7}{8}$	22	1.0
1	25	1.6

(f) For nominal sizes that are in even increments of inches, even multiples of 25 mm were generally used. Intermediate values were interpolated, rather than converting and rounding to the nearest millimeter. See examples in the following table [Note that this table does not apply to nominal pipe sizes (NPS), which are covered below.]:

Size, in.	Size, mm
1	25
$1\frac{1}{8}$	29
$1\frac{1}{4}$	32
$1\frac{1}{2}$	38
2	50
$2\frac{1}{4}$	57
$2\frac{1}{2}$	64
3	75
$3\frac{1}{2}$	89
4	100
$4\frac{1}{2}$	114
5	125
6	150
8	200

¹ The International System of Units, universally abbreviated SI (from the French *Le Système International d'Unités*), is the modern metric system of measurement. The SI was established in 1960 by the 11th General Conference on Weights and Measures (CGPM, *Conférence Générale des Poids et Mesures*). The CGPM is the international authority that ensures wide dissemination of the SI and modifies the SI as necessary to reflect the latest advances in science and technology.



Size, in.	Size, mm
12	300
18	450
20	500
24	600
36	900
40	1 000
54	1 350
60	1 500
72	1 800

Size of Length, ft	Size of Length, m
3	1
5	1.5
200	60

(g) For nominal pipe sizes, the following relationships were used:

U.S. Customary Practice	SI Practice	U.S. Customary Practice	SI Practice
NPS $\frac{1}{8}$	DN 6	NPS 20	DN 500
NPS $\frac{1}{4}$	DN 8	NPS 22	DN 550
NPS $\frac{3}{8}$	DN 10	NPS 24	DN 600
NPS $\frac{1}{2}$	DN 15	NPS 26	DN 650
NPS $\frac{3}{4}$	DN 20	NPS 28	DN 700
NPS 1	DN 25	NPS 30	DN 750
NPS $1\frac{1}{4}$	DN 32	NPS 32	DN 800
NPS $1\frac{1}{2}$	DN 40	NPS 34	DN 850
NPS 2	DN 50	NPS 36	DN 900
NPS $2\frac{1}{2}$	DN 65	NPS 38	DN 950
NPS 3	DN 80	NPS 40	DN 1000
NPS $3\frac{1}{2}$	DN 90	NPS 42	DN 1050
NPS 4	DN 100	NPS 44	DN 1100
NPS 5	DN 125	NPS 46	DN 1150
NPS 6	DN 150	NPS 48	DN 1200
NPS 8	DN 200	NPS 50	DN 1250
NPS 10	DN 250	NPS 52	DN 1300
NPS 12	DN 300	NPS 54	DN 1350
NPS 14	DN 350	NPS 56	DN 1400
NPS 16	DN 400	NPS 58	DN 1450
NPS 18	DN 450	NPS 60	DN 1500

(h) Areas in square inches (in^2) were converted to square millimeters (mm^2), and areas in square feet (ft^2) were converted to square meters (m^2). See examples in the following table:

Area (U.S. Customary)	Area (SI)
1 in^2	650 mm^2
6 in^2	4 000 mm^2
10 in^2	6 500 mm^2
5 ft^2	0.5 m^2

(i) Volumes in cubic inches (in^3) were converted to cubic millimeters (mm^3), and volumes in cubic feet (ft^3) were converted to cubic meters (m^3). See examples in the following table:

Volume (U.S. Customary)	Volume (SI)
1 in^3	16 000 mm^3
6 in^3	100 000 mm^3
10 in^3	160 000 mm^3
5 ft^3	0.14 m^3

(j) Although the pressure should always be in MPa for calculations, there are cases where other units are used in the text. For example, kPa is used for small pressures. Also, rounding was to one significant figure (two at the most) in most cases. See examples in the following table (Note that 14.7 psi converts to 101 kPa, while 15 psi converts to 100 kPa. While this may seem at first glance to be an anomaly, it is consistent with the rounding philosophy):

Pressure (U.S. Customary)	Pressure (SI)
0.5 psi	3 kPa
2 psi	15 kPa
3 psi	20 kPa
10 psi	70 kPa
14.7 psi	101 kPa
15 psi	100 kPa
30 psi	200 kPa
50 psi	350 kPa
100 psi	700 kPa
150 psi	1 MPa
200 psi	1.5 MPa
250 psi	1.7 MPa
300 psi	2 MPa
350 psi	2.5 MPa
400 psi	3 MPa
500 psi	3.5 MPa
600 psi	4 MPa
1,200 psi	8 MPa
1,500 psi	10 MPa

(k) Material properties that are expressed in psi or ksi (e.g., allowable stress, yield and tensile strength, elastic modulus) were generally converted to MPa to three significant figures. See example in the following table:

Strength (U.S. Customary)	Strength (SI)
95,000 psi	655 MPa

(l) In most cases, temperatures (e.g., for PWHT) were rounded to the nearest 5°C . Depending on the implied precision of the temperature, some were rounded to the nearest 1°C or 10°C or even 25°C . Temperatures colder than 0°F (negative values) were generally rounded to the nearest 1°C . The examples in the following table were created by rounding to the nearest 5°C , with one exception:



Temperature, °F	Temperature, °C
70	20
100	38
120	50
150	65
200	95
250	120
300	150
350	175
400	205
450	230
500	260
550	290
600	315
650	345
700	370
750	400
800	425
850	455
900	480
925	495
950	510
1,000	540
1,050	565
1,100	595
1,150	620
1,200	650
1,250	675
1,800	980
1,900	1 040
2,000	1 095
2,050	1 120

F-3 SOFT CONVERSION FACTORS

The following table of "soft" conversion factors is provided for convenience. Multiply the U.S. Customary

value by the factor given to obtain the SI value. Similarly, divide the SI value by the factor given to obtain the U.S. Customary value. In most cases, it is appropriate to round the answer to three significant figures.

U.S. Customary	SI	Factor	Notes
in.	mm	25.4	...
ft	m	0.3048	...
in. ²	mm ²	645.16	...
ft ²	m ²	0.09290304	...
in. ³	mm ³	16,387.064	...
ft ³	m ³	0.02831685	...
U.S. gal	m ³	0.003785412	...
U.S. gal	liters	3.785412	...
psi	MPa	0.0068948	Used exclusively in equations
	(N/mm ²)		
psi	kPa	6.894757	Used only in text and for nameplate
in. WC	kPa	0.249089	...
psi	bar	0.06894757	...
ft-lb	J	1.355818	...
°F	°C	$\frac{5}{9} \times (°F - 32)$	Not for temperature difference
°F	°C	$\frac{5}{9}$	For temperature differences only
R	K	$\frac{5}{9}$	Absolute temperature
lbm	kg	0.4535924	...
lbf	N	4.448222	...
in.-lb	N-mm	112.98484	Use exclusively in equations
ft-lb	N-m	1.3558181	Use only in text
Btu/hr	W	0.29230711	Use for boiler rating and heat transfer
lb/ft ³	kg/m ³	16.018463	...



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ASME CSD-1 INTERPRETATIONS VOLUME 14

Replies to Technical Inquiries
June 2008 Through September 2008

FOREWORD

This publication includes written replies issued in the year indicated by the secretary, speaking for the ASME CSDAFB Committee, to inquiries concerning interpretations of technical aspects of ASME CSD-1.

These replies are taken verbatim from the original replies except for a few typographical corrections and some minor editorial corrections made for the purpose of improved clarity. In some few instances, a review of the interpretation may reveal a need for corrections of a technical nature; in these cases, a corrected interpretation will immediately follow the original reply.

These interpretations were prepared in accordance with the accredited ASME procedures. ASME procedures provide for reconsideration of these interpretations when or if additional information is available that the inquirer believes might affect the interpretation. Further, persons aggrieved by this interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.



ASME CSD-1 INTERPRETATIONS

Interpretation: 09-01

Subject: CSD-1-2006, para. CF-120(a)

Date Issued: June 11, 2008

Question: Does para. CF-120(a) recommending fuel train design (specifically, Fig. B-3) supersede para. CF-162(c) indicating the location of the low gas-pressure switch?

Reply: No.

Interpretation: 09-02

Subject: CSD-1-2006, para. CF-162(d)

Date Issued: July 9, 2008

Question: Does a high gas-pressure switch located on the manifold between the blower and burner meet the intent of para. CF-162(c)?

Reply: No.

Interpretation: 09-03

Subject: CSD-1-2006, Exclusions

Date Issued: September 26, 2008

Question (1): Are low-pressure steam boilers constructed to ASME Boiler and Pressure Vessel Code, Section IV that typically supply steam for ovens and unfired steam-jacked kettles used in the preparation of food within the scope of CSD-1-2006?

Reply (1): Yes.

Question (2): Are electrically heated or gas-fired jacketed steam kettles constructed to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 that comply with Mandatory Appendix 19 within the scope of CSD-1-2006?

Reply (2): No (see definition of *boiler*).



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88-1	6/28/88	Gas train	1982	CF-180, Fig. CF-1	...
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89-1	9/20/89	Modular boilers	1988	CW-120, CR	2
89-2	9/20/89	Safety shutdown	1984	CF-220, Table CF-1	2
89-3	9/20/89	Safety shutdown	1984	CW-120, CR	2
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This list of interpretations refers to the following CSD-1 editions:

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1b addenda	Issued December 1, 1990	1b addenda	Issued November 30, 2001
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**Boiler and
Combustion Systems
Hazards Code**

2015



3.3.132.8 Safety Shutoff Valve (Safety Trip Valve). A fast-closing valve that automatically shuts off the gaseous or liquid fuel supply in response to a normal, emergency, or safety shutdown signal.

3.3.132.9 Supervisory Shutoff Valve. In a gaseous or liquid fuel system, a manually operated shutoff valve with a means to provide a "valve closed" position signal.

3.3.132.10 Vent Valve. A valve used to allow venting of air or gas from the system to the atmosphere.

3.3.133 Valve-Proving System. In a gaseous or liquid fuel system, a system that proves the leak tightness of all safety shutoff valves and prevents main burner or igniter light-off if the test is not satisfied.

3.3.134 Volatile Matter. The portion of mass, except water vapor, that is driven off in a gaseous form when solid fuels are heated.

Chapter 4 Fundamentals

4.1* Manufacture, Design, and Engineering.

4.1.1 The owner or the owner's representative shall, in cooperation with the manufacturer, ensure that the unit is not deficient in apparatus that is necessary for operation with respect to pressure parts, fuel-burning equipment, air and fuel metering, light-off, and maintenance of stable flame.

4.1.2 All fuel systems shall include provisions to prevent foreign substances from interfering with the fuel supply.

4.1.3* An evaluation shall be made to determine the optimum integration of manual and automatic safety features.

4.1.4* Unattended and Off-Site Operation. Unattended operation, no operator at the operating location(s), or operation of the plant from an off-site operating location shall be approved and shall require a process hazard analysis (PHA) except as allowed by Section 5.3.

4.1.5 The burner or fuel feed piping and equipment shall be designed, constructed, and located to prevent the formation of hazardous concentrations of combustibles under normal operating conditions.

4.1.6* The installation of boilers or HRSGs, including the burners or fuel feed piping and equipment, in accordance with the requirements of this code shall not in and of itself determine the electrical classification.

4.1.7 Burners and associated equipment shall be accessible for maintenance.

4.2 Installation and Commissioning.

4.2.1 The boiler, heat recovery steam generator (HRSG), combustion turbine exhaust system, or pulverized fuel system shall not be released for operation before the installation and checkout of the required safeguards and instrumentation system have been successfully completed.

4.2.2 The party responsible for the erection and installation of the equipment shall ensure that all pertinent apparatus is installed and connected in accordance with the system design.

4.2.3 The owner or owner's representative, the engineering consultant, the equipment manufacturer, and the operating

company shall prohibit operation until the safeguards have been tested for correct operation as a system.

4.2.3.1 If temporary interlocks and instrumentation are necessary to meet these requirements, any such temporary system shall be reviewed by the purchaser, the engineering consultant, the equipment manufacturer, and the operating company, and agreement shall be reached on the system's ability to protect equipment and personnel in advance of start-up.

4.2.3.2 All temporary modifications shall be documented, and permanent resolutions shall be accomplished prior to commercial operation.

4.2.4 The interlock system and protective devices shall be tested jointly by the organization responsible for the system design and by those who operate and maintain such a system and devices.

4.2.5 After installation but before initial operation, coordinated tests of all systems shall be accomplished.

4.2.6 Documentation of the plant equipment, the system, and maintenance activities shall be updated to reflect changes in the status of equipment and operating procedures.

4.2.7* Each time fuel gas is introduced to a fuel gas supply piping system containing air or inert gas upstream of the equipment isolation valve, the source of fuel gas in the piping system upstream of the equipment isolation valve shall be confirmed to be in compliance with the applicable evacuation/purging and charging requirements in NFPA 54 or NFPA 56.

4.2.8* When fuel gas is introduced into piping downstream of the equipment isolation valve, the contents shall be displaced in accordance with one of the following:

- (1) Discharged through a permanently installed venting system; or
- (2) Discharged into the boiler or HRSG in accordance with the normal startup sequence; or
- (3) Purged into service in accordance with Chapter 7 of NFPA 56

4.3 Coordination of Design, Construction, and Operation.

4.3.1* During the planning and engineering phases of plant construction, the design shall be coordinated with operating personnel.

4.3.2* The integration of the various components, including boiler or HRSG, burner, fuel and air supply equipment, controls, interlocks and safety devices, operator and maintenance functions, and communication and training, shall be the responsibility of the owner and the operating company.

4.4* Maintenance, Inspection, Training, and Safety.

4.4.1 Maintenance and Equipment Inspection. See also Annex H.

4.4.1.1* A program shall be provided for inspection and maintenance of equipment at intervals consistent with the type of equipment used, service requirements, and manufacturers' recommendations.

4.4.1.2 As a minimum, the maintenance program shall include the following:

- (1) Inspections to identify conditions that need corrective action
- (2) Planning for making repairs or modifications using qualified personnel and tools and instruments designed for the work
- (3) Equipment history and record of dates of service, conditions found, maintenance performed, and changes made

- (4) Written comprehensive maintenance procedures incorporating the manufacturer's instructions to define the tasks and skills required
- (5) Nondestructive examination requirements; tasks needing special tools; special environmental factors such as temperature limitations, dusts, contaminated or oxygen-deficient atmospheres, and limited access or confined space restrictions
- (6) Equipment condition assessment before and after maintenance
- (7) Supply of spare parts to perform required maintenance
- (8) Housekeeping essential for prevention of fires or explosions that includes the following:
 - (a) Provisions for cleaning of horizontal ledges or surfaces of buildings and equipment to prevent the accumulation of dust deposits greater than the minimum required to create an explosion hazard
 - (b) Water washing or vacuum cleaning methods to reduce the possibility of creating dust clouds
 - (c) Prohibition of the use of compressed air for cleaning

4.4.1.3* Operation, set points, and adjustments shall be verified by testing at specified intervals, and the results shall be documented.

4.4.1.4* Defects shall be reported and corrected, and the changes or repairs documented.

4.4.1.5 System configuration, including logic, set points, and sensing hardware, shall not be changed without detailed engineering review and documentation.

4.4.1.6 System operation shall be tested and verified for compliance with the design criteria whenever a controller is replaced, repaired, reprogrammed, or updated before returning it to service.

4.4.1.7 When a unit that fires liquid fuel is out of service and available for inspection, personnel shall check for any accumulation of unburned fuel in the boiler or HRSG enclosure, especially in the fin-tube area of a HRSG.

4.4.2 Purging Fuel Gas Piping Into and Out of Service.

4.4.2.1 Prior to the opening of fuel gas piping systems for maintenance, the piping section shall be isolated from the fuel gas supply, and the fuel gas piping system downstream of the equipment isolation valve shall be purged out of service in accordance with Chapter 8 of NFPA 56.

4.4.2.2 Following maintenance, fuel gas shall be introduced into piping downstream of the equipment isolation valve in accordance with 4.2.8.

4.4.3 Training.

4.4.3.1 Operator Training.

4.4.3.1.1* The owner or the owner's representative shall be responsible for establishing a formal training program that is consistent with the type of equipment and hazards involved to prepare personnel to operate equipment.

4.4.3.1.2 Operating procedures shall be established that cover normal and emergency conditions.

4.4.3.1.2.1 Start-up, shutdown, and lockout procedures shall all be covered in detail.

4.4.3.1.2.2 Where different modes of operation are possible, procedures shall be prepared for each operating mode.

4.4.3.1.2.3 Procedures also shall be prepared for switching from one mode to another.

4.4.3.1.3 The owner or owner's representative shall verify that operators are trained and competent to operate the equipment under all conditions prior to their operation of such equipment.

4.4.3.1.4 The owner or owner's representative shall be responsible for retraining operators, including reviewing their competence, at intervals determined by the owner.

4.4.3.1.5 The training program and operating and maintenance manuals shall be kept current with changes in equipment and operating procedures and shall be available for reference and use at all times.

4.4.3.1.6 Operating procedures shall be directly applicable to the equipment involved and shall be consistent with safety requirements and the manufacturer's recommendations.

4.4.3.2 Maintenance Training.

4.4.3.2.1* The owner or owner's representative shall be responsible for establishing a formal and ongoing program, consistent with the equipment and hazards involved, for training maintenance personnel to perform all required maintenance tasks.

4.4.3.2.2 Maintenance procedures and their associated training programs shall be established to cover routine and special techniques.

4.4.3.2.3 Environmental factors such as temperature, dusts, contaminated or oxygen-deficient atmospheres, internal pressures, and limited access or confined space requirements shall be included in the maintenance procedures.

4.4.3.2.4 Maintenance procedures shall be consistent with safety requirements and the manufacturer's recommendations and shall be kept current with changes in equipment and personnel.

4.5 Basic Operating Requirements.

4.5.1 Operating procedures with a minimum number of manual operations shall be established.

4.5.2 Standard operating procedures that result in well-defined and controlled operations shall be established.

4.5.3 Interlocks shall be provided to ensure correct operating sequences and to interrupt sequences when conditions are not correct for continuation.

4.5.4* The design shall not require any deliberate defeating of an interlock to start or operate equipment.

4.5.5 Interlock devices shall be permitted to be temporarily removed from service in accordance with the following:

- (1) Removal of the interlock shall be authorized by a competent person and documented in accordance with operating procedures.
- (2) Alternate means shall be substituted to supervise this interlock function in accordance with operating procedures.

4.5.6 Purge and start-up procedures with necessary interlocks shall be established.

4.5.7 Written operating procedures and detailed checklists for operator guidance shall be provided for achieving all automatic and manual operating functions.



4.6* Structural Design. The furnace shall be capable of withstanding transient design pressures and normal operating pressures without permanent deformation due to yield or buckling of any support member. Transient pressures to be considered shall include, but shall not necessarily be limited to, misoperation of fans or dampers and a master fuel trip while operating at maximum design load. (*Refer to individual chapters for additional guidance.*)

4.7 Functional Requirements of Fuel-Burning System. See also Annex I.

4.7.1 Function. The fuel-burning system shall function to convert continuously any ignitable input into unreactive products of combustion at the same rate that the fuel(s) and air reactants enter the combustion chamber.

4.7.2 Compatibility. The fuel-burning system shall be sized to meet the operating requirements of the unit, shall be compatible with other component systems, and shall be capable of being controlled for the full operating range of the unit.

4.7.3 System Requirements.

4.7.3.1* The fuel-burning system shall provide means for start-up, operation, and shutdown of the combustion process, including openings and configurations in the component assemblies to allow observation, measurement, and control of the combustion process.

4.7.3.2 The fuel-burning system shall consist of the boiler or HRSG enclosure and the following subsystems, as applicable: air supplies, fuel supplies, main fuel burning, ignition, and combustion products removal and re-injection. Each shall be sized and interconnected to meet the requirements of 4.7.4 through 4.7.8.

4.7.4 Enclosures. The boiler enclosure or HRSG enclosure shall meet the requirements of 4.7.4.1 through 4.7.4.3.

4.7.4.1 The enclosure shall be sized and arranged with respect to the main fuel-burning subsystem so that stable flame is maintained.

4.7.4.2 The enclosure shall be free from "dead pockets" when prescribed purge procedures are followed.

4.7.4.3 Observation ports shall be provided to allow visual inspection of the combustion chamber, igniter and burner flames (including the ignition zone), overfire air ports, re-burn injectors, and stoker grates.

4.7.5* Air Supply Subsystem. The air supply subsystem shall meet the requirements of 4.7.5.1 through 4.7.5.3.

4.7.5.1 The air supply equipment shall be sized and arranged to ensure a continuous airflow for all operating conditions on the unit.

4.7.5.2 Drain and access openings shall be provided and shall be accessible.

4.7.5.3 The air supply equipment shall be capable of continuing the required airflow during anticipated combustion chamber pressure pulsations.

4.7.6 Fuel Supply Subsystem. Fuel supplies and main fuel-burning subsystems shall meet the applicable requirements in Chapters 5 through 10 for specific systems.

4.7.7* Ignition Subsystem. The ignition subsystem shall meet the requirements of 4.7.7.1 through 4.7.7.13.

4.7.7.1 The ignition subsystem shall be sized and arranged to ignite the main burner input within the limitation of the igniter classification as follows:

- (1) It shall be verified through testing that the igniters furnished meet the requirements of the class specified in the design.
- (2) Igniters shall be designated as Class 1, Class 2, or Class 3 as defined in 3.3.73.1, 3.3.73.2, and 3.3.73.3 and as verified by test.

4.7.7.2 Class 1 igniters shall be permitted to be used as Class 2 or Class 3 igniters. Class 2 igniters shall be permitted to be used as Class 3 igniters.

4.7.7.3 Where Class 2 igniters are used, the burner shall be operated under controlled conditions to limit the potential for abnormal operation, as well as to limit the charge of fuel in the event that ignition does not occur during light-off.

4.7.7.4 Class 2 igniters shall not be used to ignite the main fuel under uncontrolled or abnormal conditions.

4.7.7.5 Where Class 3 igniters are used, the igniter shall be turned off as a part of the burner light-off procedure when the time trial for ignition of the main burner has expired, to ensure that the main flame is not dependent on ignition support from the igniter.

4.7.7.6 Class 2 igniters shall not be used to extend the turn-down range but shall be permitted to be used to support ignition under low-load or adverse operating conditions.

4.7.7.7 Class 3 igniters shall not be used to support ignition or to extend the burner turndown range.

4.7.7.8 Except for periods when the main burner is being scavenged, Class 3 special igniters shall not be used unless supervision of the individual main burner flame is provided.

4.7.7.9* Where Class 1 and Class 2 igniters are used, the tests described in 6.6.3.2.2, 6.7.3.2.2, and 6.8.3.2.2 shall also be performed with the ignition subsystem in service to verify that the igniters furnished meet the requirements of the class specified in the design.

4.7.7.10 Tests shall be performed to determine transient limits in the ignition air and fuel supplies or in the main air and fuel supplies that do not extinguish the igniter flame or reduce the igniter's ability to perform its intended function or adversely affect other burners and igniters in operation.

4.7.7.11 Igniters shall be permanently installed under the following conditions:

- (1) They shall be supervised to verify that the requirements of 4.7.7.1 and 4.7.7.2 are met.
- (2) This supervision shall include igniter capacity and individual igniter flame monitoring.
- (3) The capacity shall be measured by igniter header pressure as a minimum.
- (4) On single burner boilers, igniters shall not require supervision of igniter capacity.

4.7.7.12 The ignition equipment shall be located in an environment free of excessive heat and accessible for maintenance.

4.7.7.13 All igniter safety shutoff valves shall be located to minimize the volume of fuel that is downstream of the valve in the individual igniter fuel lines or that could flow by gravity into the combustion chamber after an emergency shutdown or a burner shutdown.

4.7.8 Combustion Products Removal Subsystem. The combustion products removal subsystem shall meet the requirements of 4.7.8.1 through 4.7.8.5.

4.7.8.1 The flue gas ducts, fans, and stack shall be sized and arranged to remove the products of combustion at the same rate at which they are generated by the fuel-burning process during operation of the unit.

4.7.8.2 Drain and access openings shall be provided and shall be accessible.

4.7.8.3 The flue gas ducts shall be designed so that they do not contribute to combustion chamber pulsations.

4.7.8.4 Components common to more than one boiler or HRSG shall not limit the rate of removal of products of combustion generated during the operation of all boilers or HRSGs.

4.7.8.5 Boilers or HRSGs that share a common component between the furnace outlet and the stack shall be in accordance with the following:

- (1) There shall be provisions to bypass the common component for unit purge when the common component contains a possible ignition source.
- (2) A common component shall not interrupt the open-flow air path of a boiler or HRSG during operation or purge.
- (3)*A common component shall not permit the flow of combustion products into an idle boiler or HRSG.

4.8 Multiple Boilers or HRSGs.

4.8.1 Where multiple boilers or HRSGs are supplied from the same fuel supply source, an equipment isolation valve shall be provided for each boiler and HRSG.

4.8.2 Dedicated safety shutoff valving, with related alarm, interlock, and control instrumentation, shall be provided for each boiler and HRSG.

4.9 Gaseous Vent System Requirements.

4.9.1* The discharge from atmospheric vents shall be located away from occupied areas, sources of ignition, combustion air intakes, building ventilation systems, or the windows of a boiler or HRSG room or adjacent buildings and shall be extended above the boiler or HRSG and adjacent structures so that gaseous discharge does not present a hazard.

4.9.2 Vent line sizes and vent valve port diameters shall not be less than the values shown in Table 4.9.2.

4.9.3 Manifolding of Vents.

4.9.3.1 Vents from systems operating at different pressure levels shall not be manifolded together.

4.9.3.2 Vents from systems served from different pressure-reducing stations shall not be manifolded together.

4.9.3.3 Vents from different boilers or HRSGs shall not be manifolded together.

4.9.3.4 Vents from systems using different fuel sources shall not be manifolded together.

4.9.3.5 Header vents shall be permitted to be manifolded together only with other header vents and only when operated and tripped in parallel.

4.9.3.6 Burner vents shall be permitted to be manifolded together only with other burner vents.

4.9.3.7 Igniter vents shall be permitted to be manifolded together only with other igniter vents.

4.9.3.8 Lance vents shall be permitted to be manifolded together only with other lance vents.

4.9.4 The cross-sectional area of the manifold line shall not be less than the greater of the following:

- (1) The cross-sectional area of the largest vent plus 50 percent of the sum of the cross-sectional areas of the additional vent lines
- (2) The sum of the cross-sectional areas of the two largest vent lines

4.10 Fuel System Piping.

4.10.1 Fuel Gas Piping Systems. Fuel gas piping material and system design shall be in accordance with NFPA 54 (for fuel gas piping inside industrial and institutional buildings), ASME B31.1, *Power Piping* (for fuel gas piping in power applications), or ASME B31.3, *Process Piping* (for fuel gas piping in process applications).

4.10.1.1 Equipment Isolation Valves. An equipment isolation valve shall be provided and shall be readily accessible at the fuel gas supply piping system connection.

Table 4.9.2 Vent Sizes

Fuel Line Size		Minimum Vent Line Size	
DN (mm)	NPS (in.)	DN (mm)	NPS (in.)
≤40	≤1½	20	¾
50	2	25	1
65 to 80	2½ to 3	32	1¼
90	3½	40	1½
100 to 125	4 to 5	50	2
150	6	65	2½
175	7	80	3
200	8	90	3½
>200	>8	Vent internal cross-sectional area ≥15% of the fuel line internal cross-sectional area	

4.10.1.1.1 Equipment isolation valves shall meet the following requirements:

- (1) They shall have permanently affixed visual indication of the valve position.
- (2) They shall be able to be operated from full open to full close and return without the use of tools.

4.10.2 Fuel Oil Piping Systems. Fuel oil piping materials and system design shall be in accordance with NFPA 31 (for fuel oil piping inside industrial or institutional buildings), ASME B31.1, *Power Piping* (for fuel oil piping in power applications), or ASME B31.3, *Process Piping* (for fuel oil piping in process applications).

4.10.3* Flue Gas Path Auxiliary Systems — Fuel, Oxidizer, and Combustible Reagent Piping.

4.10.3.1* The requirements in 4.10.3 shall apply to flue gas path auxiliary systems that inject fuel, oxidizer, or combustible reagent into the boiler enclosure or flue gas path when in operation.

4.10.3.2 Positive means to prevent leakage of fuel, oxidizer, or combustible reagent into an idle furnace or flue gas path shall be provided.

4.10.3.3 For gaseous fuels or gaseous combustible reagents, provisions shall include a double block and vent valve arrangement on the fuel or gaseous combustible reagent supply, separate from any other double block and vent valve arrangements for other systems.

4.10.3.4 For oxidizers, provisions shall include a block valve on the oxidizer supply, separate from any other block valves for other systems.

4.10.3.5 For gaseous fuels or gaseous combustible reagents, a double block and vent valve arrangement shall be provided in the fuel or gaseous combustible reagent line associated with each flue gas path injection system.

4.10.3.6 For gaseous fuels or gaseous combustible reagents, each flue gas path injection system that can be operated independent of other flue gas path injection systems shall have its own double block and vent valve arrangement.

4.10.3.7 For liquid or blown-in powder fuels or combustible reagents, provisions shall include a block valve on the fuel or combustible reagent supply, separate from any other block valves for other systems.

4.11* Burner Management System Logic.

4.11.1 Interlock System.

4.11.1.1 The basic requirement of an interlock system for a boiler or combustion system shall accomplish the following:

- (1) Protect personnel from injury
- (2) Protect equipment from damage
- (3) Protect operation by limiting actions to a prescribed operating sequence or by initiating trip devices when approaching an out-of-range or unstable operating condition

4.11.1.2* Additional automatic trips shall be permitted.

4.11.1.3 Fuel-specific interlocks shall be provided for each design basis fuel.

4.11.1.4* Operating personnel shall be made aware of the limitations of the interlock system.

4.11.2* As a minimum, the requirements of 4.11.3 through 4.11.11 shall be included in the design to ensure that a logic system for burner management meets the intent of those requirements.

4.11.3 The logic system for burner management shall be designed specifically so that a single failure in that system does not prevent an appropriate shutdown.

4.11.4 The burner management system interlock and alarm functions shall be initiated by one or more of the following:

- (1) One switch or transmitter dedicated to the burner management system
- (2) Voting logic derived from two or more switches or transmitters

4.11.4.1 When multiple transmitters are used in the burner management system, such signals shall be permitted to be shared with other control systems for control purposes.

4.11.4.2* When signals from multiple switches or transmitters are provided to initiate interlock or alarm functions, those signals shall be monitored in comparison to each other by divergence or other fault diagnostic alarms.

4.11.4.3 When signals from multiple switches or transmitters are provided to initiate interlock or alarm functions, the provided signals shall be generated by individual sensing devices connected to separate process taps.

4.11.5* Alarms shall be generated to indicate equipment malfunction, hazardous conditions, and misoperation.

4.11.6 The burner management system designer shall evaluate the failure modes of components, and as a minimum the following failures shall be evaluated and addressed:

- (1) Interruptions, excursions, dips, recoveries, transients, and partial losses of power
- (2) Memory corruption and losses
- (3) Information transfer corruption and losses
- (4) Inputs and outputs (fail-on, fail-off)
- (5) Signals that are unreadable or not being read
- (6) Failure to address errors
- (7) Processor faults
- (8) Relay coil failure
- (9) Relay contact failure (fail-on, fail-off)
- (10) Timer failure

4.11.7* The design of the logic system for burner management shall include and accommodate the following requirements:

- (1) Diagnostics shall be included in the design to monitor processor logic function.
- (2) Logic system failure shall not preclude proper operator intervention.
- (3) Logic shall be protected from unauthorized changes.
- (4) Logic shall not be changed while the associated equipment is in operation.
- (5) System response time (through-put) shall be short to prevent negative effects on the application.
- (6) Protection from the effects of noise shall prevent false operation.
- (7) No single component failure within the logic system shall prevent a mandatory master fuel trip.
- (8) The operator shall be provided with a dedicated manual switch(es) that shall actuate the master fuel trip relay independently and directly.

- (9) At least one manual switch referenced in 4.11.7(8) shall be identified and located remotely where it can be reached in case of emergency.
- (10)*The logic system shall be monitored for failure.
- (11) Failure of the logic system shall require a fuel trip for all equipment supervised by the failed logic system.
- (12) Logic shall be maintained either in nonvolatile storage or in other memory that retains information on the loss of system power.

4.11.8* Requirement for Independence.

4.11.8.1 The burner management system shall be provided with independent logic, independent logic solving hardware, independent input/output systems, and independent power supplies and shall be a device functionally and physically separate from other logic systems.

4.11.8.2 The burner management safety functions shall include but shall not be limited to purge interlocks and timing, mandatory safety shutdowns, trial timing for ignition, and flame monitoring.

4.11.8.3 The logic system shall be limited to one boiler or HRSG.

4.11.8.4 The same hardware type used for burner management systems shall be permitted to be used for other logic systems.

4.11.8.5 Network communications between the burner management system and other systems shall be permitted. The network communicating with other systems shall not be the same network that the burner management system uses to communicate with its input/output hardware.

4.11.8.6* Signals and the manually operated devices specified in 4.11.7(8) that initiate mandatory master fuel trips shall be hardwired.

4.11.9 Momentary Closing of Fuel Valves.

4.11.9.1 Logic sequences or devices intended to cause a safety shutdown, once initiated, shall cause a burner or master fuel trip, as applicable, and shall require operator action prior to resuming operation of the affected burner(s).

4.11.9.2 No logic sequence or device shall be permitted that allows momentary closing and subsequent inadvertent reopening of the main or ignition fuel valves.

4.11.10 **Circuit Devices.** No momentary contact or automatic resetting device, control, or switch that can cause chattering or cycling of the safety shutoff valves shall be installed in the wiring between the load side (terminal) of the primary or programming control and the main or ignition fuel valves.

4.11.11 **Documentation.** Documentation shall be provided to the owner and the operator indicating that all safety devices and logic meet the requirements of the application.

4.12 Flame Monitoring and Tripping Systems.

4.12.1 **Functional Requirements.** The basic requirements of any flame monitoring and tripping system shall be as follows:

- (1) Combustion instability situations shall be brought to the attention of the operator for remedial action.
- (2) An emergency shutdown of the involved equipment shall be automatically initiated upon detection of serious combustion problems that will lead to the accumulation of unburned fuel.

4.12.2 System Objectives.

4.12.2.1 System objectives shall be developed that include those requirements that are specifically related to the combustion conditions typical for particular combustion chamber configurations, burner or firing systems, and fuel characteristics.

4.12.2.2 Such objectives shall be consistent with the individual manufacturer's design philosophy.

4.12.3 Flame Detection.

4.12.3.1 Flame Detector Sighting.

4.12.3.1.1 Flame detector sighting shall be a factor in the initial design.

4.12.3.1.2 Field tests shall be required to establish optimum sighting angles of burners or nozzles and to check the effective angular range of flame detectors in relation to burners or nozzles.

4.12.3.2 **Clean Air Supply.** Clean air, where necessary, shall be supplied to minimize problems with dirty detector lenses.

4.12.3.3 **Self-Checking of Flame Detectors.** Where flame-sensing detectors can fail in the flame-proven mode, self-checking features shall be provided to ensure that the failure of any single component cannot result in a false indication of flame.

4.12.3.4* Reduced Emissions Control Effects.

4.12.3.4.1 Flame detector selection, sighting, and location shall be re-evaluated in accordance with 4.12.2 following implementation of methods or installation of equipment to reduce the emission of air pollutants.

4.12.3.4.2 When changes made to reduce the emission of air pollutants affect flame characteristics, main burners shall be tested for the limits of stable flame.

4.12.3.5 Flame Proving.

4.12.3.5.1 A flame detector shall not use any mechanical, electrical, or electronic means to force the flame detector into a "flame not detected" mode as part of the igniter and/or burner starting sequence.

4.12.3.5.2 A flame detector shall prove ignition of the associated fuel by proving both igniter "flame not detected" and burner "flame not detected" prior to introduction of the fuel to the igniter or burner and proving "flame detected" after introduction of that fuel to that igniter or burner.

4.12.3.5.3 An igniter flame detector shall not be required to prove "flame not detected" if the associated burner is proven in service and the associated igniter is out of service.

4.12.3.5.4 A burner flame detector shall not be required to prove "flame not detected" if an associated Class 1 igniter is proven in service.

4.12.3.5.5 The igniter flame detector(s) and/or the burner flame detector(s) shall not be required to prove "flame not detected" after the boiler load has been elevated to the point that it is no longer possible to achieve individual flame discrimination.

4.12.3.5.6 The boiler load specified in 4.12.3.5.5 shall be proven by test to be the load level at which individual igniters and/or burner flame discrimination is no longer possible, but in no case shall the boiler load be less than that for which tests show that complete combustion will occur.



4.12.3.5.7 The response time from flame failure to the initiation of the trip signal to the fuel safety shutoff devices shall not exceed 4 seconds, including any time delay associated with the flame detector.

4.13* Combustion Control System.

4.13.1 Functional Requirements.

4.13.1.1 The combustion control system shall regulate the inputs into the combustion chamber to ensure continuous combustion and stable flame under all operating conditions.

4.13.1.2 Draft control, where applicable, shall be coordinated with the combustion control system.

4.13.1.3* On multiple burner boilers, equipment shall be provided and procedures shall be established to maintain the air-fuel ratio within design limits at each burner.

4.13.1.3.1 The equipment and procedures shall not be required to be a part of the combustion control system.

4.13.1.4 Boiler or HRSG control systems shall be permitted to be combined for more than one boiler or HRSG where the control system is separated from the burner management system.

4.13.2 System Requirements.

4.13.2.1* Except as noted in 4.13.2.2, under no circumstances shall airflow demand be less than the minimum purge rate established by the designer.

4.13.2.2 For single burner boilers, airflow demand shall not be reduced below the low limit of the fuel-burning system as determined by the burner manufacturer and verified by operating test.

4.13.2.3 The fuel demand shall not increase the fuel input(s) above the available airflow.

4.13.2.4 Airflow demand shall not reduce airflow below that required by the actual fuel input(s).

4.13.2.5 The fuel demand shall not exceed the capability of the operating draft fans.

4.13.2.6 If the loss or shutdown of a draft fan causes the fuel demand to be greater than the capacity of the fans in service, the fuel(s) shall be rapidly reduced to a value that can be accommodated.

4.13.2.7 Measurements.

4.13.2.7.1 Measurements used in the combustion control system shall be accurate and reproducible to maintain stable firing conditions.

4.13.2.7.2 Pressure, temperature, density, and/or viscosity corrections shall be employed, as applicable, to meet the requirement of 4.13.2.7.1.

4.13.2.8 Where multiple fuels are fired, the fuel inputs shall be totaled on the basis of their relative heat values.

4.13.2.9 The total heat input to a given burner or combustion zone shall not exceed the maximum limits specified by the boiler or HRSG manufacturer.

4.13.2.10* Means shall be provided to enable the operator to adjust the air-fuel ratio for all boilers consistent with the fuel(s) being fired.

4.13.2.11 The equipment selection and the design of the combustion control system shall facilitate the on-line calibration, testing, and maintenance requirements described in 4.4.1.

4.13.2.12 The rate of increase of reburn fuel injection shall not exceed the response capability of the main combustion control system.

4.13.3 Additional Requirements.

4.13.3.1 Any logic commands from the burner management system shall take precedence over the combustion control system.

4.13.3.2 Where applicable, automatic control of airflow shall not be permitted unless the draft control is maintained in automatic control.

4.13.3.3* Automatic Control.

4.13.3.3.1 Except as noted in 4.13.3.3.2, automatic control of the fuel input(s) shall not be permitted unless the airflow is maintained in automatic control.

4.13.3.3.2 For HRSGs designed and operated in accordance with Chapter 8, automatic control of fuel inputs shall be permitted without automatic control of airflow.

4.13.3.4 The combustion control system shall neither automatically increase nor automatically decrease a fuel input beyond the fuel-burning system's operating range as determined by the manufacturer and verified by operating test.

4.13.3.5 The combustion control system shall not reduce the fuel feed to a pulverizer below the minimum feed rate established by the pulverizer manufacturer for the manufacturer's specified design fuel.

4.13.3.5.1 For fuels with ignition characteristics different from those of the manufacturer's design fuel, the combustion control system shall not reduce the fuel feed rate below the value that ensures stable and self-sustaining combustion at the burners served by the pulverizer.

4.13.3.5.2 The minimum feed rate for fuels not conforming to the fuel specifications used by the manufacturer in the design of the pulverizer system shall be determined by operational tests.

4.14 Power Supplies. Precautions shall be taken to ensure the availability of a failure-free power supply (electric or pneumatic) to all control and safety devices.

4.15* Operating Information.

4.15.1 Except as noted in 4.15.1.1 and 4.15.1.2, continuous trend display of steam flow rate, feedwater flow rate, total fuel flow rate, and total airflow rate as a percentage of the maximum unit load, drum level, final steam temperature, main steam pressure, and furnace or combustion chamber draft shall be simultaneously available at the operating location.

4.15.1.1* For single burner boilers, continuous trend display of operating parameters critical to operation shall be provided.

4.15.1.2 For HRSGs, continuous trend display requirements are specified in 8.7.2.3.

4.15.2 Alarms and indicators shall be grouped operationally and shall be visible to the operator to allow access to operational devices.

4.15.3 All emergency alarm indicators, push buttons, and selector switches shall be visible to the operator, labeled clearly, and protected to avoid inadvertent actuation.

4.15.4 All control functions shall be grouped for accessibility and in proximity to their associated alarm and indication devices.

4.15.5* Where video display units (VDUs) are used, data shall be displayed on monitor screens in a logical, operational grouping to minimize the number of keystroke operations needed to respond to system upsets.

4.15.6 Where VDUs are used, alarm functions shall be prioritized to appear on the monitor screen upon being sensed, regardless of any information already displayed.

4.15.7 Alarm systems shall be designed so that the operator receives audible and visual indication of the out-of-limits conditions.

4.15.8 The audible alarm shall be permitted to be silenced by the operator after actuation, but the visual indication shall continue until the condition is within specified limits and has been reset.

4.15.9 Defeating of the alarm shall be authorized by a competent person and documented in accordance with operating procedures.

4.15.10 When it is necessary to manually defeat an alarm, defeating the alarm shall be performed by authorized personnel, and the alarm shall be tagged as inoperative.

4.16* Selective Catalytic Reduction.

4.16.1 Where selective catalytic reduction (SCR) systems are selected for NO_x emission control, they shall be integrated into the design of the boiler system, HRSG, or combustion turbine exhaust system to operate in the flue gas temperature range required.

4.16.2 Areas in which either anhydrous or aqueous ammonia is stored or piped shall be ventilated to preclude toxic or flammable concentrations.

4.16.3 Areas in which anhydrous ammonia is stored or piped shall meet the requirements of CGA G-2.1/ANSI K61.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*.

Chapter 5 Single Burner Boilers

5.1 Application.

5.1.1 This chapter shall be used in conjunction with Chapters 1 through 4 and requires the coordination of operation procedures, control systems, interlocks, and structural design.

5.1.2 Where conflicts exist, the requirements of Chapter 5 shall apply.

5.1.3 All safety shutoff valves, safety interlock devices, valve-proving systems, and flame detection systems shall be listed or approved. A safety shutoff valve proof of closure switch shall be an original design component of the valve or actuator assembly and shall activate only after the valve is fully closed.

5.2 Purpose. The purpose of this chapter shall be to establish minimum requirements for the design, installation, operation, and maintenance of single burner boilers, their fuel-burning systems, and related systems to contribute to operation within design limits and, in particular, to the prevention of furnace explosions.

5.3 Unattended Operation. The process hazard analysis required by 4.1.4 shall not apply to automatic recycling and automatic nonrecycling single burner boilers designed for unattended operation unless required by the authority having jurisdiction.

5.4 Equipment Requirements.

5.4.1* Fuel Supply — Oil.

5.4.1.1 Fuel shall be stored, prepared, and delivered to the oil service connection under anticipated operating conditions in accordance with the applicable portions of NFPA 31.

5.4.1.2 Operation of the burner shall not be attempted until a continuous fuel supply is ensured.

5.4.1.3 Fuel shall be delivered continuously to the combustion chamber in a finely atomized form that can be ignited readily and consumed.

5.4.1.4 All equipment that is associated with pumping, heating, and straining the fuel from storage to the service connection shall be designed, sized, and interconnected so as to provide a fuel supply that meets the boiler design requirements over a full range of conditions.

5.4.1.5 Relief valves shall be installed after the pump to prevent overpressure in the system.

5.4.1.6 Fuel being burned shall be delivered to the burner at the temperature and pressure specified by the burner manufacturer.

5.4.1.7 Where the fuel must be heated, the interlocks and instruments shall reflect the correct values of the variable being measured, particularly in dead-end lines, where heavy oil will tend to solidify.

5.4.1.8 Oil Supply.

5.4.1.8.1 The operation of a burner system that has the capability to burn heated and unheated oils shall include a procedure to ensure that the specified grade of oil, compatible with the selected mode of operation, is being supplied to the burner.

5.4.1.8.2 Precautions shall include the intended routing of recirculated oil.

5.4.1.9 Two safety shutoff valves in series, each with a proof of closure switch, shall be provided in the oil line to the main burner.

5.4.1.10 Where pressure can develop in excess of the valve or piping rated pressure(s), the piping design shall include a means to prevent or relieve excess pressure between the valves.

5.4.1.11 Oil piping materials and system design shall be in accordance with NFPA 31 (for oil piping inside industrial or institutional buildings), ASME B31.1, *Power Piping* (for oil piping in power applications), or ASME B31.3, *Process Piping* (for oil piping in process applications).

5.4.2* Fuel Supply — Gas.

5.4.2.1 The gas supply at the gas service connection shall be controlled at the pressure for which the fuel-burning system had been designed.

5.4.2.2 Gas piping shall be sized to maintain the required pressure for maximum burner flow.



5.4.2.3* Two safety shutoff valves in series, each with a proof of closure switch, shall be provided in the fuel gas line to the main burner, and an automatic vent valve shall be provided between the two valves.

5.4.2.3.1 When a listed automatic valve-proving system is used with two safety shutoff valves in series, each with a proof of closure switch, the automatic vent valve shall be permitted to be omitted.

5.4.2.3.2* Where automatic valve-proving systems are installed, valve proving shall be performed either after every burner shutdown or prior to every burner light-off.

5.4.2.4 Foreign matter such as welding beads, chips, scale, dust, and debris shall be removed from the gas piping.

5.4.2.5 A drip leg shall be provided in the gas piping. (See *A.5.4.2.3* and *A.5.4.4.1*.)

5.4.2.6 Gas piping material and system design shall be in accordance with NFPA 54 (for gas piping inside industrial and institutional buildings), ASME B31.1, *Power Piping* (for gas piping in power applications), or ASME B31.3, *Process Piping* (for gas piping in process applications).

5.4.2.7 Valve Leakage Test.

5.4.2.7.1 Permanent means shall be provided for making manual valve leakage tests of the main burner gas safety shutoff valves.

5.4.2.7.2 Manual valve leakage tests of the main safety shutoff valves shall be conducted at least annually.

5.4.2.7.3 The use of an automatic valve-proving system shall not eliminate the annual leak test required in 5.4.2.7.2.

5.4.3 Alternate Fuel Firing.

5.4.3.1 Manual Fuel Selection. Where oil and gas are to be burned alternately, a manual fuel selector switch shall be provided to permit operation of the necessary interlocks, fuel safety shutoff valves, and controls for the fuel to be fired.

5.4.3.2 Automatic Fuel Selection.

5.4.3.2.1 Where oil and gas are to be burned alternately, an automatic change from one fuel to the other shall be accomplished only after a shutdown.

5.4.3.2.2 Provisions for manual changeover of the system shall be provided in accordance with 5.4.3.1 and Section 5.8.

5.4.3.2.3 For simultaneous firing of oil and gas fuels, Section 5.7 shall apply.

5.4.4 Fuel-Burning Equipment.

5.4.4.1* Ignition.

5.4.4.1.1 The main burner shall be equipped with a permanently installed igniter.

5.4.4.1.1.1 Class 1 Igniter.

(A) Where a Class 1 igniter is used, the main burner flame shall be proven by a flame detector.

(B) Either the main flame or the igniter flame shall be proven.

5.4.4.1.1.2 Class 2 Igniter.

(A) Where a Class 2 igniter is used, it shall not be used to ignite main fuel under uncontrolled or abnormal conditions.

(B) The burner shall be operated under controlled conditions to limit the potential for abnormal operation as well as to limit the charge of fuel to the furnace in the event that ignition does not occur during light-off.

(C) If the Class 2 igniter is not shut down once the main flame sequence is successfully completed, then the main burner flame shall be proven by a flame scanner independently of the igniter.

5.4.4.1.1.3 Class 3 Igniter.

(A)* Where a Class 3 igniter is used, the igniter shall be shut down as part of the burner light-off procedure when the time trial for ignition of the main burner has expired.

(B) The use of such igniters to support ignition or to extend the burner control range shall be prohibited.

(C) The main flame shall be proven by a flame scanner.

5.4.4.1.1.4 Class 3 Special Igniter. Where a Class 3 special igniter is used, the main burner flame shall be proven by a flame scanner.

5.4.4.1.2 The igniter flame or arc shall impinge on the main burner air-fuel mixture and shall supply ignition energy to provide immediate ignition of all fuel discharge from the main burner under light-off conditions.

5.4.4.1.3* Igniter Safety Shutoff Valves. Two safety shutoff valves in series shall be provided in the fuel gas line to the igniter, and an automatic vent valve shall be provided between the two valves.

5.4.4.1.3.1 When a listed automatic valve-proving system is used with two safety shutoff valves in series, the automatic vent valve shall be permitted to be omitted.

5.4.4.1.3.2* Where an automatic valve-proving system is installed, valve-proving shall be performed either after every burner shutdown or prior to every burner light-off.

5.4.4.1.4 The igniter shall be designed for periodic removal, cleaning, and maintenance.

5.4.4.2 Main Burner.

5.4.4.2.1 The main burner shall direct the fuel and air into the furnace so as to provide a stable flame and efficient combustion over its entire operating range.

5.4.4.2.2 The limits of stable flame for the burner shall be determined by tests.

5.4.4.2.2.1 These tests shall be performed without the igniter in service and shall include the intended range and grade of fuel(s).

5.4.4.2.2.2* The tests shall verify that transients that are generated in the fuel and air systems do not adversely affect burner operation.

5.4.4.2.3 Each manual adjustment feature on the burner shall be provided with means for securing it in its intended position.

5.4.4.2.4 The atomizing equipment for oil burners shall be designed for periodic removal, cleaning, and maintenance.

5.4.4.2.5 Any procedure for clearing the atomizer and piping into the furnace prior to shutdown shall be accomplished while the fan is operating and the igniter is re-established or the main flame is proven continuously during this operation.

5.4.4.2.6 Clearing of the oil passages of the atomizer into the furnace immediately after a shutdown shall be prohibited.

5.4.4.3 Atomizing Medium for Oil Burners.

5.4.4.3.1 Where the fuel is to be atomized with the assistance of another medium, this atomizing medium shall be supplied free of contaminants that could cause an interruption of service.

5.4.4.3.2 The atomizing medium shall be provided at the pressure and temperature specified by the burner manufacturer.

5.4.4.3.3 Provisions shall be made to ensure that fuel cannot enter the atomizing medium line during or after operation.

5.4.4.4 Combustion Air Supply.

5.4.4.4.1 The combustion air supply equipment shall be capable of supplying combustion air for the optimum air-fuel ratio over the entire operating range of the burner.

5.4.4.4.2 Provisions shall be made for periodic cleaning of the combustion air supply equipment.

5.4.4.4.3 The requirements for the availability of combustion air shall be determined from NFPA 31 and NFPA 54.

5.4.4.4.3.1 Louvers and grilles shall be fixed in the open position or interlocked with the equipment so that they are opened automatically or manually during equipment operation. The interlock shall be placed on the driven member.

5.4.4.4.3.2 Fans supplying air to the boiler room for combustion shall be interlocked with the burner so that airflow is proven during equipment operation.

5.4.4.5 Furnace. The furnace shall be designed to promote main burner stability while minimizing zones that cannot be purged.

5.4.4.6 Combustion Products Removal.

5.4.4.6.1* The outlet draft equipment shall be capable of removing combustion products without adversely affecting stable flame conditions.

5.4.4.6.2 Where two or more boilers are connected to a common stack, each connection shall be equipped with a damper system.

5.4.4.6.2.1 All boiler outlet dampers shall be equipped with accessible operating and locking devices.

5.4.4.6.2.2 This equipment shall be compatible with the combustion control system of the boiler.

5.4.4.6.2.3 Interlocks shall be provided to prevent firing against a closed damper.

5.4.4.6.2.4 To prevent the interlock from being rendered nonfunctional if the linkage becomes disconnected, one of the following means shall be provided:

- (1) Placing the interlock on the driven member
- (2) Utilizing a furnace pressure switch
- (3) Other approved means

5.4.4.6.2.5 Dampers shall not be required on the outlet of boilers of a type in which maintenance operations are performed from outside the boiler.

5.4.4.6.3* Permanently installed flue gas analyzers shall not present an ignition source hazard to the flue gas stream being sampled.

5.4.5* Combustion Control System.

5.4.5.1 The combustion control system shall be installed in accordance with the requirements of 4.13.1.

5.4.5.2 The combustion control system shall maintain air-fuel mixtures at pre-established ratios throughout the operating range of the burner and during changes in the firing rate.

5.4.5.3* The system shall provide limits on fuel and air to prevent furnace input from being reduced below the point of stable burner operation.

5.4.5.4 The minimum and maximum points of stable burner operation shall be defined by the burner manufacturer and verified by operational tests.

5.4.6 Interlock System.

5.4.6.1 In addition to the requirements in Section 4.11, the boiler control system for single burner boilers shall be permitted to be combined with the burner management system under one of the following conditions:

- (1) *If the fuel-air ratio is controlled externally from the boiler control system; or
- (2) If the combined boiler control and burner management system is specifically listed or labeled for the application; or
- (3) *A single safety-rated programmable logic system shall be permitted to be used to implement both burner management system safety and process logic where both of the following conditions are met:
 - (a) The processor and input/output (I/O) modules are approved or certified by a notified body according to IEC 61508, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems*, to be at least SIL 3 capable; and
 - (b) The burner management system logic is isolated from other logic and boiler controls, and the related data of the burner management system program, including I/O data, are protected from being unintentionally affected by data of other user programs.

5.4.6.2 The system shall be equipped with a method of determining the operating state of each interlock without disassembling any of the interlock devices.

5.4.6.3 Each interlock shall be provided with a method of establishing the set point.

5.4.6.4 Interlock devices shall be designed for anticipated environmental conditions, such as temperature, humidity, vibration, and corrosive agents.

5.4.6.5 Bypass.

5.4.6.5.1 The design shall not require any deliberate defeat-ing of an interlock to start or operate equipment.

5.4.6.5.2 Interlocks shall be permitted to be bypassed as allowed by 5.5.3.2.1(4), and 5.5.3.3.1(4).

5.4.6.5.3 Interlock devices shall be permitted to be temporarily removed from service for maintenance or testing in accordance with the following:

- (1) Removal of the interlock shall be authorized by a competent person and documented in accordance with operating procedures.
- (2) Alternate means shall be substituted to supervise this interlock function in accordance with operating procedures.



5.4.6.5.4 The interlocks on the low water cutouts shall be permitted to be bypassed during normal operation for blow-down purposes only.

5.4.6.5.4.1 The bypass of 5.4.6.5.4 shall be of a type that is temporarily held during blowdown.

5.4.6.6* Each safety control ac circuit shall be two wires, one side grounded, and shall be protected with a suitable fuse or circuit breaker in the hot side only.

5.4.6.7 Safety Control dc Circuits.

5.4.6.7.1 Safety control dc circuits shall be arranged as called for in 5.4.6.6 where grounding is possible.

5.4.6.7.2 Where grounding is not possible and the circuit voltage exceeds 50 volts, the circuit shall have switching contacts in one side of the line and shall be provided with ground-fault circuit interrupters.

5.4.7 Flame Safety Shutdown System.

5.4.7.1 The response time from flame failure to de-energization of the safety shutoff valves shall not exceed 4 seconds.

5.4.7.2 The response time from de-energization of the safety shutoff valves to full closure shall not exceed 1 second.

5.4.7.3 Where flame-sensing detectors can fail in the flame-proven mode, self-checking features shall be provided unless the burner is operated for periods less than 24 hours and the burner management system includes a safe-start component checking feature.

5.4.7.4 A safe-start component checking feature shall include a circuit incorporated in the burner management system that prevents light-off if the flame-sensing relay is in the flame-present position due to component failure or due to the presence of actual or simulated flame.

5.4.8 Electrical Equipment.

5.4.8.1* All electrical equipment and wiring shall conform to *NFPA 70*.

5.4.8.2 Special fuels or applications could require components for hazardous location and shall be reviewed during the design of the system.

5.4.9* Gas and Oil Firing; Special Problems. Systems installed or designed to reduce NO_x emissions shall be evaluated to ensure that the performance of flame safety and combustion control systems are not impaired.

5.5 Starting of a Cold Boiler.

5.5.1 General.

5.5.1.1 Starting of a cold boiler shall be accomplished in conformance with the manufacturer's recommendations.

5.5.1.2 In no case shall a boiler that has been taken out of service for maintenance, repair, or extended shutdown be started from a cold condition without a trained operator present.

5.5.1.3 Start-Up Procedures.

5.5.1.3.1 Applicable start-up procedures for the provided boiler shall be followed.

5.5.1.3.2 The firing rate shall be limited in accordance with the boiler manufacturer's instructions.

5.5.2 Gas-Fired Boilers. The procedures of Section 5.6 shall be followed for starting a cold gas-fired boiler.

5.5.3 Oil-Fired Burners. When steam is not available for heating oil, as an atomizing medium, or for driving auxiliary equipment, one of the starting methods described in 5.5.3.1, 5.5.3.2, or 5.5.3.3 shall be used.

5.5.3.1 Auxiliary Air Atomizing of Oil. When auxiliary air atomizing of oil is used for a cold start-up, all the equipment, facilities, and procedures listed in 5.5.3.1.1, 5.5.3.1.2, and 5.5.3.1.3 shall be required.

5.5.3.1.1 Required Equipment. The following equipment shall be required:

- (1) Forced draft (FD) fan
- (2) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with a stable flame (only for fuel oils that require heating)
- (3) Check valves in steam and air lines to the atomizer

5.5.3.1.2* Required Facility. An alternate atomizing air supply shall be required.

5.5.3.1.3 Starting Procedure. The following procedural steps shall be followed:

- (1) Circulate and heat oil, using auxiliary heater and recirculating system, to satisfy all interlocks, where included.
- (2) Follow the prefiring and light-off cycles as described in Section 5.6, using air as the atomizing medium.
- (3) Set combustion control at the light-off firing rate.
- (4) When steam pressure has reached the point required for heating and atomizing the oil, shut down in accordance with the normal shutdown procedure described in Section 5.6.
- (5) Close the atomizing air supply and open the atomizing steam supply, making certain that dry steam is available.
- (6) Change over from auxiliary oil heater to steam oil heater.
- (7) Continue the boiler start-up sequence.

5.5.3.2 Auxiliary Mechanical Atomizing of Heavy Oil. When auxiliary mechanical atomizing of heavy oil is used for a cold start-up, all the equipment, facilities, and procedures in 5.5.3.2.1 and 5.5.3.2.2 shall be required.

5.5.3.2.1 Required Equipment. The following equipment and facilities shall be required:

- (1) FD fan.
- (2) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with stable flame.
- (3) Mechanical atomizer.
- (4) Means to bypass atomizing medium interlocks. The bypassed interlocks shall be made evident to the operator by means of warning devices.

5.5.3.2.2 Starting Procedure. The following procedural steps shall be followed:

- (1) Circulate and heat oil using auxiliary heater and recirculating systems to satisfy oil interlocks, where included.
- (2) Bypass atomizing medium interlocks. [See 5.5.3.2.1(4).]
- (3) Insert mechanical atomizer.
- (4) Follow the prefiring and light-off cycles as described in Section 5.6.
- (5) Set combustion control at the light-off firing rate.
- (6) When steam pressure has reached the point required for heating and atomizing the oil, shut down in accordance with the normal shutdown procedure as described in Section 5.6.

- (7) Remove the mechanical atomizer.
- (8) Insert the steam atomizer.
- (9) Make the atomizing medium interlocks operable and place into service.
- (10) Change over from auxiliary oil heater to steam oil heater.
- (11) Continue the boiler start-up sequence.

5.5.3.3 Auxiliary Mechanical Atomizing of Light (Unheated) Oil. When auxiliary mechanical atomizing of light (unheated) oil is used for a cold start-up, all the equipment, facilities, and procedures in 5.5.3.3.1 through 5.5.3.3.3 shall be required.

5.5.3.3.1 Required Equipment. The following equipment shall be required:

- (1) FD fan.
- (2) Mechanical atomizer.
- (3) Check valves in the heavy and light oil lines.
- (4) Means to bypass atomizing medium interlocks. The bypassed interlocks shall be made evident to the operator by means of warning devices.

5.5.3.3.2 Required Facility. A light oil supply shall be required.

5.5.3.3.3 Starting Procedure. The following procedural steps shall be followed:

- (1) Shut off heavy oil to the system.
- (2) Insert the mechanical atomizer.
- (3) Bypass heavy oil and atomizing medium interlocks. [See 5.5.3.3.1(4).]
- (4) Open the light oil supply into the system.
- (5) Follow prefiring and light-off cycles described in Section 5.6.
- (6) Set combustion control at the light-off rate.
- (7) When steam pressure has reached the point required for heating and atomizing the heavy oil, shut down in accordance with the normal shutdown procedure as described in Section 5.6.
- (8) Shut off the light oil supply to the system.
- (9) Remove the mechanical atomizer.
- (10) Insert the steam atomizer.
- (11) Make the heavy oil and atomizing medium interlocks operable by removing bypasses.
- (12) Open the heavy oil supply to the system.
- (13) Continue the boiler start-up sequence.

5.6 Operating Systems.

5.6.1* General. This section shall be used to define requirements for automatic recycling and automatic nonrecycling operating systems.

5.6.1.1 Manual systems shall not be installed for new installations or major alterations.

5.6.1.2 Different arrangements shall be permitted if they provide protection and meet the intent of this code. (See Figure A.5.4.1, Figure A.5.4.2.3, and Figure A.5.4.4.1 for typical arrangements.)

5.6.2 Automatic (Recycling) Systems for Watertube Boilers.

5.6.2.1 An automatic (i.e., recycling) unit shall not be started from a cold condition unless a trained operator is present.

5.6.2.2 Underlying all the requirements of 5.6.2 shall be the premise that the unit is hot and that steam pressure and operating water level shall have been established.

5.6.2.3 The fuel to be fired shall have been manually selected.

5.6.2.4 The alternate fuel system shall be placed in a nonfiring condition, and the manual burner valve(s) shall be closed.

5.6.2.5 An igniter as specified in 5.4.4.1.1 shall be provided.

5.6.2.6 An automatic (i.e., recycling) unit shall recycle on high steam pressure, high water temperature, or low water level (not determined by the auxiliary low water cutout) and perform four major functions as given in 5.6.2.6.1 through 5.6.2.6.4.4.

5.6.2.6.1 Prefiring Cycle. The prefiring cycle shall accomplish the following steps in the listed order, except that the order of steps (5), (6), and (7) in the sequence shall be permitted to vary:

- (1) Prove the main fuel safety shutoff valves are closed.
- (2) Prove no flame is present at the burner.
- (3) Start the fan.
- (4) Satisfy the fan interlock.
- (5) Where an atomizing medium is used and if not already on, admit medium to main burner.
- (6) Where an atomizing medium is used, satisfy the atomizing medium interlocks.
- (7) Satisfy fuel interlocks.
- (8) Prove the purge airflow by satisfying one of the following items:
 - (a) Air pressure and "open damper" interlocks for all dampers in the flow path
 - (b) Airflow interlock
- (9) Purge airflow must reach no less than 70 percent of the airflow required at maximum continuous capacity of the unit.
- (10) The purge must be for at least eight air changes. Airflow during the period of opening the damper and returning it to light-off position is permitted to be included in computing the time for eight air changes.
- (11) Set controls to light-off position.
- (12) Prove the dampers and fuel control valve are in light-off position.
- (13) If a flue gas recirculation system is supplied, then it shall be purged per the manufacturer's instructions.

5.6.2.6.2 Light-Off Cycle.

5.6.2.6.2.1 Class 3 Igniter. The light-off cycle for a burner with a Class 3 igniter shall accomplish the following in the listed order:

- (1)*Energize the ignition transformer and igniter fuel valves.
- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves; for a Class 3 special igniter, proof of igniter operation is not required.
 - (a) If proven, admit fuel to main burner. For an oil burner other than a return flow type, simultaneously shut off oil-recirculating flow.
 - (b) If not proven, establish safety shutdown.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, shut off igniter.
- (4) Prove main flame (see 5.4.4.1.1.3 and 5.4.4.1.1.4) and proceed as follows:
 - (a) If proven, release to modulating control where provided.
 - (b) If not proven, establish safety shutdown.

5.6.2.6.2.2 Class 2 Igniter. The light-off cycle for a burner with a Class 2 igniter shall accomplish the following in the listed order:

- (1)*Energize the ignition transformer and igniter fuel valves.



- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves and proceed as follows:
 - (a) If proven, admit fuel to the main burner. For an oil burner other than a return flow type, simultaneously shut off the recirculating flow.
 - (b) If not proven, establish safety shutdown.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, prove the main flame (see 5.4.4.1.1.2) and proceed as follows:
 - (a) If proven, release to combustion control for modulation, where provided.
 - (b) If not proven, establish safety shutdown.

5.6.2.6.2.3 Class 1 Igniter. The light-off cycle for a burner with a Class 1 igniter shall accomplish the following in the listed order:

- (1)*Energize the ignition transformer and igniter fuel valves.
- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves and proceed as follows:
 - (a) If proven, admit fuel to the main burner. For an oil burner other than a return flow type, simultaneously shut off recirculating flow.
 - (b) If not proven, establish safety shutdown.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, prove the main flame (see 5.4.4.1.1.1) and proceed as follows:
 - (a) If proven, release to combustion control for modulation, where provided.
 - (b) If not proven, establish safety shutdown.

5.6.2.6.3 Modulation. Modulation, where provided, shall be accomplished by a combustion control system.

5.6.2.6.4 Shutdown.

5.6.2.6.4.1 Normal Shutdown. For automatic (i.e., recycling) boilers, high steam pressure, high water temperature, or low water level (not determined by the auxiliary low water cutout) shall accomplish a normal shutdown, and the burner shall be allowed to recycle when steam pressure, water temperature, or water level has returned to within the preset operating range.

5.6.2.6.4.2 Normal Shutdown Cycle. The normal shutdown cycle shall accomplish the following in the listed order:

- (1) Shut off the fuel supply to the main burner.
- (2) For oil, proceed as follows:
 - (a) If a Class 1 igniter is used, use the manufacturer's instructions to purge the main burner oil gun prior to continuing the normal shutdown.
 - (b) Where used, open the recirculating valve.
 - (c) Shut off atomizing medium, if required by operating procedures.
- (3) Shut off the fuel supply to the igniter if in operation.
- (4) Perform a postpurge of the furnace and boiler gas passes; the duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (5) Shut down the fan, if required by operating procedures.

5.6.2.6.4.3* Safety Shutdown. Any of the conditions in 5.6.2.6.4.3(A) or 5.6.2.6.4.3(B) shall accomplish a safety shutdown, and the burner shall not be allowed to recycle 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 prior to restarting.

(A) Oil conditions shall include the following:

- (1) Low fuel pressure
- (2) Low temperature of heated oils
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy
- (6) Power failure
- (7) Low water level as determined by the auxiliary low water cutout
- (8) Loss of atomizing medium, where used, as interlocked by flow or two pressure switches (one located at the service connection and the other at the burner, either one of which shall initiate a safety shutdown on low pressure)
- (9) Excessive steam pressure or water temperature
- (10) High temperature of heated oil

(B) Gas conditions shall include the following:

- (1) High gas pressure
- (2) Low gas pressure
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy
- (6) Power failure
- (7) Low water level as determined by the auxiliary low water cutout
- (8) Excessive steam pressure or water temperature

5.6.2.6.4.4 Safety Shutdown Cycle. The safety shutdown cycle shall accomplish the following in the listed order and shall activate an alarm:

- (1) Shut off the fuel supply to the main burner.
- (2) Shut off the fuel supply and interrupt spark to the igniter if in operation.
- (3) For oil, proceed as follows:
 - (a) Where used, open the recirculating valve.
 - (b) Where used, shut off the atomizing medium, if required by operating procedures.
- (4) Where the inerting system is used, energize it simultaneously with 5.6.2.6.4.4(1).
- (5) Perform a postpurge of the furnace and boiler gas passes. The duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (6) After postpurge, shut down the fan, if desired.
- (7) Require manual reset.

5.6.3 Automatic (Nonrecycling) Systems for Watertube Boilers.

5.6.3.1 The provisions of 5.6.2.1, 5.6.2.3, 5.6.2.5, and 5.6.2.6 shall apply.

5.6.3.2 The provisions of 5.6.2.6.4.1 shall not apply.

5.6.3.3 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle.

5.6.3.4 A trained operator shall initiate the restart.

5.6.4 Automatic (Recycling) Systems for Firetube Boilers.

5.6.4.1 Underlying all the requirements of 5.6.4 shall be the premise that the equipment is in accordance with Section 5.4, that the boiler has been placed in service in accordance with Section 5.6, and that the operating water level has been established.

5.6.4.2 An automatic (i.e., recycling) unit shall recycle on high steam pressure, high water temperature, or low water level (not determined by the auxiliary low water cutout) and perform four major functions as given in 5.6.4.2.1 through 5.6.4.2.4.4(B).

5.6.4.2.1 Prefiring Cycle. The prefiring cycle shall accomplish the following steps in the listed order, except that the order of steps 5.6.4.2.1(5), 5.6.4.2.1(6), and 5.6.4.2.1(7) in the sequence shall be permitted to vary:

- (1) Prove the fuel safety shutoff valves are closed.
- (2) Prove no flame is present at burner.
- (3) Start the fan.
- (4) Satisfy the fan interlock.
- (5) Where an atomizing medium is used and if not already on, admit the medium to the main burner.
- (6) Where an atomizing medium is used, satisfy the atomizing medium interlocks.
- (7) Satisfy the fuel interlocks.
- (8) Prove purge airflow by satisfying one of the following two items:
 - (a) Air pressure and "open damper" interlocks for all dampers in the flow path
 - (b) Airflow interlock
- (9) Purge airflow must reach no less than 70 percent of the airflow required at maximum continuous capacity of the unit.
- (10) The purge of the furnace and boiler gas passes must be for at least four air changes and under the following conditions:
 - (a) During the purge, the air damper must be driven to the full open position.
 - (b) Airflow during the time to open the damper and return it to light-off position is permitted to be included in computing the time for four air changes.
- (11) Prove the control system is in light-off position.
- (12) If a flue gas recirculation system is supplied, then it shall be purged per the manufacturer's instructions.

5.6.4.2.2 Light-Off Cycle. The light-off cycle shall accomplish the following in the listed order:

- (1)*Energize the ignition transformer and igniter fuel valves.
- (2) Prove the igniter flame within 10 seconds of the energization of the igniter fuel valves and proceed as follows (for a Class 3 special igniter, proof of igniter operation is not required):
 - (a) If proven, admit fuel to main burner.
 - (b) If not proven, establish safety shutdown.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, shut off the igniter.
- (4) Prove the main flame and proceed as follows:
 - (a) If proven, release to modulating control where provided.
 - (b) If not proven, establish safety shutdown.

5.6.4.2.3 Modulation. Modulation, where provided, shall be accomplished by a combustion control system.

5.6.4.2.4 Shutdown.

5.6.4.2.4.1 Normal Shutdown Cycle. The normal shutdown cycle shall accomplish the following in the listed order:

- (1) Shut off the fuel supply to the main burner.
- (2) For oil, proceed as follows:

- (a) Where used, open the recirculating valve.
- (b) Where the manufacturer's instructions permit, purging the main burner oil gun in conjunction with the operation of its igniter is permitted.
- (c) Where used, shut off the atomizing medium, if required by operating procedures.

- (3) Perform a postpurge of the furnace and boiler gas passes. The duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (4) After postpurge, shut down the fan, if required by operating procedures.

5.6.4.2.4.2 Normal Shutdown. High steam pressure, high water temperature, or low water (not determined by the auxiliary low water cutoff) shall accomplish a normal shutdown, and the burner shall be allowed to recycle when steam pressure, water temperature, or water level has returned to within the preset operating range.

5.6.4.2.4.3 Safety Shutdown Cycle. The safety shutdown cycle shall accomplish the following in the listed order:

- (1) Shut off the fuel supply to the main burner.
- (2) Shut off the fuel supply and interrupt the spark to the igniter, if in operation.
- (3) For oil, proceed as follows:
 - (a) Where used, open the recirculating valve.
 - (b) Where used, shut off the atomizing medium, if required by operating procedures.
- (4) Where the inerting system is used, energize it simultaneously with 5.6.4.2.4.3(1).
- (5) Perform a postpurge of the furnace and boiler gas passes. The duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (6) After postpurge, shut down the fan, if required by operating procedures.
- (7) Require manual reset.

5.6.4.2.4.4* Safety Shutdown. Any of the conditions in 5.6.4.2.4.4(A) or 5.6.4.2.4.4(B) shall accomplish a safety shutdown, and the burner shall not be allowed to recycle 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 prior to restarting.

(A) Oil conditions shall include the following:

- (1) Low oil pressure
- (2) Low temperature of heated oils
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy
- (6) Low water level as determined by the auxiliary low water cutout
- (7) Loss of atomizing medium where used
- (8) Excessive steam pressure or water temperature
- (9) Power failure
- (10) High temperature of heated oil

(B) Gas conditions shall include the following:

- (1) High gas pressure
- (2) Low gas pressure
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy



- (6) Low water level as determined by the auxiliary low water cutout
- (7) Excessive steam pressure or water temperature
- (8) Power failure

5.6.5 Automatic (Nonrecycling) Systems for Firetube Boilers.

5.6.5.1 The provisions of 5.6.4.1 and 5.6.4.2 shall apply, except that 5.6.4.2.4.2 shall not apply.

5.6.5.2 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle.

5.6.5.3 A trained operator shall initiate the restart.

5.6.6 Manual Supervised Burner Management Systems for Oil-Fired Watertube Boilers.

5.6.6.1 For oil-fired watertube boilers, the steps listed in Table 5.6.6.1(a) through Table 5.6.6.1(d) shall be taken by a trained operator when starting a manual supervised unit, and the indicated interlocks shall be satisfied at each step.

5.6.6.1.1 Fuel pressure and temperature, atomizing medium, control system energy, power, and water level shall have been established.

5.6.6.1.2 When interlocks have been satisfied, this fact shall be indicated to the operator.

5.6.6.2 The fuel to be fired shall be selected.

5.6.6.2.1 The alternate fuel system shall be placed in a non-firing condition.

5.6.6.2.2 The supervisory or safety shutoff valve(s) shall be closed.

5.6.6.3 An igniter as specified in 5.4.4.1.1 shall be provided.

5.6.6.4* Any of the following conditions shall accomplish a safety shutdown, and the burner shall not be restarted until a trained operator goes out to the boiler, determines the cause of the shutdown, and takes the necessary corrective action to ensure that conditions are within specified operating limits prior to restarting:

- (1) Low pressure in the fuel supply
- (2) Loss of combustion air supply
- (3) Loss or failure to establish flame
- (4) Loss of control system actuating energy
- (5) Power failure
- (6) Low water level as determined by the auxiliary low water cutout
- (7) Loss of atomizing medium
- (8) Excessive steam pressure or water temperature

5.6.6.5 Where oil heating is provided, either of the following conditions shall cause alarms to sound:

- (1) Low oil temperature
- (2) High oil temperature

5.6.7 Manual Supervised Burner Management Systems for Gas-Fired Watertube Boilers.

5.6.7.1 For gas-fired watertube boilers, the steps listed in Table 5.6.7.1(a) through Table 5.6.7.1(d) shall be taken by a

trained operator when starting a manual supervised unit, and the indicated interlocks shall be satisfied at each step.

5.6.7.1.1 Control system energy, power, and water level shall have been established.

5.6.7.1.2 When interlocks have been satisfied, this fact shall be indicated to the operator.

5.6.7.2 The fuel to be fired shall be selected.

5.6.7.2.1 The alternate fuel system shall be placed in a non-firing condition.

5.6.7.2.2 The supervisory or safety shutoff valve(s) shall be closed.

5.6.7.3 An igniter as specified in 5.4.4.1.1 shall be provided.

5.6.7.4 Any of the following conditions shall accomplish a safety shutdown, and the burner shall not be restarted until a trained operator goes out to the boiler, determines the cause of the shutdown, and takes the necessary corrective action to ensure that conditions are within specified operating limits prior to restarting:

- (1) High gas pressure
- (2) Low gas pressure
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control systems actuating energy
- (6) Power failure
- (7) Low water level as determined by the auxiliary low water cutout
- (8) Excessive steam pressure or water temperature

5.6.8 Soot Blowing. Where soot blowers are used, the following shall apply:

- (1) Soot blowing at nonoptimum air-fuel ratios has been known to lead to explosive formations of air-soot clouds within the boiler and shall be avoided.
- (2) Soot blowers shall be operated only while burners are firing at rates such that the burner flame cannot be extinguished.
- (3) Boilers that are equipped with automatic soot-blowing equipment shall have their controls interlocked to prevent operation when the burner is shut down or in the prefiring or light-off cycles.

5.7 Simultaneous Firing of Oil and Gas Fuels.

5.7.1* General. The equipment and procedures required in 5.7.1.1 through 5.7.1.3 shall be used to avoid a hazardous furnace condition when firing oil and gas simultaneously in a single burner boiler on a continuous basis.

5.7.1.1 Class 1 or Class 2 igniters shall be used during the light-off of the second fuel as required by the manufacturer or as established by test.

5.7.1.2 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.7.1.3 The initial prefiring cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.

Table 5.6.6.1(a) Oil-Fired Watertube Boilers: Prefiring Cycle

Operator Actions*	Interlock Functions
(1) Check that fuel safety or supervisory shutoff valve is closed.	(1) Fuel safety or supervisory shutoff valve is closed.
(2) Start fan.	(2) Fan is on.
(3) Where used, open atomizing medium valve.	(3) Atomizing medium supply is available.
(4) Open damper(s) to purge position.	(4) (a) Air pressure and open damper(s) or (b) airflow. [See 5.6.2.6.1(9) and 5.6.2.6.1(10).]
(5) Start purge timer.	(5) Purge is complete.
(6) Place damper and fuel control valve in light-off position.	(6) Damper and fuel control valve are in light-off position. If light-off airflow is less than purge airflow rate, start light-off time limit timer.
(7) None.	(7) Spark, igniter, and main safety shutoff valves are ready for operation.

*In listed order.

Table 5.6.6.1(b) Oil-Fired Watertube Boilers: Light-Off Cycle

Operator Actions*	Interlock Functions
(1) Energize ignition transformer and igniter safety shutoff valves.	(1) Prove igniter flame within 10 seconds of energization of igniter fuel valves. (For Class 3 special igniter, proof of igniter operation is not required.)
(2) Open fuel safety shutoff valve to main burner.	(2) None.
(3) Close recirculating valve, where used.	(3) None.
(4) Open manual fuel shutoff valve.	(4) Prove main flame within 10 seconds for Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils. Close igniter safety shutoff valve(s).
(5) Bring unit to present operating pressure at rate specified by manufacturer, maintaining air-fuel ratios as established by tests.	(5) None.
(6) On reaching preset pressure range, change to automatic combustion control.	(6) None.

*In listed order.

Table 5.6.6.1(c) Oil-Fired Watertube Boilers: Normal Shutdown Cycle

Operator Actions*	Interlock Functions
(1) Shut off fuel supply to main burner.	(1) Fuel safety shutoff valve(s) to main burner is closed.
(2) Open fuel recirculating valve, where used.	(2) None.
(3) Shut off atomizing medium, where used.	(3) None.
(4) Remove fuel atomizer.	(4) None.
(5) Perform postpurge of furnace and boiler gas passes. Duration of postpurge must be no less than 15 seconds at airflow rate not exceeding that at which unit was shut down.	(5) None.
(6) After postpurge, fan can be permitted to be shut down.	(6) None.

*In listed order.

Table 5.6.6.1(d) Oil-Fired Watertube Boilers: Safety Shutdown Cycle

Operator Actions*	Interlock Functions
(1) None.	(1) Shut off fuel supply to main burner; shut off fuel supply and interrupt spark to igniter, if in operation.
(2) Perform postpurge of furnace and boiler gas passes. Duration of postpurge must be no less than 15 seconds at airflow rate not exceeding that at which unit was shut down.	(2) None.
(3) After postpurge, fan can be permitted to be shut down.	(3) None.

*In listed order.

Table 5.6.7.1(a) Gas-Fired Watertube Boilers: Prefiring Cycle

Operator Actions*	Interlock Functions
(1) Check that gas safety shutoff valves are closed.	(1) Gas safety shutoff valves are closed.
(2) Start fan.	(2) Fan motor is on.
(3) Open damper(s) to purge position.	(3) (a) Air pressure and open damper(s) or (b) airflow. [See 5.6.2.6.1(9) and 5.6.2.6.1(10).]
(4) Start purge timer.	(4) Purge is complete.
(5) Place damper and gas control valve in light-off position.	(5) Damper and fuel control valve are in light-off position. If light-off airflow is less than purge airflow rate, start light-off time limit timer.
(6) None.	(6) Spark and igniter and main safety shutoff valves are ready for operation.

*In listed order.

Table 5.6.7.1(b) Gas-Fired Watertube Boilers: Light-Off Cycle

Operator Actions*	Interlock Functions
(1) Energize ignition transformer and igniter safety shutoff valve(s).	(1) Prove igniter flame within 10 seconds of the energization of igniter fuel valves. (For Class 3 special igniter, proof of igniter operation is not required.)
(2) Open gas safety shutoff valves to main burner.	(2) Prove main flame is within 10 seconds. Close igniter safety shutoff valve(s).
(3) Bring unit to preset operating pressure at rate specified by manufacturer, maintaining air-fuel ratios as established by tests.	(3) None.
(4) On reaching preset range, change to automatic combustion control.	(4) None.

*In listed order.

Table 5.6.7.1(c) Gas-Fired Watertube Boilers: Normal Shutdown Cycle

Operator Actions*	Interlock Functions
(1) Shut off gas supply to main burner and to igniter, if in operation, and interrupt spark.	(1) None.
(2) Perform postpurge of furnace and boiler gas passes. Duration of postpurge must be no less than 15 seconds at airflow rate not exceeding that at which unit was shut down.	(2) None.
(3) After postpurge, fan can be permitted to be shut down.	(3) None.

*In listed order.

Table 5.6.7.1(d) Gas-Fired Watertube Boilers: Safety Shutdown Cycle

Operator Actions*	Interlock Functions
(1) None.	(1) Shut off gas supply to main burner, shut off fuel supply, and interrupt spark to igniter, if in operation. Where used, simultaneously energize inerting system.
(2) Perform postpurge of furnace and boiler gas passes. Duration of postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which unit was shut down.	(2) None.
(3) After postpurge, fan can be permitted to be shut down.	(3) None.

*In listed order.



5.7.2 Equipment Requirements. The following equipment shall be provided for continuous firing of both oil and gas:

- (1) A burner that is capable of burning either oil or gas fuel individually or both fuels simultaneously
- (2) A combustion control system that is capable of performing the following functions:
 - (a) Metering and totaling the inputs from both gas and oil fuels alone or in any combination
 - (b) Proportioning the total fuel input of each fuel individually or in any combination to total airflow in order to maintain the air-fuel ratio within design limits
 - (c) Limiting fuel demand to be less than measured airflow and limiting air demand to be greater than measured fuel flow
 - (d) For items 5.7.2(2)(a) through 5.7.2(2)(c), a control system that is designed to accommodate a fixed amount of secondary fuel without metering and totaling all fuels shall be permitted, provided the system maintains air-fuel ratios within design limits throughout the entire operating range of the burner
 - (e) Limiting total fuel input to the maximum capacity of the boiler
 - (f) Controlling and maintaining a minimum airflow rate that takes into account simultaneous fuel inputs
 - (g) Controlling and maintaining minimum input rates of each fuel
 - (h) Requiring a stable return to design air-fuel ratio after the trip or shutdown of either fuel
- (3) A safety interlock system with the following capabilities:
 - (a) Meets the requirements of 5.4.6 for each fuel being fired
 - (b) Requires, on an interlock action specific to only one of the fuels being fired, that this particular fuel automatically shut down with operation continuing on the unaffected fuel in a stable manner; shutdown of both fuels permitted
 - (c) Requires that both the first and second fuels be introduced with their flow control valves in light-off positions
 - (d) Provides for the introduction of the second fuel without requiring a boiler purge
 - (e) Requires a manual reset following any interlock shutdown
 - (f) Prohibits the simultaneous light-off of both fuels
 - (g) Requires flame detector(s) in accordance with 5.4.4 to supervise any of the following conditions:
 - i. Igniter flame as permitted by igniter class
 - ii. Gas firing
 - iii. Oil firing
 - iv. Combined gas and oil firing
 - (h) Burner flame detectors permitted to supervise multiple fuels

5.7.3 Simultaneous Firing of Oil and Gas Fuels (Automated Second Fuel Start). This subsection shall define the requirements and procedures for an automated light-off and subsequent operation on a continuous basis of a second fuel.

5.7.3.1 Equipment Requirements. Equipment requirements shall be in accordance with 5.7.2 and 5.7.3.2.

5.7.3.2 A fuel transfer mode with the following functions shall be provided:

- (1) A gas-firing mode in which oil cannot be fired

- (2) An oil-firing mode in which gas cannot be fired
- (3) A gas-oil-firing mode that permits simultaneous firing of both fuels
- (4) The capability to signal the combustion control system to bias up the airflow, to position the control valve for the second fuel to light-off, and to open the safety shutoff valve(s) of the fuel being introduced
- (5) The capability to bias up the airflow by a preset value in response to a fuel transfer signal while the airflow remains in automatic mode

5.7.3.3 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the light-off cycle for the oil shall accomplish the following in the listed order:

- (1) Place fuel gas flow and airflow control loops in automatic mode.
- (2) Satisfy oil fuel system interlocks.
- (3) Install oil atomizer.
- (4) Open atomizing medium shutoff valve.
- (5) Select dual fuel firing.
- (6) Set oil control valve in light-off position.
- (7) Prove fuel oil control valve in light-off position.
- (8) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (9) Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (10) Open oil safety shutoff valves and establish oil flow through the burner.
- (11) Gradually remove airflow bias.
- (12) Verify stable flame and that the air-fuel ratio is within design limits.
- (13) Place the combustion control system into the required mode for controlling input rate of each fuel.
- (14) Shut down igniter as required.

5.7.3.4 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the light-off cycle for the gas shall accomplish the following in the listed order:

- (1) Place fuel oil flow and airflow control loops in automatic mode.
- (2) Satisfy gas fuel system interlocks.
- (3) Select dual fuel firing.
- (4) Set gas control valve in light-off position.
- (5) Prove fuel gas control valve in light-off position.
- (6) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel gas in light-off.
- (7) Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (8) Close the vent valve (where used), open the gas safety shutoff valves, and establish gas flow to the burner.
- (9) Gradually remove airflow bias.
- (10) Verify stable flame and that the air-fuel ratio is within design limits.
- (11) Place the combustion control system into the required mode for controlling input rate of each fuel.
- (12) Shut down igniter as required.

5.7.4 Simultaneous Firing of Oil and Gas Fuels (Manual Second-Fuel Start). This subsection shall define the requirements and procedures required for the manual light-off and subsequent operation on a continuous basis of a second fuel.

5.7.4.1 Equipment Requirements. Equipment requirements shall be in accordance with 5.7.2 and 5.7.4.2.

5.7.4.2 The combustion control system shall have the capability to manually bias up the airflow while the airflow remains in automatic mode.

5.7.4.2.1 Either the oxygen trim or airflow control station shall be permitted to be used.

5.7.4.3 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the light-off cycle for the oil shall accomplish the following in the order listed:

- (1) Verify that fuel gas flow and airflow control loops are in automatic mode.
- (2) Satisfy oil fuel system interlocks.
- (3) Install oil atomizer.
- (4) Open atomizing medium shutoff valve.
- (5) Place oil control valve in light-off position.
- (6) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (7) Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (8) Open oil safety shutoff valves and establish oil flow through the burner.
- (9) Gradually remove airflow bias.
- (10) Verify stable flame and that the air-fuel ratio is within design limits.
- (11) Place the combustion control system into the required mode for controlling the input rate of each fuel.
- (12) Shut down igniter as required.

5.7.4.4 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the procedure shall be in the following order:

- (1) Verify that fuel oil flow and airflow control are in the automatic mode.
- (2) Satisfy gas fuel system interlocks.
- (3) Place the gas control valve in light-off position.
- (4) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (5) Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (6) Close the vent valve (where used), open the gas safety shutoff valves, and establish gas flow to the burner.
- (7) Gradually remove airflow bias.
- (8) Verify stable flame and that the air-fuel ratio is within design limits.
- (9) Place the combustion control system into the required mode for controlling input rate of each fuel.
- (10) Shut down igniter as required.

5.7.5 Shutdown Cycle.

5.7.5.1 Normal Oil Shutdown Cycle. The normal shutdown procedure for oil while continuing to fire gas shall be in the following order:

- (1) Reduce the oil flow to the light-off rate.
- (2) Shut off the oil supply to the burner and open the oil recirculating valve, where used.
- (3) Verify stable flame and adjust air-fuel ratio in preparation for purging the oil atomizer.

- (4) Purge oil passages of the oil atomizer.
- (5) Shut off the atomizing medium, if required.
- (6) Remove the oil atomizer from the burner, if required.
- (7) Verify stable flame and that the air-fuel ratio of the gas fire is within design limits.

5.7.5.2 Normal Gas Shutdown Cycle. The normal shutdown procedure for gas while continuing to fire oil shall be in the following order:

- (1) Reduce the gas flow to the light-off rate.
- (2) Shut off the gas supply to the burner.
- (3) Verify stable flame and that the air-fuel ratio of the oil fire is within design limits.

5.7.5.3* Oil Safety Shutdowns.

5.7.5.3.1 Any of the following operating conditions shall accomplish a safety shutdown of the oil supply to the burner (i.e., fuel trip):

- (1) Low fuel pressure
- (2) Low temperature of heated oils
- (3) Loss of atomizing medium, where used, as interlocked by flow or two pressure switches, one located at the service connection and the other at the burner, either one of which shall initiate a safety shutdown on low pressure
- (4) High temperature of heated oil

5.7.5.3.2 A complete boiler safety shutdown shall occur if oil is the only fuel being fired.

5.7.5.4 Gas Safety Shutdowns.

5.7.5.4.1 Either of the following conditions shall accomplish a safety shutdown of the gas supply to the burner (i.e., fuel trip):

- (1) High gas pressure
- (2) Low gas pressure

5.7.5.4.2 A complete boiler safety shutdown shall occur if gas is the only fuel being fired.

5.7.5.5 Boiler Safety Shutdowns. Any of the following conditions shall accomplish a complete safety shutdown of the boiler:

- (1) Loss of combustion air supply
- (2) Loss of or failure to establish flame
- (3) Loss of control system actuating energy
- (4) Power failure
- (5) Excessive steam pressure or water temperature
- (6) Low water level as determined by the auxiliary low water cutout
- (7) The occurrence of either an oil or a gas fuel trip when only that fuel is being fired

5.8 Simultaneous Firing of Oil and Gas for Fuel Transfer Only.

5.8.1* General. The equipment and procedures of 5.8.1.1 through 5.8.1.4 shall be used to avoid a hazardous furnace condition when operation of the boiler is transferred from fuel oil to fuel gas or from fuel gas to fuel oil without requiring a shutdown of the boiler.

5.8.1.1 Simultaneous Firing for Fuel Transfer on a Continuous Basis. When the combustion control system and the burner management system are both designed for fuel transfer and simultaneous firing of oil and gas fuels on a continuous basis, the requirements of Section 5.7 shall apply.

5.8.1.2 Class 1 or Class 2 igniters shall be used during the fuel transfer as required by the manufacturer or established by test.



5.8.1.3 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.8.1.4 The initial prefire cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.

5.8.2 Required Equipment. The following equipment shall be required:

- (1) A burner that is capable of firing the two fuels simultaneously during the transfer period
- (2) A combustion control system that is capable of performing the following functions:
 - (a) Proportioning fuel flow for each fuel individually
 - (b) Limiting total fuel input to the maximum capacity of the boiler
 - (c) Controlling a minimum airflow rate
 - (d) Controlling minimum input rates of each fuel
 - (e) Providing a stable return to design air-fuel ratio after the trip or shutdown of either fuel
- (3) A fuel transfer mode that includes the following:
 - (a) A gas-firing mode in which oil cannot be fired
 - (b) An oil-firing mode in which gas cannot be fired
 - (c) A gas-oil-firing mode that permits simultaneous firing of both fuels, provided all interlocks for both fuels are satisfied, including light-off position for both fuel valves
 - (d) A control device, transfer timer, and an alarm for 5.8.2(3)(c), to limit continuous operation in this mode
- (4) A safety interlock system with the following capabilities:
 - (a) Meets the requirements of 5.4.6 for each fuel being fired
 - (b) Provides an independent interlock to each fuel being fired that automatically shuts down the affected fuel with operation continuing on the unaffected fuel in a stable manner; shutdown of both fuels is permitted
 - (c) Provides that both the first and second fuels be introduced with their flow control valves in light-off positions
 - (d) Provides an interlock action that will trip either fuel should its respective flow control valve leave a predetermined setting during fuel transfer
 - (e) Provides for the introduction of the second fuel without requiring a boiler purge
 - (f) Requires a manual reset following any interlock shutdown
 - (g) Prohibits the simultaneous light-off of both fuels
 - (h) Provides detector(s) to supervise any of the following conditions:
 - i. Igniter flame as permitted by igniter class
 - ii. Gas firing
 - iii. Oil firing
 - iv. Combined gas and oil firing
 - (i) Burner flame detectors shall be permitted to supervise multiple fuels.

5.8.3 Simultaneous Firing of Oil and Gas for Fuel Transfer Only (Automated Transfer). This subsection shall define the requirements and procedures to be used for an automated transfer of operation from one fuel to a second fuel without requiring a shutdown of the burner.

5.8.3.1 Required Equipment. Equipment requirements shall be in accordance with 5.8.2 and 5.8.3.1.1 through 5.8.3.1.3.

5.8.3.1.1 The combustion control system shall have the capability to automatically increase the airflow by a preset value in response to a fuel transfer signal.

5.8.3.1.2 The airflow shall be held in a fixed position for the transfer period.

5.8.3.1.3 The fuel transfer mode shall have the capability to signal the combustion control system to increase airflow and open the safety shutoff valve(s) of the fuel being introduced.

5.8.3.2 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the transfer cycle from gas to oil shall be in the following order:

- (1) Satisfy oil fuel system interlocks.
- (2) Install an oil atomizer.
- (3) Open the atomizing medium shutoff valve.
- (4) Select dual fuel firing.
- (5) Set the gas-firing rate to light-off flow.
- (6) Set the oil control valve in the light-off position.
- (7) Prove fuel gas and fuel oil control valves are in light-off position.
- (8) Gradually increase airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (9) Establish ignition energy in accordance with the manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2.2 or 5.6.2.6.2.3 for operating requirements.
- (10) Open the oil safety shutoff valves and establish oil flow to the burner.
- (11) Verify stable flame and that the air-fuel ratio is within design limits.
- (12) Select the oil firing mode, which automatically trips the gas safety shutoff valves.
- (13) Gradually remove airflow increase.
- (14) Return the combustion control system and burner firing rate to automatic operation.
- (15) Shut down igniter as required.

5.8.3.3 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the transfer cycle from oil to gas shall be in the following order:

- (1) Establish the gas fuel system to satisfy interlocks.
- (2) Select the dual fuel firing mode.
- (3) Set the oil-firing rate to light-off flow.
- (4) Set the gas control valve to the light-off position.
- (5) Prove fuel gas and fuel oil control valves are in light-off position.
- (6) Increase airflow by a preset amount corresponding to fuel input of fuel gas in light-off.
- (7) Establish ignition energy in accordance with the manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2.2 or 5.6.2.6.2.3 for operating requirements.
- (8) Close the vent valve (where used), open the gas safety shutoff valves, and establish gas flow to the burner.
- (9) Verify stable flame and that the air-fuel ratio is within design limits.
- (10) Select the gas-firing mode, which automatically trips the oil safety shutoff valves.
- (11) Gradually remove airflow increase.
- (12) Return the combustion control system and burner-firing rate to automatic operation.
- (13) Purge the oil gun into furnace, if required.
- (14) Close atomizing medium shutoff valve, if required.
- (15) Remove oil atomizer, if required.
- (16) Shut down igniter as required.

5.8.4 Simultaneous Firing of Oil and Gas for Fuel Transfer Only (Manual Transfer). This subsection shall define the requirements and procedures to be used for a manual transfer of operation from one fuel to a second fuel without requiring a shutdown of the burner.

5.8.4.1 Required Equipment. Equipment requirements shall be in accordance with 5.8.2 and 5.8.4.1.1 through 5.8.4.1.3.

5.8.4.1.1 The combustion control system shall have the capability to manually adjust the airflow.

5.8.4.1.2 Manual shutoff valves shall be provided at the burner, downstream of the safety shutoff valves for each fuel.

5.8.4.1.3 A pressure gauge shall be provided in each fuel line downstream of the manual shutoff valve.

5.8.4.2 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the procedure to transfer from gas to oil shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions as required.
- (2) Confirm that the manual oil valve at the burner is closed.
- (3) Satisfy oil fuel system interlocks.
- (4) Install an oil atomizer.
- (5) Open the atomizing medium shutoff valve.
- (6) Place the combustion control system in manual mode.
- (7) Reduce the gas-firing rate to light-off flow.
- (8) Place the oil control valve in the light-off position.
- (9) Place the fuel transfer in oil/gas mode, with the following results:
 - (a) When the oil safety interlocks are satisfied, the oil safety shutoff valves open.
 - (b) Fuel oil pressure now will be upstream of the manual oil valve at the burner.
- (10) Slowly close the manual gas shutoff valve while observing the gas pressure downstream of the valve until the gas pressure starts to drop. At this point, the gas flow rate is controlled by the manual valve instead of by the control valve.
- (11) Slowly close the manual gas valve while simultaneously opening the manual oil valve to light the oil flame from the gas flame and proceed as follows:
 - (a) Continue to increase the oil-firing rate while cutting back on the gas-firing rate to maintain a constant heat input of the combined fuels to the burner, until the manual gas valve is closed and the manual oil valve is fully open.
 - (b) Excess air must be maintained at all times by continuously observing the burner flame or by observing the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (12) Place the fuel transfer mode in the oil position.
- (13) Return the combustion control system and burner-firing rate to automatic operation.
- (14) Shut down igniter as required.

5.8.4.3 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the procedure to transfer from oil to gas shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions.

- (2) Confirm that the manual gas valve at the burner is closed.
- (3) Satisfy gas fuel system interlocks.
- (4) Place the combustion control system in manual mode.
- (5) Reduce the oil-firing rate to light-off flow.
- (6) Place the gas control valve in the light-off position.
- (7) Place fuel transfer in the gas/oil mode, with the following results:
 - (a) When the gas safety interlocks are satisfied, the gas safety shutoff valves open.
 - (b) Gas pressure now will be upstream of manual gas valve at the burner.
- (8) Slowly close the manual oil valve while observing the oil pressure downstream of the valve until the oil pressure starts to drop. At this point, the oil flow is controlled by the manual valve instead of by the control valve.
- (9) Slowly close the manual oil valve while simultaneously opening the manual gas valve to light the gas flame from the oil flame, then proceed as follows:
 - (a) Continue to increase the gas-firing rate while cutting back on the oil-firing rate to maintain a constant heat input of the combined fuels to the burner until the manual oil valve is closed and the manual gas valve is fully open.
 - (b) Excess air must be maintained at all times by continuously observing the burner flame or by observing the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (10) Place the fuel transfer mode in the gas position. The oil safety shutoff valves close.
- (11) Return the combustion control system and burner-firing rate to automatic operation.
- (12) Purge the oil gun into the furnace, if required.
- (13) Shut off the atomizing medium, if required.
- (14) Remove the oil atomizer from burner, if required.
- (15) Shut down the igniter as required.

5.8.5 Safety Shutdowns. Safety shutdowns shall be initiated in accordance with 5.7.5.3 through 5.7.5.5.

5.9 Dual Oil Atomizers in a Single Burner.

5.9.1* General. Where a burner is equipped with main and auxiliary oil atomizers for the purpose of changing atomizers for maintenance without affecting the boiler load, the changeover of atomizers shall be carried out manually under stable firing conditions by a trained operator.

5.9.1.1 Class 1 or Class 2 igniters shall be used during the fuel transfer as required by the manufacturer or established by test.

5.9.1.2 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.9.1.3 The initial prefiring cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.



5.9.2 Required Equipment. The following equipment shall be required:

- (1) A burner that is capable of firing two oil atomizers simultaneously during the transfer period
- (2) A combustion control system that is capable of limiting the total fuel input to the maximum capacity of the boiler and that has the capability to manually adjust the airflow
- (3) A safety interlock system in accordance with 5.4.6 that also prohibits the simultaneous light-off of both atomizers
- (4) Manual oil shutoff valves at the burner, downstream of the safety shutoff valves for each atomizer
- (5) A pressure gauge in the fuel line downstream of each manual shutoff valve
- (6) Manual atomizing media shutoff valves for each atomizer except on mechanically atomized systems

5.9.3 Oil Atomizer Changeover Procedure. The procedures for a manual transfer of operation from one oil atomizer (main or auxiliary) to a second oil atomizer (auxiliary or main) without requiring a shutdown of the burner shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions.
- (2) Confirm that the manual oil valve at the burner for the atomizer to be started is closed.
- (3) Install the second oil atomizer.
- (4) Place the combustion control system in manual mode.
- (5) Slowly close the manual shutoff valve while observing the oil pressure downstream of the valve until the oil pressure starts to drop. At this point, the oil flow rate is controlled by the manual valve instead of by the control valve.
- (6) For nonmechanically atomized oil atomizers, slowly open the second atomizing medium shutoff valve until it is fully open.
- (7) Slowly close the manual oil valve for the atomizer in service while simultaneously opening the manual oil valve of the second atomizer to light the second atomizer from the first and proceed as follows:
 - (a) Continue to slowly increase the oil-firing rate on the second atomizer while cutting back on the firing rate of the first atomizer to maintain a constant heat input of the combined atomizers until the manual valve of the first atomizer is closed and the manual oil valve of the second atomizer is fully open.
 - (b) Excess air shall be maintained at all times by continuous observation of the burner flame or by observation of the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (8) Close the atomizing media shutoff valve on the first atomizer, if present.
- (9) Return the combustion control system and burner-firing rate to automatic operation.
- (10) Shut down the igniter as required.

Chapter 6 Multiple Burner Boilers

6.1 Application.

6.1.1 This chapter shall be used in conjunction with Chapter 4 and requires the coordination of operation procedures, control systems, interlocks, and structural design. Where conflicts exist, the requirements of this chapter shall apply.

6.1.2 The sections of this code that are common to all fuels to be burned in a multiple burner boiler shall be used in conjunction with those sections that are applicable to a specific fuel being utilized.

6.1.3 Section 6.5 shall apply to minimizing the risk of negative furnace draft in excess of furnace structural capability.

6.1.4 Section 6.6 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing fuel gas as defined in 3.3.64.

6.1.5 Section 6.7 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing fuel oil as defined in 3.3.63.3.

6.1.6 Section 6.8 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing pulverized coal fuel as defined in 3.3.63.2.1.

6.1.7 This chapter shall also apply to fired flue gas reheaters (duct burners) installed in the flue gas path downstream of a multiple burner boiler furnace.

6.2 Purpose.

6.2.1 The purpose of this chapter shall be to contribute to operating safety and to prevent furnace explosions and implosions in multiple burner boiler installations from the forced draft fan inlet(s) to the stack inlet.

6.2.2 This chapter establishes minimum requirements that shall be followed for the design, installation, operation, and maintenance of multiple burner boilers and their fuel-burning, air supply, and combustion products removal systems.

6.2.3* The user of this chapter shall recognize the complexity of firing fuel with regard to the type of equipment and the characteristics of the fuel.

6.3 Mechanical Equipment Requirements.

6.3.1 General requirements for mechanical equipment shall be in accordance with Sections 4.6 through 4.16.

6.3.2 Forced draft (FD) and induced draft (ID) fans shall include all fans whose purpose is to supply air for combustion or remove products of combustion, including associated booster fans, and exclude fans in the pulverized coal system.

6.3.3 Fuel Gas and Fuel Oil Safety Shutoff Valves.

6.3.3.1 A header safety shutoff valve and individual burner safety shutoff valves shall be provided.

6.3.3.2 Proof of closure shall be provided for all header and burner safety shutoff valves.

6.3.3.3 Multiple burners supplied from a common set of burner safety shutoff valves shall be treated as a single (individual) burner. (See 6.6.7.1.3 and 6.7.7.1.3 for two-burner units.)

6.3.3.4 Where fuel gas or fuel oil igniters are provided, a common igniter fuel header safety shutoff valve and individual igniter safety shutoff valves shall also be provided. The igniter header safety shutoff valve shall be dedicated to the igniter subsystem.

Table B.3.4.7 Operator Actions, Normal Shutdown Cycle

Operator Actions	Interlock Functions
(1) Reduce boiler load until main fuel control valve is closed. Main fuel bypass control valve will assume control at light-off oil pressure. Airflow should not be reduced below purge rate.	(1) None.
(2) Each burner should be shut down in the following sequence if the oil gun is to be cleared into the furnace. (a) Establish igniter on the burner to be shut down. (b) Close individual burner supervisory shutoff valve. (c) Open clearing valve to clear the burner. (d) Shut off igniter. (e) Leave burner register at firing position. (f) Shut off atomizing medium to each burner. (g) All burner guns should be removed.	(2) None. (a) None. (b) As each burner supervisory shutoff valve is closed, loss of flame will cause its associated safety shutoff valve to close. After last burner supervisory shutoff valve is closed, loss of all flame should cause main safety shutoff valve to close. (c) None. (d) Igniter safety shutoff valves close, igniter atmospheric vent valve opens (for gas igniters). (e) None. (f) None. (g) None.
(3) If oil guns are not cleared into the furnace, eliminate steps (2)(a), (2)(c), and (2)(d). Remove oil guns and drain oil outside the furnace.	(3) None.
(4) A unit purge should be performed.	(4) None.
(5) Fan(s) should be shut down, if desired.	(5) Loss of airflow interlock is actuated.

Note: See Figure B.1.1(c) through Figure B.1.1(e).

Annex C Multiple Burner Boiler Low NO_x Operation — Special Considerations

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 General Considerations.

C.1.1 Regulations limiting NO_x emissions for both existing and new installations have resulted from the adoption of the Clean Air Act Amendment of 1990. Responses to the regulations have included both technologies and operating techniques that affect the quality of combustion and could have an adverse effect on flame stability. Methods to reduce NO_x, which can affect flame stability, are designed to control fuel and air mixing, distribute heat release over more area, and produce lower flame temperature and longer, less turbulent flames. It is important that the designer recognize these potential hazards and perform tests as specified in 6.6.3.2.2, 6.7.3.2.2, and 6.8.3.2.2 to determine the limits of flame stability under these new operating conditions.

C.1.2 Methods to reduce NO_x could reduce the margins formerly available to prevent or minimize accumulations of unburned fuel in the furnace during combustion upsets. For all methods of NO_x reduction, special considerations are necessary to ensure the stability of the flame envelope. In general, the combustion control system is intended to provide tighter control of fuel and airflows; the windbox design should be reviewed carefully to ensure proper distribution of flows to the burners; the type of flame detector, its location, and its sighting should be assessed and retested; and distribution, mixing, and injection of recirculated gas into the process should be analyzed carefully. All the methods described tend to increase the possibility of unburned combustibles throughout the unit

and ducts. Therefore, the use of flue gas combustibles analyzers is recommended. A number of risks could arise, among them the following:

- (1) In-furnace NO_x control technologies could reduce the margins formerly available to prevent or minimize accumulations of unburned fuel in the furnace during combustion upsets.
- (2) In-furnace NO_x control technologies could increase the propensity for furnace wall tube corrosion due to very low excess air or even fuel-rich flue gas conditions.
- (3) In-furnace NO_x control technologies could result in burner flames that are more difficult to scan and that operate closer to an unstable regime across the load range.
- (4) In-furnace NO_x control technologies that utilize staged fuel injection could result in combustion conditions that are not detectable with existing flame detector technology.

C.1.3 Any change in flame characteristics to reduce NO_x emissions could necessitate changing the type of flame detector, or flame detectors might need to be relocated on existing units.

C.2 Technology Overview.

C.2.1 Low NO_x Burners.

C.2.1.1 For burners having a high air side pressure drop [generally greater than 102 mm (4 in.) water column at full boiler load], one way to indicate proper air-fuel ratio is to compare burner airflow with burner fuel flow as determined by windbox-to-furnace differential and burner header pressure. The ratio thus determined, plus the open register procedure, provides a guide for proper operation of burners under

start-up conditions where flows might be out of the range of other meters. Windbox-to-furnace differential taps, where provided, should be located at the burner level.

C.2.2 Overfire Air.

C.2.2.1 Overfire Air Supply.

C.2.2.1.1 The overfire air supply system should be sized and arranged to ensure airflow adequate for all operating requirements of the unit. Consideration should be given to the effects of or on the main combustion air system if the overfire air is supplied from any part of the furnace combustion air system. This should include coordination of the main overfire air control damper(s), booster fan (if used), and overfire air port dampers (if used), with the furnace combustion control system. The overfire air supply equipment should be designed with careful consideration of operating environment and ambient conditions. Proper personnel and equipment protection should be utilized when preheated combustion air is used for overfire air.

C.2.2.2 Overfire Air Port Cooling.

C.2.2.2.1 Overfire air port cooling should be permitted when the overfire air system is not in service, provided the cooling flow is sufficient to provide a positive flow during all furnace operation and purge procedures. If positive flow overfire air port cooling is not provided, tight shutoff dampers should be provided on the overfire air ports as near the furnace as possible to prevent furnace gases from entering the out-of-service overfire air system. All leakage or cooling airflows must be accounted for by the combustion control system.

C.2.3 Reburning.

C.2.3.1 When fuel is injected through reburn injectors without air, there might be no visible combustion taking place at the reburn injectors. Consequently, flame detectors might not provide a useful input to a burner management system in reburn applications. A very rapid chemical reaction does take place, however, due to the elevated temperatures and rapid mixing of the reburn fuel with the products of combustion from the main burner zone, whereby any oxygen in the flue gas from the main burner zone is almost immediately consumed.

C.2.4 Flue Gas Recirculation.

C.2.4.1 Where flue gas recirculation is used, special methods and devices are to be provided to ensure adequate mixing and uniform distribution of recirculated gas and air to the windboxes. Where flue gas recirculation is introduced into the total secondary air to the windboxes, means are to be provided to monitor either the ratio of flue gas to air or the oxygen content of the mixture. Where flue gas recirculation is introduced so that only air, not the mixture, is introduced at the fuel nozzles, adequate means are to be provided to ensure the prescribed distribution of air and the recirculating flue gas-air mixture.

Annex D Fluidized Bed Boilers Supplemental Information

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Terminology. The following terms are specific to fluidized bed boiler applications.

D.1.1 Agglomerating. A characteristic of coal that causes coking on the fuel bed during volatilization.

D.1.2 Air.

D.1.2.1 Primary Air (in a Bubbling Fluidized Bed). That portion of total air used to transport or inject fuel or sorbent and to recycle material to the bed.

D.1.2.2 Primary Air (in a Circulating Fluidized Bed). That portion of total air introduced at the base of the combustor through the air distributor.

D.1.2.3 Secondary Air (in a Bubbling Fluidized Bed). That portion of the air introduced through the air distributor.

D.1.2.4 Secondary Air (in a Circulating Fluidized Bed). That air entering the combustor at levels above the air distributor.

D.1.2.5 Transport Air (in a Fluidized Bed). The air used to convey or inject solid fuel or sorbent or to recycle material.

D.1.3 Atmospheric Fluidized-Bed Combustion. A fuel-firing technique using a fluidized bed operating at near-atmospheric pressure on the fire side.

D.1.4 Auxiliary Load-Carrying Burner. In a fluidized bed boiler, a burner whose primary purpose is load carrying, that is located over the bed, and that has its own air supply.

D.1.5 Over Bed Burner. In a fluidized bed boiler, a warm-up burner located above the bed and firing over or into the bed.

D.1.6 Elutriation. The selective removal of fine solids from a fluidized bed by entrainment in the upward flowing products of combustion.

D.1.7 Hogged Fuel. Wood refuse that has been chipped or shredded by a machine known as a hog.

D.1.8 Main Fuel Temperature Permit. The minimum fluidized bed temperature at which the main fuel can be introduced with resulting stable combustion.

D.1.9 Minimum Fluidization Velocity. In a fluidized bed, the lowest velocity sufficient to cause incipient fluidization.

D.1.10 Recirculation (Solids or Recycle). The reintroduction of solid material extracted from the products of combustion into a fluidized bed.

D.1.11 Recycle Rate. In a fluidized bed, the rate at which a mass of material is reinjected into the bed. This value is often expressed as the ratio of the amount being reinjected to the total amount being elutriated from the fluidized bed.

D.1.12 Recycle Ratio. In a fluidized bed, the mass of material being reinjected into the bed divided by the mass of fuel being fed into the bed.

D.1.13 Reinjection. In a fluidized bed boiler, the return or recycling of material removed or carried from the furnace back to the furnace. Also refers to fly ash collected and returned to the furnace or combustion chamber, sometimes expressed as a percentage of the total collected.

D.1.14 Spent Bed Material. In a fluidized bed boiler, material removed from the bed generally comprising reacted sorbent, calcined limestone, ash, and solid, unburned combustibles. For some applications, the spent bed material might also contain some inert material, such as sand.



Specifications and Requirements for Portable Gas Analyzers

If acceptable by permit, exhaust emissions may be determined using Portable Gas Analyzers which meet the following specifications and requirements:

Specifications:

The analyzer must meet the measurement system performance specifications of ASTM D6522. A brief summary of the specifications are as follows:

Zero Calibration Error:	Less than or equal to $\pm 3\%$ of the span gas value for pollutant gases and less than or equal to $\pm 0.3\%$ for oxygen concentration.
Span Calibration Error:	Less than or equal to $\pm 5\%$ of the span gas value for pollutant gases and less than or equal to $\pm 0.5\%$ for oxygen concentration.
Interference Response:	Less than or equal to $\pm 5\%$ of the measured stack concentration.
Resolution:	NO and NO ₂ - 1 PPM, O ₂ - 0.1%.

The calibration of the analyzer may be done by the manufacturer and shall be done on their recommended schedule, usually annually. A signed copy of the most recent calibration certification sheet shall be included in the test report.

Requirements:

Measurement system performance verifications shall be completed at the test location and documented in the test report. Gases used for calibration verifications shall be certified according to standard EPA protocols and be in an appropriate range to bracket the stack concentration of each pollutant measured.

The verification of the analyzer should demonstrate linearity across three points (high, medium, and zero range).

A minimum of one hour (sixty one-minute readings) of pollutant measurements shall constitute a test.

Verification of absence of stack gas stratification shall be conducted.

To verify the appropriateness of portable analyzer test procedures, a pre-test protocol should be submitted to the Department for approval prior to testing.

Pollutant emissions shall be reported in all units required by permit, but at a minimum, shall include parts per million by volume (dry basis) and lbs/hr.

The volumetric flow rate may also be determined by either EPA Methods 1-4 or Method 19 "F-factor". The "F-factor" is calculated based on the specific gas analysis, which relates exhaust gas flow to heat or energy input via the specific fuel. Fuel consumption and volumetric emissions levels are the main parameters involved in the calculation for mass emissions rates. The equation to determine mass emission rates using rated volumetric flow rate and sample calculation to determine mass emission rate using EPA's Method 19 "F-factor" is shown in Appendix A.

Appendix A

A. Mass Basis Emission Calculations using volumetric flow rate:

The mass emission rate can be calculated using the following equation:

$$\text{lb/hr} = \frac{\text{PPM} * \text{MW} * \text{dscf/hr} * (10^{-6}) \text{ parts/million parts}}{385.3 \text{ dscf / lb - mol}}$$

B. Mass Basis Emission Calculations using EPA's Method "F-factor":

Fd (for natural gas) - Factor of 8710 dry standard cubic feet per 10⁶ BTU as listed in Table 19-1 of EPA Method 19.

The emission rate can be calculated using the following equation:

$$\text{Em: Cd} * \text{Fd} * 20.9 / (20.9 - \% \text{O}_2) * \text{Qh} * \text{HHV}$$

Where,

Em	=	Pollutant emission rate in lbs/hr
Cd	=	Pollutant concentration in lb/dscf
Fd	=	Average F-factor for Cd measurement on a dry basis, dscf per 10 ⁶ BTU (8710 dscf per 10 ⁶ BTU for natural gas)
%O ₂	=	Exhaust oxygen concentration in percent, measured on a dry basis
Qh*	=	Fuel rate in standard cubic feet per hour
HHV	=	Higher heating value of the fuel in BTU/SCF

* The fuel rate must be determined using a calibrated fuel flow monitor; calibration certification sheet must be included in test report.

The following conversion factor may be used to correct the pollutant concentration from PPM to lb/scf

<u>To convert from</u>	<u>To Cd</u>	<u>Multiply By</u>
PPM	lb/scf	pollutant molecular weight/385.3/10 ⁶

Sample Calculation for Mass Basis Emission Calculations using EPA's Method 19 "F-factor":

Assuming 60 ppm @ 17.5% O₂, Fuel Rate - 250 scfm, HHV=1000 BTU/scf

$$\begin{aligned} \text{Em} &= (60 * 46.01 / 385.3 / 10^6) \frac{\text{lbs}}{\text{dscf}} * \frac{8710 \text{ dscf}}{10^6 \text{ Btu}} * \frac{20.9}{(20.9 - 17.5)} * 250 \frac{\text{scf}}{\text{min}} * 60 \frac{\text{min}}{\text{hr}} * 1000 \frac{\text{Btu}}{\text{scf}} \\ &= 5.65 \text{ lbs/hr} \end{aligned}$$

Horsepower Basis Emission Rate (gms/bhp-hr):

Assuming the engine was operating at 1450 BHP

$$\begin{aligned} \text{Em in gms/bhp-hr} &= 5.65 \text{ lbs/hr} * 454 \text{ gms/lb} * 1/1450 \text{ bhp} \\ &= 1.77 \text{ gms/bhp-hr} \end{aligned}$$

PREFERRED UTILITIES MFG. CORP.

31-35 South Street, Danbury, Connecticut 06810

TEL.: (203) 743-6741 - FAX: (203) 798-7313

Manufacturers of Combustion Equipment, Controls and Instruments

INSTALLATION CHECKLIST

IMPORTANT NOTICE – MUST READ

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's manufacturing, engineering and administrative headquarters is located in Danbury, Connecticut with regional sales offices located in Massachusetts, Florida, Oklahoma, Texas and Oregon. Preferred's regional sales offices serve to continuously strengthen independent sales representative organization's sales and service activities throughout North America.

Checklist Overview

The purpose of this Checklist is to draw attention and expose common installation and operator errors, therefore ensuring a reliable and satisfactory performance. The following Checklist serves multiple purposes; First, and most important, it ensures proper installation. Secondly, once the Checklist is completed and returned to Preferred Utilities Manufacturing Corporation, customers have the opportunity to take advantage of our **24 Month Extended Warranty** from the original control system ship date. Customers who fail to return a completed Installation Checklist will receive our standard, 12 Month Limited Warranty.

Please Note: Careful attention to detail must be applied during the engineering and installation of this control system. A control being installed as a component of a new system, or a replacement of control in an existing system, could have a considerable impact on other existing systems. As with any control system, if this is not applied, installed, or programmed correctly, it may require considerable troubleshooting efforts during the commissioning and routine operations.

Remember: Most control problems are caused by wiring errors. Reviewing this Installation Checklist, in conjunction with the BurnerMate Universal Rev 2.1 Manual, will resolve most problems. You **MUST** sign and return this Checklist before contacting Technical Support for BurnerMate Universal installation related assistance.

Project Information

Location Name: _____
Contact Name: _____
Contact Title: _____
Phone Number: _____
Fax Number: _____
Job Address: _____

Technician Name: _____
Phone Number: _____
Cell Phone: _____

BurnerMate Universal Information

BMU Serial #: _____
BMU Model: _____
Start Up Date: _____

Notes: _____

BurnerMate Universal Installation Checklist:

The following is a checklist of items to consider/inspect prior to commissioning the BurnerMate Universal (BMU) or contacting Technical Support. Review and initial each group after careful consideration and thorough inspection.

Basic Rules

- Control has been installed by a properly trained technician. _____
- BMU is operating within specified environmental conditions. _____
- Incoming AC Power ground is connected to the 'Ground Stud' located on the BMU base plate. _____
- Plug-in terminal blocks (Orange) are inserted properly. _____
- 120 VAC is wired to terminals 1-99 only and low voltage (4-20mA, 0-5VDC) is wired to terminals 100-197 only. _____
- AC and DC wiring are run in separate conduit or troughs, except where noted. _____
- Line and Low Voltage wiring is properly routed in panel, refer to recommended sub-plate layout supplied with wiring diagram. _____
- DC input/output wiring should be 22 gauge minimum, 100% foil shield and have twisted pairs (Belden 8737 or equal), except where noted. _____
- DC cable shielding removed for wire termination should be kept to a minimum. _____
- DC cable shields and drain wires on all DC shielded cables are connected at one end only, as shown on the wiring diagram. _____
- DC cable shield and drain wires must be properly insulated to prevent accidental connection to earth or power ground. _____
- Wiring diagrams and manuals for the BMU and all other equipment should be reviewed for additional instructions and notes. _____

The General Wiring has been reviewed and applied to the BMU where applicable.

Technician Initial: _____ Date: _____

BMU Device Wiring

Scanner Wiring**

- BMU Scanner is wired exactly as shown on the wiring diagram provided with controller. _____
- Scanner shield drain is not connected at terminals T102 or T105. _____
- Cable shielding removed for wire termination should be kept to a minimum. _____
- If a non-BMU scanner to be used and the flame intensity input is to be utilized, Preferred Utilities must be contacted to insure proper wiring procedures have been followed. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

The Scanner Wiring has been reviewed and wired as shown in the manual and wiring diagrams.

Technician Initial: _____ Date: _____

The Scanner Wiring has been reviewed and variations found as noted.

Technician Initial: _____ Date: _____

BMU Device Wiring (Continued)

Oxygen Analyzer**

- P/N 190130 cable was used for Oxygen (O2) detector wiring. _____
- O2 cable is run in a separate conduit back to the control panel. If stack temperature is utilized, a shielded thermocouple wire can be run in the same conduit, but no other exceptions are made. _____
- The maximum length of O2 cable used does not exceed 500 ft and wired exactly as shown in manual and wiring diagram, refer to wiring diagram provided with controller. _____
- O2 cable shielding removed for wire termination should be kept to a minimum. _____
- O2 cable shielded drain wire is connected to the (S) terminal as shown on the wiring diagram. _____
- O2 cable shield and drain wires are properly insulated to prevent accidental connection to earth ground. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

The Oxygen Analyzer Detector Wiring has been reviewed and wired as shown in the manual and wiring diagrams.

Technician Initial: _____ Date: _____

The Oxygen Analyzer Detector Wiring has been reviewed and variations found as noted.

Technician Initial: _____ Date: _____

The Oxygen Analyzer Detector is not installed.

Technician Initial: _____ Date: _____

LCD Wiring**

- BMU-CABLE-XX has been used to connect the LCD to the BurnerMate Universal controller. _____
- The Ferrite Suppressor is installed as shown in the wiring diagram, refer to wiring diagram provided with controller. _____
- Cable shielding removed for wire termination should be kept to a minimum. _____
- LCD cable shielded drain wires are connected as shown on the wiring diagram, refer to wiring diagram provided with controller. _____
- LCD cable shield and drain wire are properly insulated to prevent accidental connection to earth ground. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

____ **The LCD Wiring has been reviewed and wired as shown in the manual and wiring diagrams.**

Technician Initial: _____ Date: _____

____ **The LCD Wiring has been reviewed and variations found as noted.**

Technician Initial: _____ Date: _____

BMU Device Wiring (Continued)

Servo Wiring**

- BMU-CABLE-XX and (3) #16 gauge wires (Hot, Neutral, Ground) are run in dedicated conduit with no other wires as shown on wiring diagram, refer to wiring diagram provided with controller. _____
- Total servo wiring length does not exceed 500 ft and contains no splices. _____
- No other load circuits are connected to the Hot, Neutral or Ground wires used for the servos. _____
- BMU servos are wired as shown in Section 4 of the manual. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

_____ **The Servo Wiring has been reviewed and wired as shown in the manual and wiring diagrams.** Technician Initial: _____ Date: _____

_____ **The Servo Wiring has been reviewed and variations found as noted.**

Technician Initial: _____ Date: _____

Variable Speed Drive (VSD) Wiring**

- Wiring from the VSD output to the motor must be run in a dedicated conduit separate from other wiring. This conduit should contain only the (3) phase power wires and a Ground wire; Ground wire must be connected at the VSD frame to the motor. _____
- A second ground wire is installed from the AC power source to the VSD frame for NEC safety grounding. _____
- Output wiring from VSD can not be run through junction boxes that include other wiring. _____
- The VSD to motor conduit must be metal conduit and must have either threaded or non-insulating compression fittings. Please Note: PVC conduit, BX, Greenfield or EMT set screw-style hubs connectors are not permitted. _____
- All DC signal wiring must be run in dedicated conduit and kept as far away from VSD-to-motor conduit as possible. _____
- AC power source to VSD must be run in dedicated conduit. Running AC supply-to-VSD and VSD-to-motor wiring in same conduit is not allowed. _____
- Cable shielding removed for wire termination should be kept to a minimum. _____
- Cable shield and drain wires are properly insulated to prevent accidental connection to earth ground. _____
- Cable shield drain wires must be connected as shown on the wiring diagram, refer to wiring diagrams provided with controller. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

_____ **The VSD Wiring has been reviewed and wired as shown in the manual and wiring diagrams.** Technician Initial: _____ Date: _____

_____ **The VSD Wiring has been reviewed and variations found as noted.**

Technician Initial: _____ Date: _____

_____ **The VSD is not installed.**

Technician Initial: _____ Date: _____

BMU Device Wiring (Continued)

Ignition Transformer Wiring**

- The ignition transformer is mounted as close to the spark electrode as possible. _____
- The igniter lead is as short as possible. _____
- The igniter spark gap should be as small as possible but within burner manufacturers recommendations. _____
- There should be good grounding contact of the transformer and of the igniter assembly. _____
- Only automotive style "Resistor Core" ignition cable should be used, do not use copper core ignition wire. _____
- BMU manual and wiring diagrams have been reviewed for additional instructions and notes. _____

The Ignition Transformer Wiring has been reviewed and meets the requirement listed above.

Technician Initial: _____ Date: _____

The Ignition Transformer Wiring has been reviewed and variations found as noted.

Technician Initial: _____ Date: _____

** Please include additional notes if needed.

I have read and understand these warranty terms and completed the Installation Checklist:

Name (Print): _____ Date: _____
Name (Signature): _____
Company: _____
Address: _____

On Site Technical Support:

If you request a Preferred Utilities field engineer, upon receipt of this request and purchase order Preferred will provide expert service assistance for the commissioning of a BurnerMate Universal system as well as advanced troubleshooting. Field service and/or advanced troubleshooting are not included in the product warranty. These services are only provided if commissioning services were originally purchased. If the BurnerMate Universal is not installed as the manual instructs, the service assistance will be billed at our standard service rates, see document Preferred Instruments Field Service Rates and Terms, (copy attached). However, if there is a problem with our equipment which is "installed correctly" the problem will be corrected at no charge.

A purchase order with a confirmation of these terms or a Credit Card payment number is required prior to any engineering assisted trouble shooting is performed.

Payment terms are net 10 days with approval of the Credit Department at the Danbury Office. All late payments are subject to a finance charge of 1-1/2% per month on the unpaid balance.

I have read and accept these Rates, Terms, and Conditions:

Name (Print): _____ Credit Card: MC, VISA, Discover
Name (Signature): _____
Company: _____ Card No.: _____
Address: _____
Telephone / Fax: _____ Card Name: _____
Date: _____ Expiration Date: _____
P.O. # _____ 3-Digit Code: _____

BurnerMate Universal Boiler Combustion Data Sheet

Job Location:		Installation Contractor:		Commissioning Tech:	
Boiler Model:		Burner Model:		Fuels Fired:	
BMU SN:		Release:		Notes:	
BMU Date:		Ignition		BTU Input:	
Standby		Purge		Burner/Mate Curve Point #	
				1 2 3 4 5 6 7 8 9 10 11	
Fuel Servo Deg.					
FD Damper Servo Deg.					
FD Fan VSD Hz					
Aux Servo Deg.					
FGR Damper Servo Deg					
FGR Fan VSD Hz					
Draft Damper Servo Deg					
Feedwater Valve Servo Deg					
Atom. Servo Deg.					
Combustion Data					
Combustion Air Temp.					
BMU Stack Temperature					
BMU ZP O2 (%)					
O2 (%) Analyzer					
CO (ppm) Analyzer					
NOx (ppm) Raw Analyzer					
NOx (ppm) Corr. To 3.0% O2					
BMU Comb. Efficiency (%)					
Operating Data					
Gas Flow- SCFH					
Oil Flow- GPM, GPH					
Steam Flow or Btu/hr					
Feedwater Flow GPM- #/hr.					
Boiler Outlet: psig, F. C					
Fuel Supply Press. (psig)					
Fuel Temp. (deg. F)					
Burner Fuel Press. (psig)					
Atom. Supply Press. (psig)					
Burner Atom. Press (psig)					
Windbox Draft (in w.c.)					
Furnace Draft (in w.c.)					
Outlet Draft. (in w.c.)					

Notes/Comments:

Abbreviated BurnerMate Universal (BMU) Commissioning Steps New Installations

1. BMU Initial Power Up (page 5-3)

Before proceeding further, ensure that all of the field devices have been properly installed and that all electrical wiring has been completed. Numerous internal errors may be indicated but will clear after the servos are set up.

2. Obtaining a Temporary Password and Create Permanent Passwords (page 5-5)

From the Keypad "Utilities" menu, record the current Date, Time and Serial Number. Once you have this information, contact Preferred Instruments in Danbury, CT (203-743-6741) or an Authorized Distributor, and they will issue a temporary password.

3. Application Review and Configuration of Parameters (page 5-6)

As shipped, a new BMU will not fire the burner until critical parameters are set up to match the job site conditions. This can be done by using the BMU Keypad, the BMU-OIT Touch Screen or by using a laptop computer and BMU-Edit Software (optional).

4. Servo Set Up (page 5-13)

Below are the five simple steps required to set up and calibrate the servos:

1. Manually stroke the servo to set up the minimum and maximum travel limit switches as they best suit that device.
2. Address the servo based on its position in the daisy chain wiring. Reset the BMU Internal Errors.
3. Configure the servo according to its address and required function.
4. Set the servo zero position and rotation direction (CW or CCW)
5. Seek the limits so the BMU can learn the open and closed servo positions.

5. Place BMU in Commission Mode (page 5- 19)

When the **BurnerMate Universal** is first installed, there is no data in the combustion curves, and the Combustion Control will not allow the burner to start. The technician must enable Commission Mode in order to enter data into the start positions and combustion curves.

6. Preset Standby, Purge and Ignition Positions (page 5- 21)

The three primary positions, Purge, Ignition and Standby must be preset prior to the start of the burner sequence. Combustion curve points can be either preloaded or set up while running the burner.

7. Start the Burner

Close the manual fuel valve closest to the burner. Using the Keypad access Parameter 1.2.1, "Pilot Test Hold". This will lock the start sequence at the pilot so the technician can insure a stable pilot and steady Flame Signal. Note that this parameter must be set after every burner cycle during this phase of the commissioning.

8. Verify the Purge and Ignition Positions (page 5-22)

Confirm the purge position is correct and then establish the pilot (Ignition). After the pilot is confirmed stable, return to Parameter 1.2.1 and turn off the "Pilot Test Hold". The main fuel valves will energize. Slowly open the manual fuel valve until a stable low fire is established. Note that the light off point will usually serve as the first point on the combustion curve. Note that the ignition point must be within the F/A ratio curve.

9. Fuel/Air Ratio Curve Data Entry (page 5-24)

At this time, the Commission Mode is still enabled and the burner has successfully lit the main flame, firing at the same fuel position as during the Ignition position. Before storing this first point as the first curve point, ensure that the air is adjusted to the desired excess air level and that there is no smoke or appreciable carbon monoxide present.

10. Verify Curve Points (page 5- 26)

The **BMU** has a unique safety feature. Before the technician can disable Commission Mode or put the burner controls into automatic, each curve point and midpoint must be verified as being safe.

11. Set the Low Fire and High Fire Points and Exit Commission Mode (Page 5-28)

12. Tune the PID Control Loops (page 5-29)

13. Final Documentation and Data (page 5-32)

We recommend that the technician upload a copy of the final **BMU** program onto a laptop computer using BMU Edit Software.

14. Operator Training

BurnerMate Universal Boiler and Burner Safety and Operating Limit Switches

Job Location:		Installation Contractor:		Commissioning Tech:	
Boiler Model:		Burner Model:		Fuels Fired:	BTU Input:
BMU SN:	BMU Date:	Release:	Notes:		
Limit & Terminal	Set Point	Operation	Message/Comments		
Fixed Speed Input T3					
Low Water Alarm T5					
High Water Alarm T6					
Local Call for Heat T8					
Remote Call for Heat T9					
Burner On/Off T10					
Operating Steam Limit T11					
Low Water Level Cutout T12					
Low Water Flow T13					
Fresh Air Damper/ Air Sw. T14					
Spare Recycle Interlock T15					
Oil Firing Requested T16					
High Oil Pressure T17					
Low Oil Pressure T18					
Low Atom. Air PSI T19					
Low Atom Air Flow T20					
Gas Firing Requested T23					
High Gas Pressure T24					
Low Gas Pressure T25					
Emergency Stop-Panel, T29					
Emergency Stop- Door, T29					
High High Steam PSI, T32					
Minimum Air Flow (CAFS) T33					
Fixed Speed FD Fan On T34					
VSD Running with no Faults, T35					
Low Low Water Level Cutout, T36					
High Water Level Cutout T37					
Low Draft Switch T38					
ID Fan Energized T39					
FGR Fan Energized T40					
Spare 1 Non-Recycle Limit T41					
Spare 2 Non-Recycle Limit T42					
Spare 3 Non-Recycle Limit T43					
Outlet Damper Interlock T44					
Purge Air Flow Interlock, T46					
Oil SSOV POCS, T47					
Gas SSOV POCS, T48					
Low O2 Alarm- BMU- P1.10.2					
Low Low O2 Trip- BMU- P1.10.3					
High Flue Alarm- BMU- P2.4.2					
High Flue Trip- BMU- P2.4.4					

BurnerMate Universal Parameter Configuration Worksheet

Job Location:	Installation Contractor:	Commissioning Tech:
Boiler Model:	Burner Model:	Fuels Fired:
BMU SN:	Release:	Notes:
	BMU Date:	BTU Input:

The (6) BMU Parameters Categories: (1) Flame Safety (2) Fuel-Air (3) Firing Rate (4) Draft Control (5) Feedwater Control (6) Atomizing Control									
A detailed description of each of the following parameters can be found in the BurnerMate Universal Manual, Section 3									
Category	Parameter	Value	Default	Other Possible Values					
Flame Safety	< Basic (P1.1.x)								
1.1.1	Fuel 1 Enable		DISABLE		OIL	FUEL 1			
1.1.2	Fuel 2 Enable		DISABLE		GAS		DGAS	OGAS	FUEL2
1.1.3	Fuel 3 Enable		DISABLE		GAS	BCAS	DGAS	OGAS	FUEL3
1.1.4	Fuel Request Source		CONTACTS		DISPLAY				
1.1.5	PAF Switch Installed		YES		NO		DISPLAY OR MODBUS		
1.1.6	ID Fan Installed		YES		NO				
1.1.7	Ignition Xlmr Mode		EARLY TERMINATE		WITH PILOT	DIRECT SPARK			
1.1.8	Oil MTFI Sec		10 sec		10-15				
1.1.9	Purge Time		30 sec		15-1800				
1.1.10	Post Purge Time		20 sec		15-1800				
1.2.1	Pilot Test Hold		n/a						
Flame Safety	<General (P1.3.x)								
1.3.1	Power Fail Response		Recycle		Lockout				
1.3.2	Assured Low Fire Cut Off		Disable		Enable				
1.3.3	Fuel1 POC Installed		Yes		No				
1.3.4	Fuel2 POC Installed		Yes		No				
1.3.5	Fuel3 POC Installed		Yes		No				
Flame Safety	<Scanner (P1.4.x)								
1.4.1	Dual Flame Scanners		Disable		Enable				
1.4.2	Scanner 1 Signal		4-20 mA		0-20 mA	0-5 Vdc	0-3 Vdc	0-1 Vdc	
1.4.3	Scanner 2 Signal		4-20 mA		0-20 mA	0-5 Vdc	0-3 Vdc	0-1 Vdc	
1.4.4	Scanner Alarm SP		0 %		0 - 90				
Flame Safety	< Fan Start (P1.5.x)								
1.5.1	FD Fan Start Mode		PreStart		FADLimit	Purge Position			
1.5.2	FD Fan Start Delay		1 sec		1 - 120				
1.5.3	Aux Fan Start Delay		1 sec		1 - 120				
Flame Safety	< Time Delays (P1.6.x)								
1.6.1	Min Air Flow Trip Delay		0 sec		0 - 4				
1.6.2	Low Fuel Pressure Delay		0 sec		0 - 4				
1.6.3	Low Atomizing Flow Delay		0 sec		0 - 4				
1.6.4	Low Draft Cutout Delay		0 sec		0 - 8				
1.6.5	HOLD Alarm Delay		45 sec		10 - 601				
1.6.6	HOLD Lockout Delay		120 sec		30 - 600				
Flame Safety	< Auxiliary Relays (P1.7.x)								
1.7.1	Aux Relay 1 Function		CommonAlarm		Choices for ALL Option Relays:				
	Aux Relay 2 Function		CommonAlarm		Disabled	AuxFan Starter	HotWater PumpValve	Blowdown Valve	Limits Made
1.7.2	Aux Relay 3 Function		CommonAlarm		Common Auxiliaries	Fuel1 Auxiliaries	Fuel2 Auxiliaries	Fuel3 Auxiliaries	
1.7.3	Aux Relay 4 Function		CommonAlarm		FlameOn	Fuel1Open	Fuel2Open	Fuel3Open	
1.7.4	Aux Relay 5 Function		CommonAlarm						
1.7.5	Hot Water Pump/ Valve Stop Delay		300 sec		1 - 1200				
1.7.6									

Note:
 ** means a parameter is shown in 2 or more places.
 *** means that this is a primary parameter and must be setup before attempting to operate the BMU.

BurnerMate Universal Parameter Configuration Worksheet

Catagory	Parameter	Value	Default	Other Possible Values
Flame Safety	<Options			
	< Gas Leak Test (P1.8.x)			
	1.8.1 Gas (Fuel2) Leak Test Option		Disable	Enable
	1.8.2 leak test w/o Vent Valve Option		Disable	Enable
Flame Safety	<Options			
	1.8.3 Upstream Test Sec		60 sec	10 - 90
	1.8.4 Downstream Test Sec		60 sec	10 - 90
	< Oil Gun Purge (P1.9.x)			
Flame Safety	<Options			
	1.9.1 Oil Gun Purge Option		Disable	BlowThru
	1.9.2 Oil Gun Purge Sec		10 sec	5 - 45
	< High Flue Temp (P1.10.x)			
Flame Safety	<Options			
	1.10.1 Flue Gas T/C Type		J_T/C	K_T/C
	1.10.2 Alarm SP, Flue Temp		1000 deg	100 - 1000
	1.10.3 Lockout SP, Flue Temp		1000 deg	100 - 1000
Flame Safety	<Options			
	1.11.1 LWC Auto Blowdown (P1.11.x)		Disable	Enable
	1.11.2 Failed Test Response, Blowdown		Lockout	Alarm
	1.11.3 Min Steam Pressure, Blowdown		50.0 psi	0.3 - 1500.0
Flame Safety	<Options			
	1.11.4 Time of Day, Blowdown		8:00	0:00 - 23:00
	1.11.5 Blowdown Seconds		10 sec	2 - 30
	1.11.6 LWC Bypass Release Delay		5 sec	0 - 10
Flame Safety	<Options			
	<Fuel Transfer (P1.12.x)			
	1.12.1 Fuel Transfer Method		Restart	Low Fire
	1.12.2 Low Fire Xfer Pilot Option		Disable	Enable
Flame Safety	<Options			
	1.12.3 Dual Fuel Time Limit, Sec		20	10 - 90
	1.12.4 Low Fire Xfer Air Bias %		10.0	2.0 - 50.0
Fuel-Air	<Basic (P2.1.x)			
	2.1.1 Fuel-Air Control Type		Positioned Servo	Meiterd Servo
	2.1.2 FGR Servo Check		close then open	open then close
	<Options			
Fuel-Air	< FD VSD Setup (P2.2.x)			
	2.2.1 FD Fan VSD Option		Disable	Enable
	2.2.2 FD VSD Feedback Adjust		1.00	0.970 - 1.030
	2.2.3 FD VSD Ramp Rate, Sec/30Hz		15 sec	8 - 15
Fuel-Air	<Options			
	2.2.4 FD VSD Min Hz		5.0 Hz	5.0 - 50.0
	2.2.5 FD VSD Off-curve Lockout Deadband Hz		0.4 Hz	0.2 - 0.8
Fuel-Air	<Aux 2 Setup (P2.3.x)			
	2.3.1 Aux 2 Curve Option		Disable	Enable
	2.3.2 Aux 2 FGR Trim Option		Disable	Enable
	2.3.3 4-20 Feedback Adjust, Aux 2		1.00	0.970 - 1.030
Fuel-Air	<Options			
	2.3.4 4-20 Ramp Rate, Sec/100%, Aux 2		30 sec	8 - 60
	2.3.5 4-20 Off-Curve Lockout Deadband %, Aux 2		1.5%	0.2 - 4.8 %
Fuel-Air	<Oxygen Analyzer (P2.4.x)			
	2.4.1 O2 Analyzer Option		Disable	Enable
	2.4.2 Low O2 Alarm SP		0.0%	0.0 - 20.0
	2.4.3 Low O2 Lockout Option		Disable	Enable
Fuel-Air	<Options			
	2.4.4 Low O2 Lockout SP		0.5 %	0.5 - 5.0
	2.4.5 Low O2 Lockout Delay		1 sec	1 - 40
	2.4.6 O2 Fault Lockout Option		Disable	Enable
Fuel-Air	<Options			
	2.4.7 O2 Low Cal Gas %		0.400 %	0.300 - 3.000
	2.4.8 O2 High Cal Gas %		8.000 %	7.000 - 19.000
	2.4.9 O2 Cell Slope Cal Data		20742	0 - 30000
Fuel-Air	<Options			
	2.4.10 O2 Cell Offset Cal Data		20596	17000 - 23000
	2.4.11 O2 Cell Temp Cal Data		10730	10330 - 11130
	2.4.12 O2 Cal Data Checksum		0000	-32768 to +32767
Fuel-Air	<Options			
	#5 Oil Efficiency Option		Disable	Enable

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values
Fuel-Air	<Options	<Oxygen Trim		
2.5.1		O2 Trim Option	Disable	Enable
2.5.2		Low Fire Disable, O2 Trim	5.0 %	1.0 - 40.0
2.5.3		Burner Warmup Delay Sec, O2 Trim	120 sec	30 - 300
Fuel-Air	<Options	<Oxygen Trim- Test/Tuning Screen		
2.6.1		SP Lag Time, O2 Trim	8.0 sec	2.0 - 12.0
2.6.2		Proportional Band, O2 Trim	6.50 %	1.00 - 9.99
2.6.3		Repeats Per Minute, O2 Trim	0.50	0.2 - 2.50
2.6.4		+/- Max Fire Trim, O2	10.00 %	5.00 - 15.00
2.6.5**		Min Fire Trim Scaler, O2 Trim or Full Metered	0.20	0.01 - 0.80
Fuel-Air	<Options	<Fuel Flow Setup <Oil Flow Meter (P2.7.x)		
2.7.1		Xmitr Signal, Oil Flow	4-20 mA	Pulser
2.7.2		Decimal Point, Oil Flow	xxxx	xxx.x
2.7.3		GPH Span, Oil Flow	400	15 - 9999
2.7.4		Dec. Point, Oil Flow Pulser Frequency Span	xx.xx	xxx.x
2.7.5		Pulser Frequency Span, Oil Flow	50.00 Hz	4.00 - 65.00
Fuel-Air	<Options	<Fuel Flow Setup <Gas Flow Meter (P2.8.x)		
2.8.1		Decimal Point, Gas Flow	xx.xx	xxxxx
2.8.2		Flow @ 20 mA, Gas Flow	1.00	1.00 - 32.00
2.8.3		Sq Root, Gas Flow	Disabled	10.0 - 320.0
2.8.4		Pressure Comp Option, Gas Flow	Disabled	Enable
2.8.5		Gas PSIG Xmitr Span	30.00 psig	5.00 - 300.00
2.8.6		Flow Comp Design PSIG, Gas Flow	5.00 psig	0.50 - 25.00
Fuel-Air	<Options	<Fuel 3 Flow Meter (P2.9.x)		
2.9.1		Decimal Point, Fuel 3 Flow	xxx.x	xxxxx
2.9.2		Flow @ 20 mA, Fuel 3 Flow	10.0	1.00 - 32.00
2.9.3		Sq Root Option, Fuel 3 Flow	Disabled	Enable
Fuel-Air	<Options	<Fuel Flow Setup <Totalizers (P2.10.x)		
2.10.1		Flow Totalizer Option	Disabled	Enable
Fuel-Air	<Options	<Full Metered Setup <Air Flow Meter (P2.11.x)		
2.11.1		Sq Root Option, Air Flow	Enabled	Disabled
2.11.2		Temp Comp Option, Air Flow	Disabled	Enable
Fuel-Air	<Options	<Full Metered Setup <Misc. Meter Setup (P2.12.x)		
2.12.1**		Air Flow %, Disable Full Metered	10.0 %	0.0 - 25.0
2.12.2		% Air Flow, Low Fire Deviation Lockout	20.0 %	2.0 - 30.0
2.12.3		% Air Flow, High Fire Deviation Lockout	10.0 %	2.0 - 30.0
2.12.4		% Fuel Flow, Deviation Lockout	25 %	2 - 30
2.12.5		Sec. Flow Deviation Lockout Delay	6 sec	2 - 30
Fuel-Air	<Options	<Full Metered Tune (P2.13.x)		
2.13.1		Gap Band, Full Metered Tune	0.3	0.1 - 3.0
2.13.2		Prop Band, Full Metered Tune	6.0	3.0 - 60.0
2.13.3		Min/Repeat, Full Metered Tune	0.10	0.05 - 0.40
2.13.4		Max Fire Trim +/-, Full Metered Tune	10.00	0.01 - 25.00
2.6.5**		Min Fire Trim Scaler, O2 Trim or Full Metered	0.20	0.01 - 0.60
2.12.1**		Trim Null Air Flow %, Full Metered Tune	10.0 %	0.0 - 25.5
2.13.7		Xmitr Filter Sec, Full Metered Tune	2.0 sec	0.1 - 10.0
2.13.8		Flow SP Lag Sec, Full Metered Tune	2.5 sec	0.1 - 10.0

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values	
Fuel-Air	<Options	<FGR O2 Trim Setup (P2.14.x)			
	2.14.1	Windbox Oxygen FGR Trim Option	Disabled	Enabled	
	2.14.2	Windbox Oxygen @ 20 mA, Xmr Cal	21.00 %	18.00 - 25.00	
Fuel-Air	<Options	<FGR O2 Trim Tune (P2.15.x)			
	2.15.1	SP Lag Seconds, FGR Trim Tune	8.0	0.5 - 20.0	
	2.15.2	Proportional Band, FGR Trim Tune	5.00	0.50 - 20.00	
	2.15.3	Minutes per Repeat, FGR Trim Tune	0.50	0.20 - 3.00	
	2.15.4	Max Fire Trim +/-, FGR Trim Tune	10.00 %	0.01 - 15.00	
	2.15.5	Min Fire Scale +/-, FGR Trim Tune	0.20	0.01 - 1.25	
Firing Rate	<Basic Setup	< Blr Outlet Sensor (P3.1.x)			
	3.1.1	Sensor Channel, Boiler Outlet	AI-3	AI-6	
	3.1.2	AI3 Sensor Type	THERMISTOR	4-20 mA	0-5 Vdc
	3.1.3	AI6 Sensor Type	J/T/C	K/T/C	
	3.1.4	Degrees C Scaling	DISABLE	ENABLE	
	3.1.5	Decimal Point, Boiler Outlet	x	x	
	3.1.6	Xmr Span, Boiler Outlet	25.0	5.0 - 2000.0	
	<Basic Setup	< Local/Remote Mode (P3.2.x)			
	3.2.1	CFH Local Mode	SPDEVIATION	TERMINAL8	
	3.2.2	Enable Remote Mode	ENABLE	DISABLE	
	3.2.3	CFH Remote Mode	TERMINAL9	MODBUS	
	3.2.4	Remote Modulation	AI4_FR	AI4_SP	MODBUS_SP
	3.2.5	Remote Fault Response	LOCAL	REMOTE	MODBUS_FR
	3.2.6	Remote Rate Cutback SP	2000.0	0.5 - 2000.0	
	3.2.7	AI4 Signal Type	4-20mA	1-5 Vdc	0-5 Vdc
	3.2.8	Remote SP Span	200.0	0.0 - 2000.0	
	3.2.9	Remote SP Zero	0.0	0.0 - 2000.0	
Firing Rate	<Basic Tuning	< Firing Rate Tuning (P3.3.x)			
	3.3.1	CFH Start Deviation	5.0	-50.0 to + 500.0	
	3.3.2	CFH Stop Deviation	10.0	0.1 - 500.0	
	3.3.3	Proportional Band, Rate PID	5.00	0.05 - 50.00	
	3.3.4	Minutes Per Repeat, Rate PID	1.25	0.75 - 10.00	
	3.3.5	Rate Local SP	200.0	0.0 - 2000.0	
	3.3.6	Rate Max SP	240.0	0.5 - 2000.0	
3.3.7	Rate Min SP	0	0	0.0 - 1900.0	
Firing Rate	<Options	< Miscellaneous (P3.4.x)			
	3.4.1	Sec/100% Rate Limit, Firing Rate	25	25 - 120	
	3.4.2	Avoid Gap +/-, Firing Rate	0.5	0.2 - 3.0	
	3.4.3	Output Channel, Firing Rate	A02	A06	
Firing Rate	<Options	< Outdoor Reset < Sensor Setup			
	3.5.1	Sensor Channel, Outside Air	AI5	AI21	
	3.5.2	AI5 Sensor Type	Thermistor	1-5 Vdc	0-5 Vdc
	3.5.3	AI5 Xmr Span, Outdoor Temp	130	-30 to +150	4-20 mA dc
Firing Rate	<Options	< Outdoor Reset< Reset Curve			
	3.6.1	Outdoor Cutoff Deg	-30	-50 to +40	
	3.6.2	Low OAT Deg	120	5 to 120	
	3.6.3	High OAT Deg	10	-40 to 40	
Firing Rate	<Options	< Normal SP at Low OAT	45	0 to 70	
	3.6.4	Normal SP at High OAT	220	245 to +45	
	3.6.5	Setback SP at Low OAT	190	245 to +45	
	3.6.6	Setback SP at High OAT	200	245 to +45	
Firing Rate	<Options	< Alt Local Setpoint	170	245 to +45	
	3.7.1	Alt Local SP Option	Disable	Enable	
	3.7.2	Alt Local Setpoint	125.0	0.0 to 2000.0	

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values
Firing Rate	< Domestic Hot Water			
3.8.1	DHW Override Option		Disable	Enable
3.8.2	DHW Setpoint		180.0	0.0 to 2000.0
Firing Rate	< Warm Standby			
3.9.1	Warm Standby Option		Disable	Terminal7
3.9.2	Start SP, Warm Standby		85.0	0.0 - 1900.0
3.9.3	Stop SP, Warm Standby		110.0	0.0 - 2000.0
3.9.4	Sensor Channel, Warmup		AI6	Boileroutlet
3.9.5	AI5 Sensor Type		Thermistor	1-5 Vdc
3.9.6	AI5 Xmitr Span, Warm Temp		300	50 - 800
3.9.7	AI6 Sensor Type		J, T/C	K, T/C
Firing Rate	< Cold Start Warmup			
3.10.1	Cold Start Warmup Option		Disable	Enable
3.10.2	Activate SP, Cold Start		40.0	0.1 - 1800.0
3.10.3	Deactivate SP, Cold Start		100.0	0.1 - 1800.0
3.10.4	Setpoint Step, Cold Start		10.0	0.1 - 200.0
3.10.5	Firing Rate Step, Cold Start		10.0	2.0 - 30.0
3.10.6	Override Minutes, Firing Rate Step		20	1 - 120
Firing Rate	< Low Fire Hold			
3.11.1	Low Fire Hold Option		Disable	Terminal7
3.11.2	Override Seconds, Low Fire Hold		300 sec	1 - 1800
3.11.3	Low Fire Hold SP		80.0	0.0 - 200.0
Firing Rate	< FGR Low Fire Hold			
3.12.1	FGR Temp Low Fire Hold Option		Disable	Enable
3.12.2	Release Temp, FGR LFH		300.0 deg	100.0 - 600.0
3.12.3	Min Temp, FGR Cutback		180.0 deg	0.0 - 400.0
3.12.4	Fuel1 Cutback %, FGR Min Temp		0.0 %	0.0 to 20.0%
3.12.5	Fuel2 Cutback %, FGR Min Temp		0.0 %	0.0 to 20.0%
3.12.6	Fuel3 Cutback %, FGR Min Temp		0.0 %	0.0 to 20.0%
Draft Control	< Draft Basic Setup			
4.1.1	Draft Control Option		Disable	FloatingServo
4.1.2	Draft @ 4mA, Xmitr Cal		+1.000	PID420
4.1.3	Draft @ 20mA, Xmitr Cal		-1.000	-25.000 to +25.000
4.1.4	Outlet Damper Purge Position		deg. or %	-25.000 to +25.000
4.1.5	ID Fan VSD Purge Hz		55.0 Hz	30.00 - 200.00
Draft Control	< Draft Alarm Setup			
4.2.1	Low Alarm SP, Draft		+25.00	10.0 - 60.0
4.2.2	Alarm Delay Sec, Draft		8 sec.	-25.000 to +25.000
Draft Control	< Draft Misc setup			
4.3.1	Modulate Delay Sec, Draft		0 sec.	0 - 60
4.3.2	Cooldown Delay Sec, Draft		0 sec.	0 - 900
4.3.3	Draft Servo Check Option		Enable	Disable
Draft Control	< Draft Adj Start			
4.4.1	Adjustable Start Draft Option		Disable	Enable
4.4.2	Adj Start Draft SP		-0.500 in.	-0.100 to -5.000
4.4.3	Fuel 1 (oil) Adj Start Position		50.00 deg	10.00 - 120.00
4.4.4	Fuel 2 (gas) Adj Start Position		50.00 deg	10.00 - 120.00
4.4.5	Fuel 3 Adj Start Position		50.00 deg	10.00 - 120.00
Draft Control	< Floating Draft Tuning			
4.5.1	Proportional Band, Floating Draft		0.600	0.200 - 15.00
4.5.2	Deadband, Floating Draft		0.030	0.010 - 0.500

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values
Draft Control	< Draft Tuning			
	< Floating & PID Tuning			
	Filler Sec, Draft Xmitr		2.0 sec	0.5 - 5.0
	Max Damper Position in Auto, Draft		100.00	20.00 - 200.00
4.6.2	Min Damper Position in Auto, Draft		0.00	-20.00 to +90.00
4.6.3	Sec/90 deg Damper Rate Limit, Draft		25	15 - 60
Draft Control	< Draft Tuning			
	< PID Draft Tuning			
	Proportional Band, Draft PID		0.600	0.200 - 15.000
	Minutes Per Repeat, Draft PID		0.25	0.12 - 2.00
4.7.1	Gap, Draft PID		0.030	0.010 - 0.500
4.7.2	Gap Gain, Draft PID		0.30	0.10 - 0.75
4.7.3	< PID Feedforward Curve			
Draft Control	< Draft Tuning			
	< PID Feedforward Curve			
	Draft Feed Forward Curve: Fuel1			
	Firing Rate %: 0		0.00	0.00 - 160.00
4.8.1			0.00	0.00 - 160.00
4.8.2			0.00	0.00 - 160.00
4.8.3			0.00	0.00 - 160.00
4.8.4			0.00	0.00 - 160.00
4.8.5			0.00	0.00 - 160.00
4.8.6			0.00	0.00 - 160.00
4.8.7			0.00	0.00 - 160.00
4.8.8			0.00	0.00 - 160.00
4.9.x	Draft Feed Forward Curve: Fuel2			
	Firing Rate %: 0		0.00	0.00 - 160.00
			0.00	0.00 - 160.00
			0.00	0.00 - 160.00
4.9.1			0.00	0.00 - 160.00
4.9.2			0.00	0.00 - 160.00
4.9.3			0.00	0.00 - 160.00
4.9.4			0.00	0.00 - 160.00
4.9.5			0.00	0.00 - 160.00
4.9.6			0.00	0.00 - 160.00
4.9.7			0.00	0.00 - 160.00
4.9.8			0.00	0.00 - 160.00
4.10.x	Draft Feed Forward Curve: Fuel3			
	Firing Rate %: 0		0.00	0.00 - 160.00
			0.00	0.00 - 160.00
			0.00	0.00 - 160.00
4.10.1			0.00	0.00 - 160.00
4.10.2			0.00	0.00 - 160.00
4.10.3			0.00	0.00 - 160.00
4.10.4			0.00	0.00 - 160.00
4.10.5			0.00	0.00 - 160.00
4.10.6			0.00	0.00 - 160.00
4.10.7			0.00	0.00 - 160.00
4.10.8			0.00	0.00 - 160.00
Draft Control	< ID Fan VSD Tune			
	Max VSD Hz in Auto, Draft		60.00 Hz	20.00 - 60.00
	Min VSD Hz in Auto, Draft		10.00 Hz	0.00 - 40.00
	Sec/60Hz VSD Rate Limit, Draft		25	15 - 60
4.11.1				
4.11.2				
4.11.3	SP Offset, Draft VSD/Damper Dual Output Mode		0.510	0.020 - 0.510
4.11.4				

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values			
Feedwater Control	<Feedwater Setup	<Feedwater Basic Setup (P5.1.x)					
5.1.1	Feedwater Control Option		Disable	SingleElement	TwoElement	ThreeElement	
5.1.2	Valve/Pump Output Type		ServoValve	AO3Valve	AO3VSD		
5.1.3	Drum Level @ 4 mA, Xmtr Cal		+10.00	-50.00 to +99.00			
5.1.4	Drum Level @ 20 mA, Xmtr Cal		-10.00	-50.00 to +99.00			
Feedwater Control	<Feedwater Setup	< Feedwater Alarm Setup (P5.2.x)					
5.2.1	Low Alarm SP, Drum Level		-50.00	-50.00 to +99.00			
5.2.2	High Alarm SP, Drum Level		+99.00	-50.00 to +99.00			
5.2.3	Alarm Delay Sec, Drum Level		10	0 - 90			
Feedwater Control	<Feedwater Setup	< Steam Flow Setup (P5.3.x)					
5.3.1	Decimal Point, Steam Flow		xxx.x	xxxx	xx.xx		
5.3.2	Flow @ 20 mA, Steam Flow		100.0	10 - 32000	1.0 - 999.9	1.00 - 99.99	
5.3.4	Filler Sec, Steam Flow		1.5 sec	0.5 - 6.0			
5.3.5	Low Flow Cutoff %, Steam Flow		1.00 %	0.00 - 20.00 %			
Feedwater Control	<Feedwater Setup	< Feedwater Flow Setup (P5.4.x)					
5.4.1	Decimal Point, Feedwater Flow		xxx.x	xxxx	xx.xx		
5.4.2	Flow @ 20 mA, Feedwater Flow		100.0	10 - 32000	1.0 - 999.9	1.00 - 99.99	
5.4.3	Sq Root Option, Feedwater Flow		Disable	Enable			
5.4.4	Filler Sec, Feedwater Flow		1.0 sec	0.5 - 6.0			
5.4.5	Low Flow Cutoff %, Feedwater Flow		1.00 %	0.00 - 20.00 %			
Feedwater Control	<Feedwater Setup	< Pressure Compensate (P5.5.x)					
5.5.1	Pressure Units, Boiler Outlet Xmtr		psig	bar_g	kPa_g		
5.5.2	Drum Level Pressure Comp Option		Disable	Enable			
5.5.3	Steam Flow Press Com Option		Disable	Enable			
5.5.4	Steam Flow Design Pressure		125.0	0.5 - 1500.0			
Feedwater Control	<Feedwater Tuning	< Level Xmtr Tune (P5.6.x)					
5.6.1	Filter Sec, Drum Level		1.5 sec	0.5 - 6.0			
5.6.2	Drum Level Adjust		1.030	0.850 - 1.350			
Feedwater Control	<Feedwater Tuning	< 1 Element Level PID (P5.7.x)					
5.7.1	Proportional Band, 1 Elem FW		5.00	3.00 - 30.00			
5.7.2	Minutes Per Repeat, 1 Elem FW		5.00	2.00 - 15.00			
Feedwater Control	<Feedwater Tuning	< 2/3 Elem Level PID (P5.8.x)					
5.8.1	Proportional Band, 2/3 Elem FW		7.00	3.00 - 30.00			
5.8.2	Minutes Per Repeat, 2/3 Elem FW		6.50	2.00 - 15.00			
5.8.3	Feed forward Type, FW		LinearGain	Curve			
5.8.4	Feedforward Gain, FW		0.75	0.25 - 1.25 %			
5.8.5	Steam Flow %, 1 Elem Fallback		2.00	0.00 - 25.00 %			
5.8.6	Fallback On Delay Sec, FW		10 sec	2 - 30			
5.8.7	Fallback Off Delay, Sec, FW		10 sec	2 - 30			
Feedwater Control	<Feedwater Tuning	< FW FeedFwd Curve (P5.9.x)					
5.9.x	Drum Level Steam Flow Feedforward Curve						
5.9.1	Steam Flow Rate %: 0		0.00	-20.00 to +120.00	Valve degrees, VSD Hz, or FW Flow %		
5.9.2	10		0.00	-20.00 to +120.00			
5.9.3	20		0.00	-20.00 to +120.00			
5.9.4	30		0.00	-20.00 to +120.00			
5.9.5	40		0.00	-20.00 to +120.00			
5.9.6	60		0.00	-20.00 to +120.00			
5.9.7	80		0.00	-20.00 to +120.00			
5.9.8	100		0.00	-20.00 to +120.00			
Feedwater Control	<Feedwater Tuning	< 3 Element Flow PID (P5.10.x)					
5.10.1	Flow Prop Band		150.00	100.00 - 320.00			
5.10.2	Flow Min Per Repeat		0.20	0.10 - 0.50			
Feedwater Control	<Feedwater Tuning	< FW Pump VSD Curve (P5.11.x)					
5.11.1	No Flow VSD Hz, FW		30.00	5.00 - 50.00			
5.11.2	No Flow PID %, FW		8.00	4.00 - 20.00			

BurnerMate Universal Parameter Configuration Worksheet

Category	Parameter	Value	Default	Other Possible Values
Atomizing Control	< Atomizing Setup (P6.1.x)			
6.1.1	Atomizing Pressure Control Option		Disable	Enable
6.1.2	Pressure @ 4 mA, Xmtr Cal		0.0	-500.0 to 0.0
6.1.3	Pressure @ 20 mA, Xmtr Cal		100.0	1.0 - 999.9
Atomizing Control	< Atomizing Tuning			
6.2.1	Proportional Band, Atomizing		10.00	2.00 - 320.00
6.2.2	Minutes per Repeat, Atomizing		1.00	0.50 - 15.00
6.2.3	Gap Band, Atomizing Pressure		0.2	0.1 - 20.0
6.2.4	Minimum Modulation, Valve Degrees		-5.00	-50.00 to 180.00
Atomizing Control	< Atomizing Tuning			
6.3.1	Low Oil deg		0.0	-20.0 to 200.0
6.3.2	Low Atom deg		0.0	-20.0 to 200.0
6.3.3	High Oil deg		0.0	-20.0 to 200.0
6.3.4	High Atom deg		0.0	-20.0 to 200.0

Additional Setup Notes and Comments:

[illegible]

Boiler #1 Instruments

Steam Flow Transmitter Tag- FT-191
Foxboro- IDP10-A-22-C-2-1-F-M1
S/N- 20090309.675 Calibration- 0-200 inches
Units- 0-58 K#/hr
Loop Check-

Sample

Gas Flow Meter Tag- FT-162
18 PSI Supply Pressure 0-70 KSCFH
Foxboro- 84F-U-03-S-1-S-S-T-J-K
S/N- 20090302.032
Loop Check-

Boiler Steam Pressure Tag- PT-191
Foxboro- IGP-10-A-22-E-1-F
S/N- 20090309.716
Calibration- 0-400 PSI
Loop Check-

Air Flow Transmitter Tag- FT-112
Foxboro- IDP10-A-22-2-2-1-F-M1
S/N- 20090303.692
Calibration- 0-8.6 inches
Loop Check-

Drum Level Transmitter Tag-
Foxboro- IDP10-A-22-A-2-1-F-M1
S/N- 20090303.701
Calibration Range- 20 inches
Loop Check-

CUSTOMER: _____ DATE: _____
 JOB LOCATION: Janssen Pharmaceuticals _____ JOB# _____
 BURNER MANAGEMENT SYSTEM DATA: _____

F:/ENG/Safety Limit Sheet.xlsx

ThyssenKrupp Boiler Control Panel Commissioning
Incoming Supply Power Check at Start-up

Sample

Boiler #1	8/6/10	with Jimmy Dunnee, Electrician
Main 3 ph incoming power-	476 VAC	
	478 VAC	
	477 VAC	
120 VAC power transformer for the AC unit-	122 VAC	
120 VAC power transformer for the controls-	119 VAC	
After 15 amp breaker- term "L", "N", and "G"	119 VAC	

Boiler #2	8/7/10	with Jimmy Dunnee, Electrician
Main 3 ph incoming power-	476 VAC	
	478 VAC	
	477 VAC	
120 VAC power transformer for the AC unit-	120.6 VAC	
120 VAC power transformer for the controls-	117.7 VAC	
After 15 amp breaker- term "L", "N", and "G"	118.0 VAC	

Boiler #3	8/26/10	with TK I&E Mike Ross
Main 3 ph incoming power-	479 VAC	
	479.5 VAC	
	477.5 VAC	
120 VAC power transformer for the AC unit-	120.85 VAC	
120 VAC power transformer for the controls-	118.5 VAC	
After 15 amp breaker- term "L", "N", and "G"	118.35 VAC	



Preferred Services
A Division of Preferred Utilities Mfg. Corporation



Field Instrument Documentation

Customer:	Thyssen Krupp Stainless Steel USA, LLC	Date: 8/10/10
Job Location:	Calvert, AL	Job#: J10998E
Description	Boiler #1 Air Flow Transmitter	
Tag or I.D.	FT-112	
Manufacturer	Foxboro	
Model No.	IDP10-A-22-2-2-1-F-M1	
Serial No.	20090303.692	
Cal Range	0 to 8.6 inches w.c.	
Loop Check	Loop checked OK	
Display Locations	BMU LCD and OIT Touch Screen 0- 100%	



Preferred Services
A Division of Preferred Utilities Mfg. Corporation



Field Instrument Documentation

Customer:	Thyssen Krupp Stainless Steel USA, LLC	Date: 8/10/10
Job Location:	Calvert, AL	Job#: J10998E
Description	Boiler #1 Drum Level Transmitter	
Tag or I.D.	FT-184	
Manufacturer	Foxboro	
Model No.	IDP10-A-22-A-2-1-F-M1	
Serial No.	20090303.701	
Cal Range	0 to 20 inches w.c.	
Loop Check	Loop checked OK	
Display Locations	BMU LCD and OIT Touch Screen +13 to -7 inches w.c. Adjusted so that "0" equals the center of the glass.	



Preferred Services
A Division of Preferred Utilities Mfg. Corporation



Field Instrument Documentation

Customer:	Thyssen Krupp Stainless Steel USA, LLC	Date: 8/10/10
Job Location:	Calvert, AL	Job#: J10998E
Description	Boiler #1 Steam Flow Transmitter	
Tag or I.D.	FT-191	
Manufacturer	Foxboro	
Model No.	IDP10-A-22-C-2-1-F-M1	
Serial No.	20090309.675	
Cal Range	0 to 200 inches w.c.	
Loop Check	Loop checked OK	
Display Locations	BMU LCD and OIT Touch Screen 0-58,000 lbs/hr	

Preferred Utilities Mfg. Corporation

Variable Speed Drive Commissioning Form

Date:		SO# or J#	
Job Name:			
Address:			
Customer:			
Contact Info:			
Boiler Ref. #:			

Motor Data:	HP		Volts		RPM	
	SF		Amps		Kw.	

Manufacturer	
Model Number	

Application Notes:

VSD Info:	Manufacturer	
VSD Number		
Part Number		Serial Number
VSD Rating	HP	
	FLA	

Additional VSD Nameplate Data:

Tag ID		VSD Order # (P15-46)	
Drive SW Ver (P15-43)		Motor Hz (P16-13)	
Motor IRMS (P16-14)		HS Temp (P16-34)	

Bypass Y/N		Bypass Fuse Data	
Drive Fuse Data			

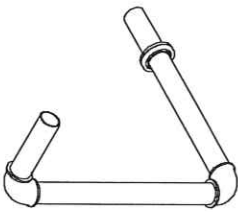
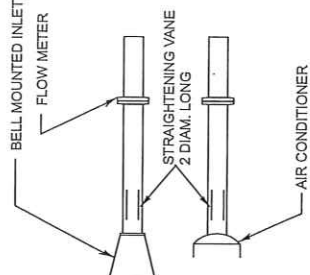
Installation, clearances, ventilation, ambient temperatures, etc.:

Voltage Checks	
L1-L2:	L2-L3:
L1- gnd:	L2- gnd:

Additional Notes/Comments:

FLOW METER PIPING REQUIREMENTS

"Diameters" of straight pipe required for various types of flow meters

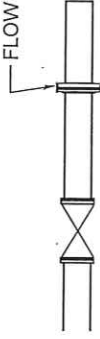
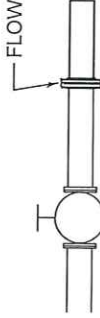
Diameter (D) = Nominal Pipe Size			Two Elbows, > 10 Diameters, Fittings in Different Planes	Two Elbows, < 10 Diameters, Fittings in Different Planes	Reducer or Expander (Unless Another Upstream fitting Needs More)	Atmospheric Intake
Example: 13 Diameters of 6" pipe = 78" 13 Diameters of 10" pipe = 130" Beta = (Bore I.D./Pipe I.D.) Bore is the smallest diameter of an orifice or nozzle Up = Upstream Diameters Down = Downstream Diameters						
Orifice/Nozzle	Beta = 0.5	Up	16	20	9	8
		Down	3	3	3	3
Venturi	Beta = 0.7	Up	23	30	12	9
		Down	4	4	4	4
	Beta = 0.5	Up	21	21	5 (reducer), 2 (expander)	□
		Down	2	2	2	□
Vortex	Beta = 0.7	Up	21	21	8 (reducer), 4 (expander)	□
		Down	2	2	4	□
		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:

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 Example: 13 Diameters of 6" pipe = 78" 13 Diameters of 10" pipe = 130"		Fully Open Gate Valve (Unless Another Upstream Fitting Needs More)	Fully Open Globe or Non-Return Valve (Unless Another Upstream Fitting Needs More)	Partially Open Valve or Regulator
Beta = (Bore I.D./Pipe I.D.) Bore is the smallest diameter of an orifice or nozzle Up = Upstream Diameters Down = Downstream Diameters				
Orifice/Nozzle	Beta = 0.5	6	11	26
	Down	3	3	3
	Beta = 0.7	10	15	38
	Down	4	4	4
Venturi	Beta = 0.5	5	7	7
	Down	2	2	2
	Beta = 0.7	9	26	26
	Down	4	4	4
Vortex	Up	25	25	30
	Down	5	5	5
Thermal	Up	15	15	40
	Down	5	5	5
Turbine	Up	10	10	10
	Down	5	5	5
Annubar	Up	8	9	24
	Down	3	3	4

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.

PREFERRED UTILITIES MANUFACTURING CORP.

31-35 SOUTH STREET, DANBURY, CONN. 06810
TEL: (203) 743-6741 • FAX: (203) 798-7313

CONTROL DIAGRAMMING SYSTEM SAMA LOGIC SYMBOLS

ENCLOSURE SYMBOLS			
	MEASURING OR READOUT		MANUAL SIGNAL PROCESSING
	AUTOMATIC SIGNAL PROCESSING		FINAL CONTROLLING

MEASURING OR READOUT LETTERS			
THESE LETTERS ARE TO BE USED WITHIN MEASURING OR READOUT (CIRCULAR) ENCLOSURE SYMBOL			
PROCESS VARIABLE			FUNCTION
A - ANALYSIS *	L - LEVEL	T - TEMPERATURE	R - RECORDING (RECORDER)
C - CONDUCTIVITY	M - MOISTURE	V - VISCOSITY	U - DIGITAL ACO. SYSTEM (DA)
D - DENSITY	P - PRESSURE	W - WEIGHT	I - INDICATING (INDICATOR)
F - FLOW	S - SPEED	Z - POSITION	T - TRANSMITTER
* SELF-DEFINING SYMBOLS (O ₂ , pH, Hz, ETC.) MAY BE USED IN PLACE OF "A"			Q - TOTALIZING (INTEGRATING)

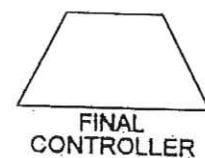
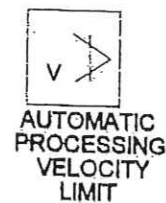
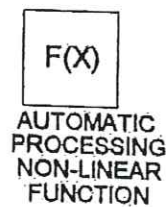
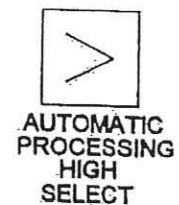
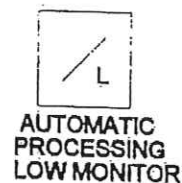
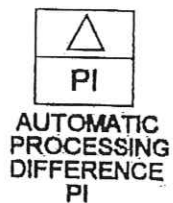
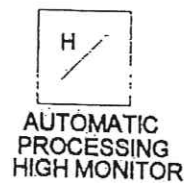
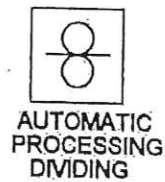
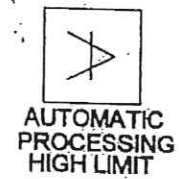
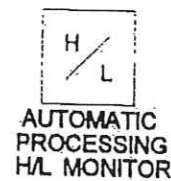
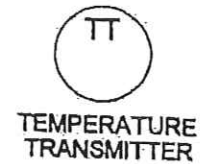
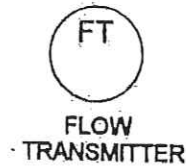
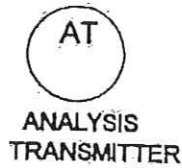
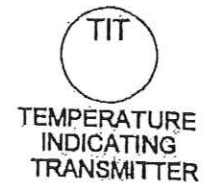
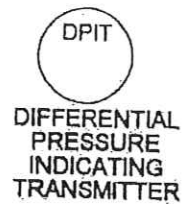
SIGNAL PROCESSING SYMBOLS			
	- PROPORTIONAL		- DIFFERENCE
	- INTEGRAL		- SUMMING
	- DERIVATIVE		- AVERAGING
	- REVERSE PROPORTIONAL		- ROOT EXTRACTION
	- NON-LINEAR FUNCTION		- MULTIPLYING
	- TIME FUNCTION		- DIVIDING
	- TRANSFER		- INTEGRATE OR TOTALIZE
	- SIGNAL GENERATOR		- TRI-STATE SIGNAL
			- HIGH SELECTING
			- LOW SELECTING
			- HIGH LIMITING
			- LOW LIMITING
			- VELOCITY LIMITING
			- HIGH SIGNAL MONITOR (HIGH ALARM)
			- LOW SIGNAL MONITOR (LOW ALARM)
			- HIGH/LOW SIGNAL MONITOR (HIGH ALARM)

NOTES:

1. THE CIRCULAR (MEASURING OR READOUT) SYMBOL CONTAINS MEASURING OR READOUT LETTERS FOR PROCESS VARIABLE OR FUNCTION AS NEEDED.
2. THE OTHER ENCLOSURE SYMBOLS (MANUAL SIGNAL PROCESSING, AUTOMATIC SIGNAL PROCESSING, AND FINAL CONTROLLING) CONTAIN SIGNAL PROCESSING SYMBOLS AS APPROPRIATE.
3. SYMBOLS CAN BE COMBINED TO REPRESENT COMPLEX FUNCTIONS
4. SAMA (SCIENTIFIC APPARATUS MAKERS ASSOCIATION) SYMBOLS SHOWN HERE ARE AS USED BY CTI ON CONTROL DIAGRAMS.

SAMA LOGIC SYMBOLS

TYPICAL EXAMPLES



AUTOMATIC SIGNAL PROCESSING

1SP_SORT		SQUARE ROOT	1SP_D_		DIFFERENCE
1SP_SUM		SUMMING	1SP_DUAL		
1SP_AVG		AVERAGING	1SPHSEL		HIGH SELECTING
1SP_DIV		DIVIDING	1SPLOSEL		LOW SELECTING
1SP_MULT		MULTIPLYING	1SPHILIM		HIGH LIMITING
1SP_F(X)		NON-LINEAR FUNCTION	1SPLOIM		LOW LIMITING
1SP_DL		DIFFERENCE	1SP_V		VELOCITY LIMITING
1SP_DPI		PROPORTIONAL INTEGRAL	1SP_H		HIGH ALARM
1SP_DID		DIFFERENCE INTEGRAL DERIVATIVE	1SP_L		LOW ALARM
1SP_DPID		PROPORTIONAL INTEGRAL DERIVATIVE	1SP_HL		HIGH/LOW ALARMS
1SPSNGL			1SP_HLIM		HIGH/LOW LIMITS
1SPSNGLS			1SP_BIAS		BIAS
1SP_IP		I TO P XDUCER	1SP_Q		INTEGRATE OR TOTALIZE
1SP_SMSQ					

MEASURING OR READOUT

1M_PIT		PRESSURE INDICATING TRANSMITTER	1M_PT		PRESSURE TRANSMITTER
1M_FIT		FLOW INDICATING TRANSMITTER	1M_FT		FLOW TRANSMITTER
1M_AIT		ANALYSIS INDICATING TRANSMITTER	1M_AT		ANALYSIS TRANSMITTER
1M_DPIT		DIFFERENTIAL PRESSURE INDICATING TRANSMITTER	1M_DPT		DIFFERENTIAL PRESSURE TRANSMITTER
1M_TIT		TEMPERATURE INDICATING TRANSMITTER	1M_TT		TEMPERATURE TRANSMITTER
			1M_T		TRANSMITTER

DRAWING SYMBOLS

2CKVLV		MANUAL CHECK VALVE
2MSOVLV		MANUAL SHUT-OFF VALVE
2PNUCV		PNEUMATIC SHUT-OFF VALVE
2SSQV3W		3-WAY SAFETY SHUT-OFF VALVE
2SSOV2W		2-WAY SAFETY SHUT-OFF VALVE
2FAN		FAN
2ACT		ACTUATOR
2DMPR		DAMPER

MANUAL SIGNAL PROCESSING

1MP_A		SIGNAL GENERATOR	1MP_TA		TRANSFER/SIGNAL GEN
1MP_T		TRANSFER	1MP_ATA		SIG GEN/TRANSFER
1MP_AT		SIGNAL GEN/TRANSFER			

FINAL CONTROLLING

1FC_F(X)		FINAL CONTROL ELEMENT NON-LINEAR
1FC_		FINAL CONTROL ELEMENT

OTHER

1ARROW		ARROW
--------	--	-------

12.3 GRAPHIC SYMBOLS

The following figures show some of the graphic symbols which may be encountered in the design, construction and operation of process control systems by the engineer, technician or operator. The symbols are used in the preparation of plan and elevation drawings for architectural and mechanical construction; in flow diagrams to indicate process flow conditions from raw material input to product output; in line, ladder and schematic diagrams to

indicate process flow conditions from raw material input to product output; in line, ladder and schematic diagrams to

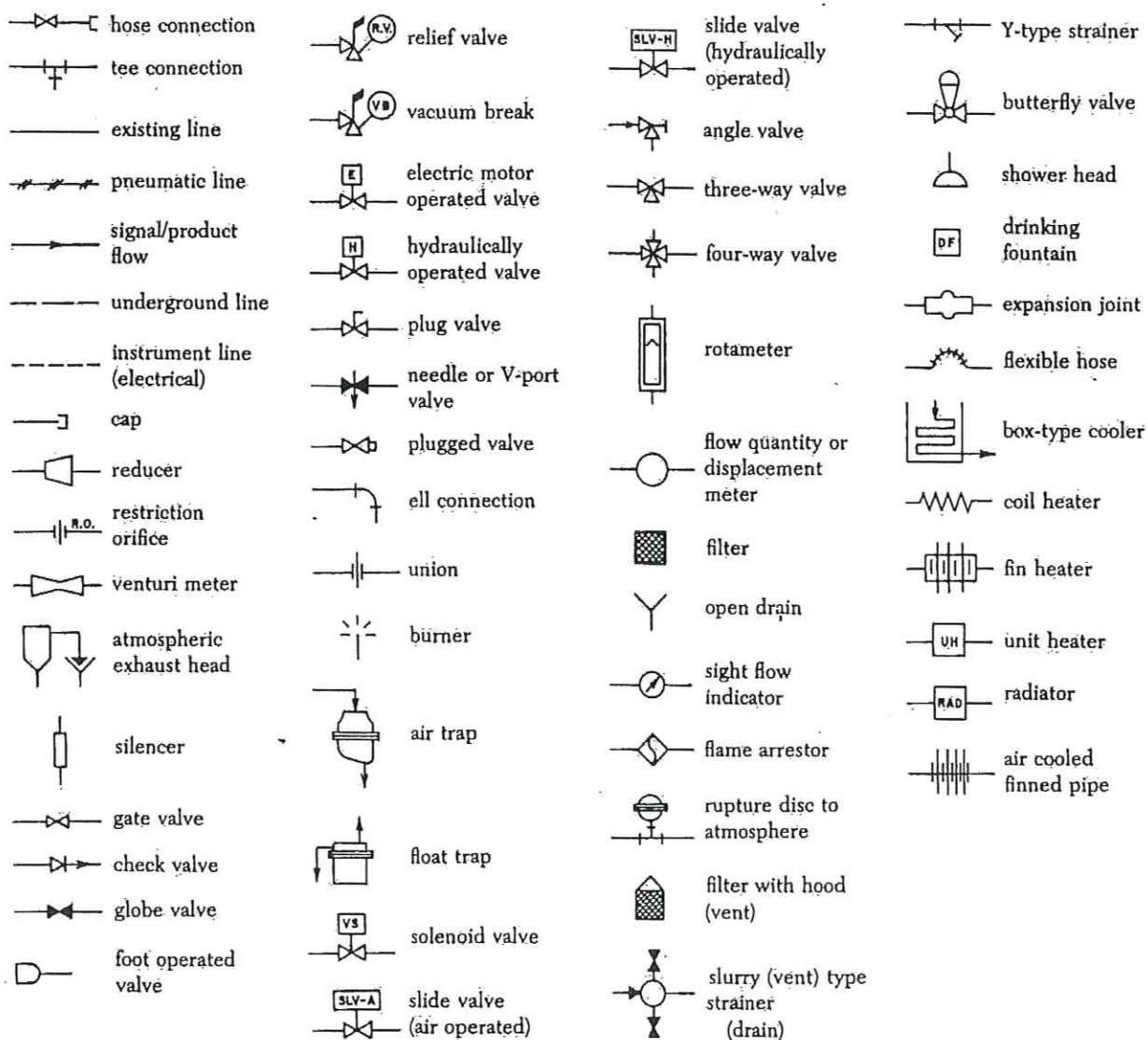


Fig. 12.3a Flow Sheet Symbols.

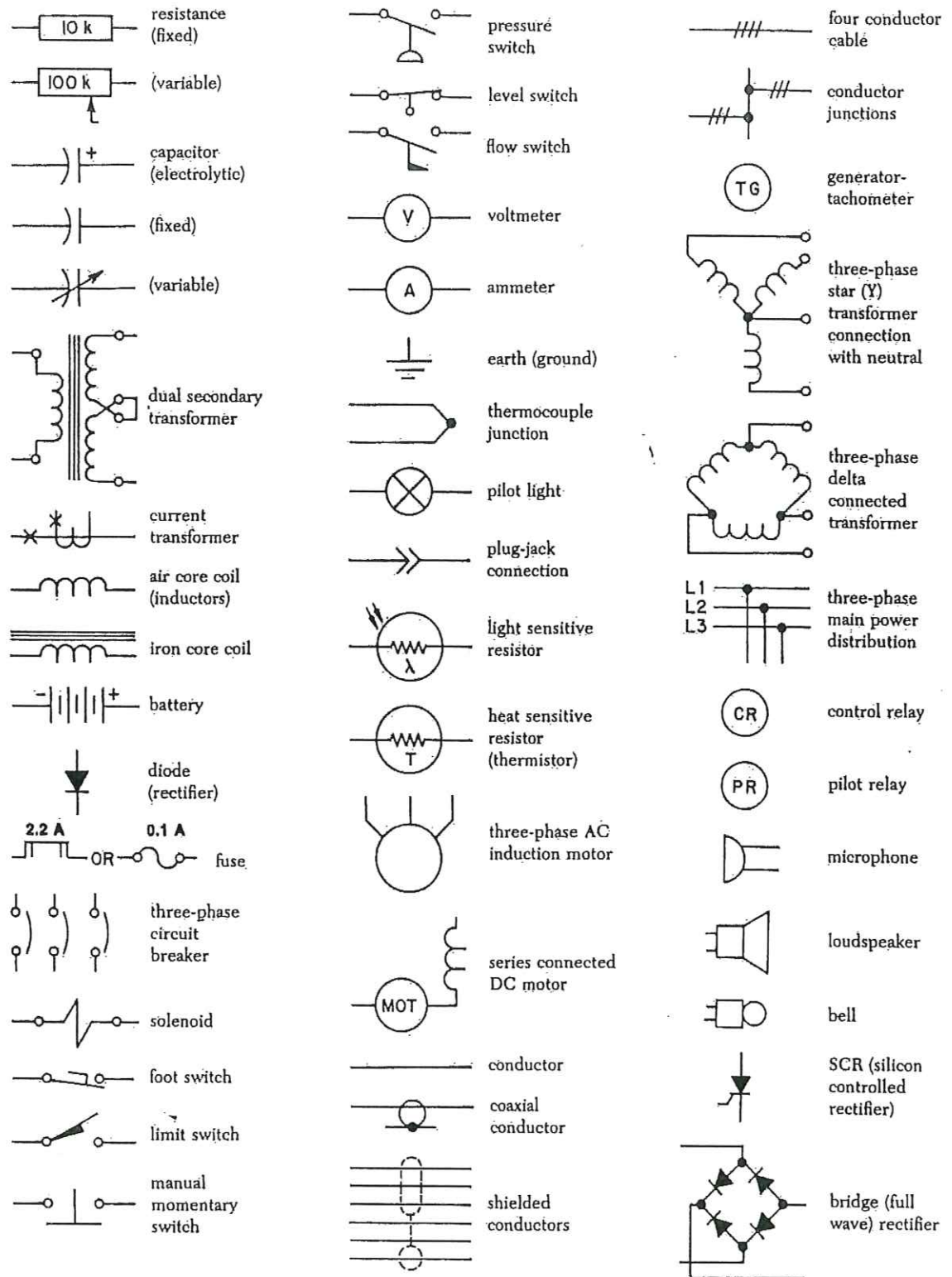


Fig. 12.3c Electrical symbols

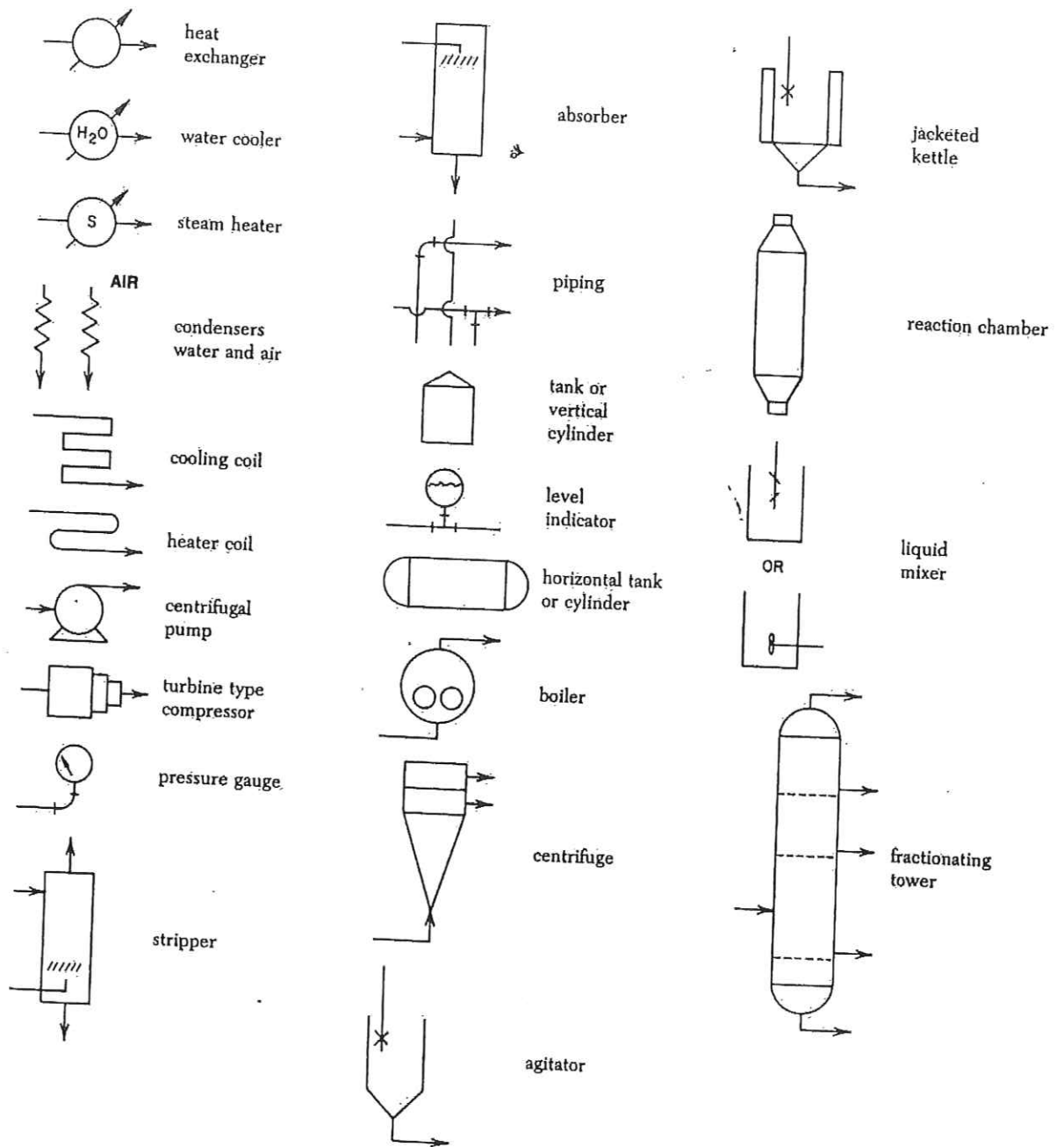
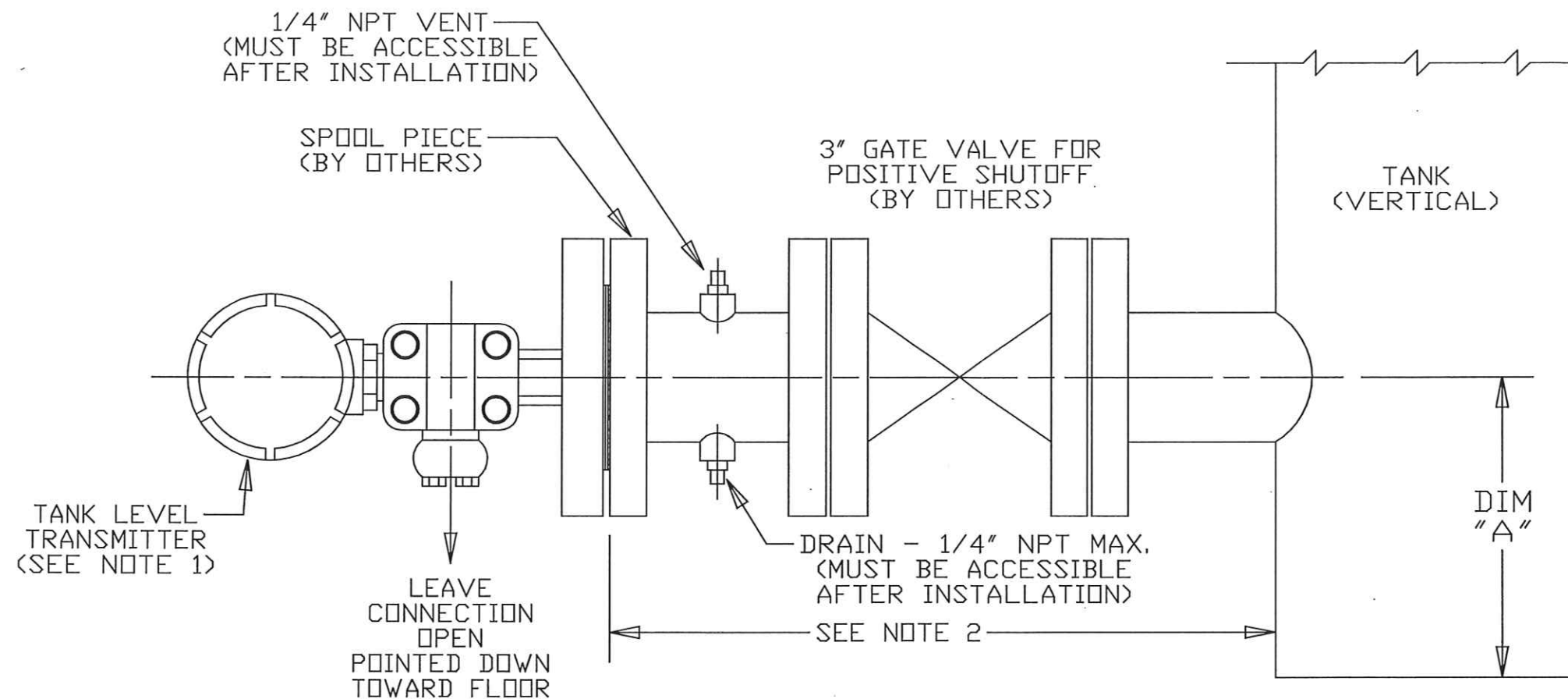


Fig. 12.3b Equipment symbols



NOTES:

1. TRANSMITTER SHOULD BE PROTECTED FROM PHYSICAL DAMAGE.
2. WHEN TANK CONTAINS HEATED OIL, THIS AREA MUST BE INSULATED & HEAT TRACED. MAX. LENGTH NOT TO EXCEED 16".
3. DIMENSION "A", TANK PRINT, AND TYPE OF FLUID REQUIRED FOR PROPER CALIBRATION.



PREFERRED INSTRUMENTS

31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.

FLANGE MOUNTED TANK LEVEL TRANSMITTER INSTALLATION DETAILS

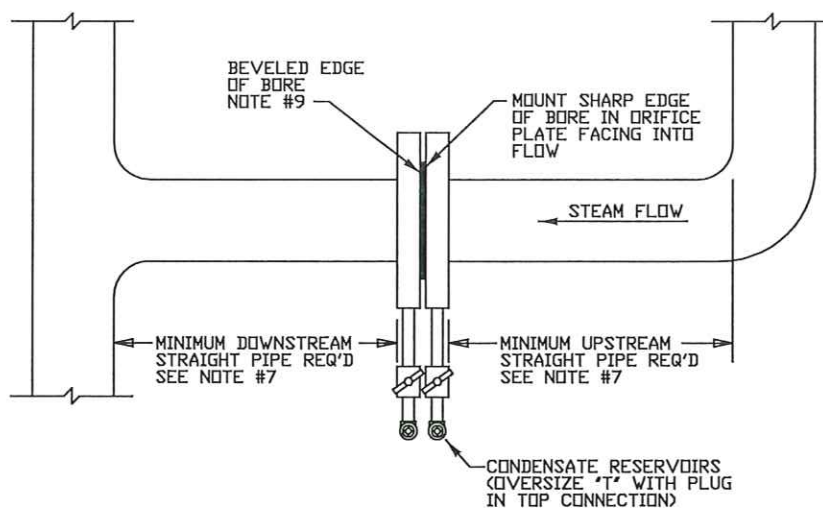
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SUPERSEDES:		ASS'Y NO.:
MATERIAL:		SCALE: NONE
DRAWN: S. MOLA 10-23-96		SDW-1800
APPR'D:		

FILE #S1800

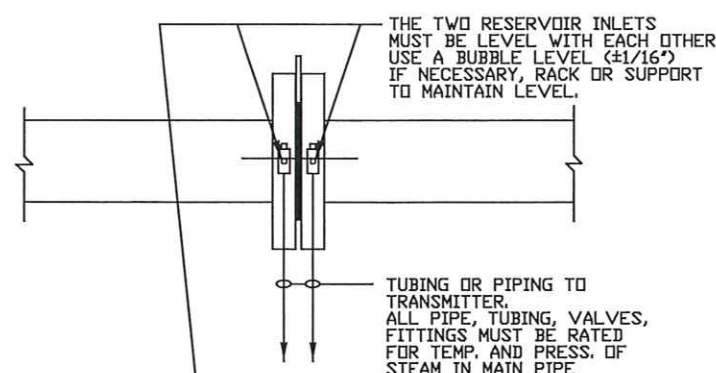
LET.

REVISIONS

DATE OF CHANGE

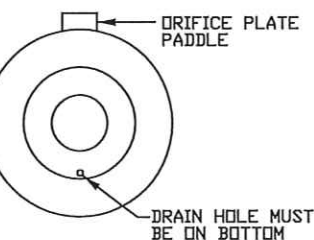


TOP VIEW

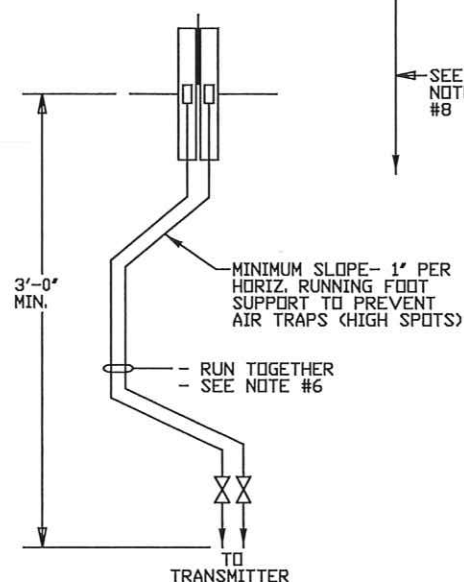


SIDE VIEW

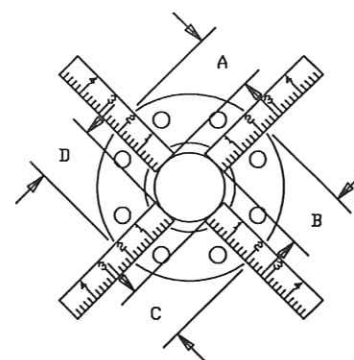
PITCH DOWN SLIGHTLY TOWARD STEAM PIPE TO ALLOW CONDENSATE TO DRAIN INTO STEAM PIPE



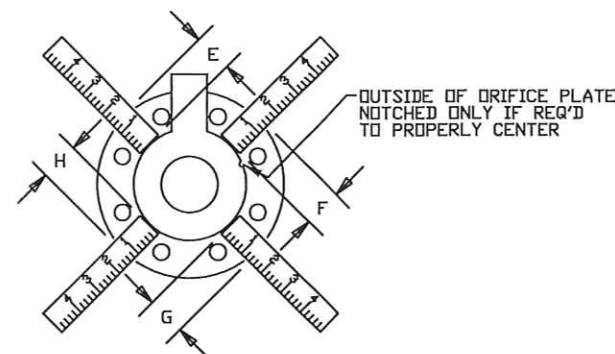
END VIEW



IMPULSE AND TRANSMITTER PIPING



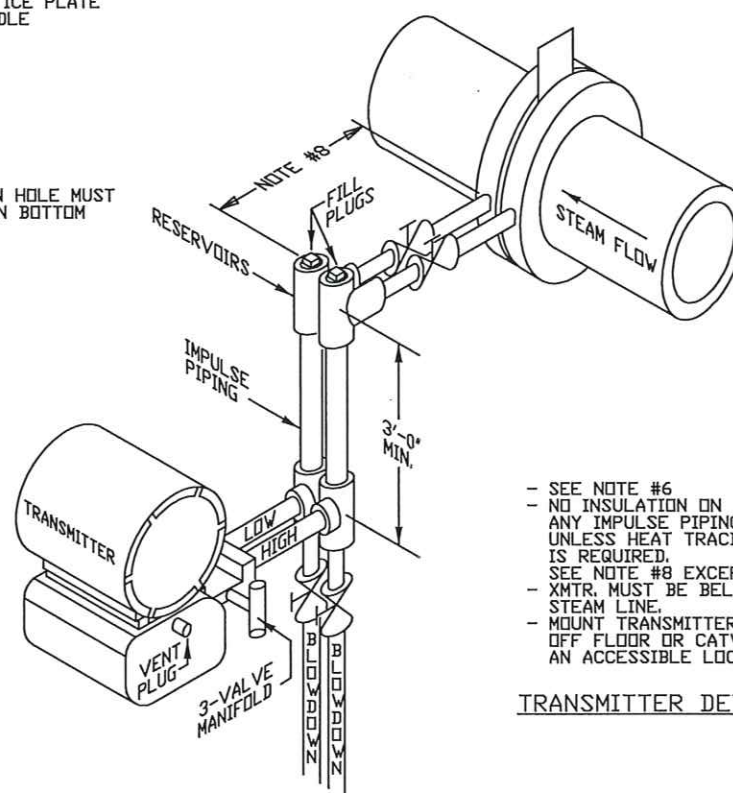
1. MEASURE CONCENTRICITY OF FLANGE TO PIPE I.D.



2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE
3. DIFFERENCE BETWEEN DIMENSIONS AT CORRESPONDING POINTS OF MEASUREMENT SHOULD BE THE SAME
A-E = B-F = C-G = D-H = CONSTANT VALUE

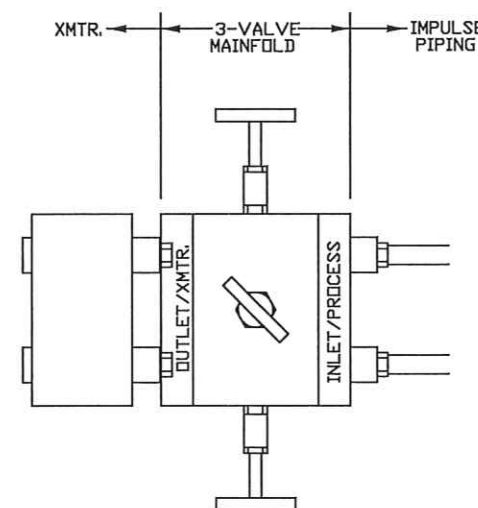
CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$



- SEE NOTE #6
- NO INSULATION ON ANY IMPULSE PIPING UNLESS HEAT TRACING IS REQUIRED.
- SEE NOTE #8 EXCEPTION
- XMTR. MUST BE BELOW STEAM LINE.
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW
3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

SERVICE: _____

MAX FLOW: _____ lbs./hr.

NORMAL FLOW: _____ lbs./hr.

MIN MEASURABLE: _____ lbs./hr.

STEAM PRESSURE: _____ PSIG

STEAM TEMP.: _____ (SAT or °F)

NOMINAL PIPE SIZE: _____ inches

PIPE WALL: _____ schedule

PIPE I.D.: _____ inches

ORIFICE PL. BORE: _____ inches

XMTR. DIFFERENTIAL: _____ inches W.C.

MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches

MIN DNSTEAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

- IMPULSE PIPING MUST BE SLOPED TO ALLOW AIR BUBBLES TO BE PURGED FROM SYSTEM.
- CONDENSATE RESERVOIRS MUST BE LEVEL WITH EACH OTHER.
- WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
- REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
- INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
- BOTH IMPULSE PIPES MUST BE KEPT AT THE SAME TEMPERATURE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.
- SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
- MINIMIZE THIS LENGTH. FOR LENGTHS OVER 12', INSULATE FROM FLANGE TAP UP TO WITHIN 12' FROM RESERVOIR.
- 8" PIPES AND LARGER, ORIFICE PLATE MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.



PREFERRED INSTRUMENTS

31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.

ORIFICE PLATE INSTALLATION
DETAILS FOR HORIZONTAL
STEAM PIPES W/FLANGE TAPS

MODEL	SIZE	TYPE
SUPERSEDES: SDW-800-1	ASS'Y NO:	
MATERIAL:	SCALE: NONE	
DRAWN: CFA 5/5/97		

FILE # S1801

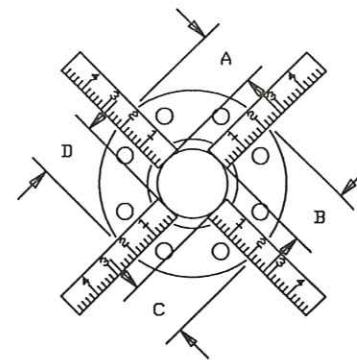
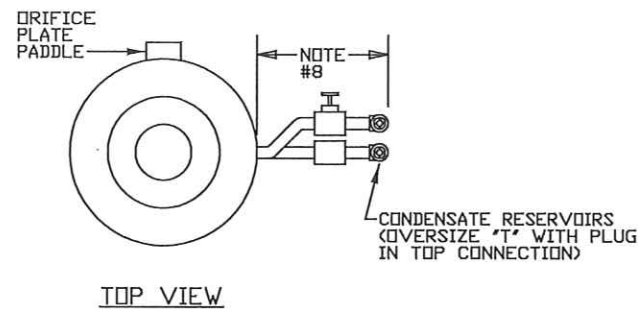
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REVISIONS

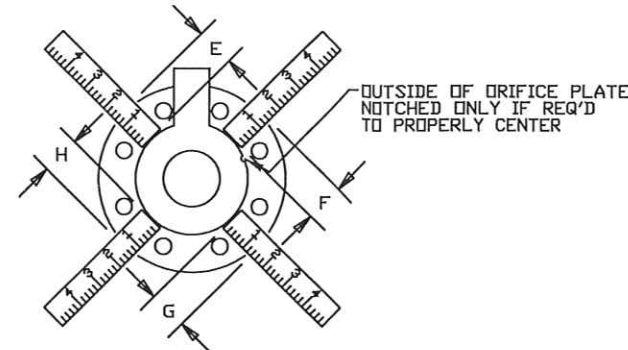
DATE OF CHANGE

APPR'D:

SDW-1801



1. MEASURE CONCENTRICITY OF FLANGE TO PIPE I.D.

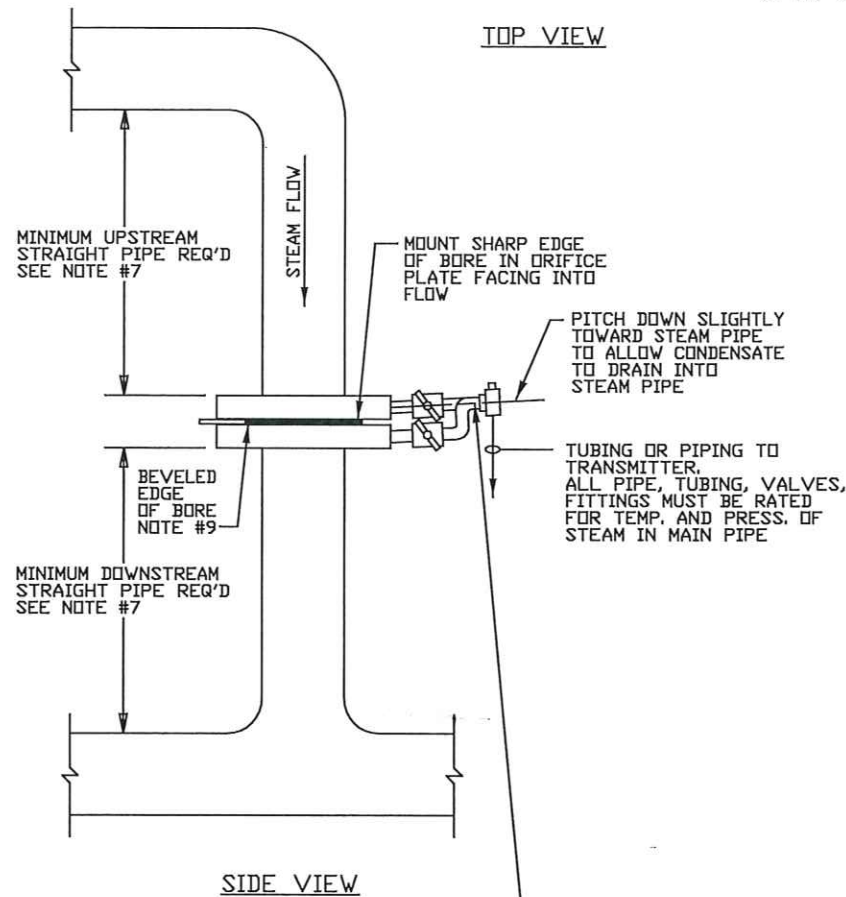


2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE

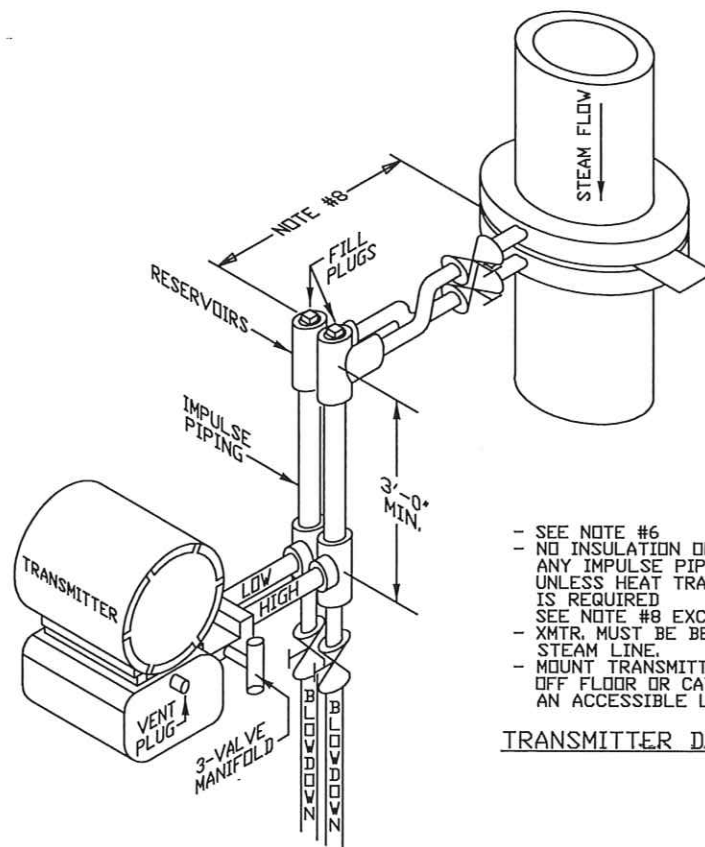
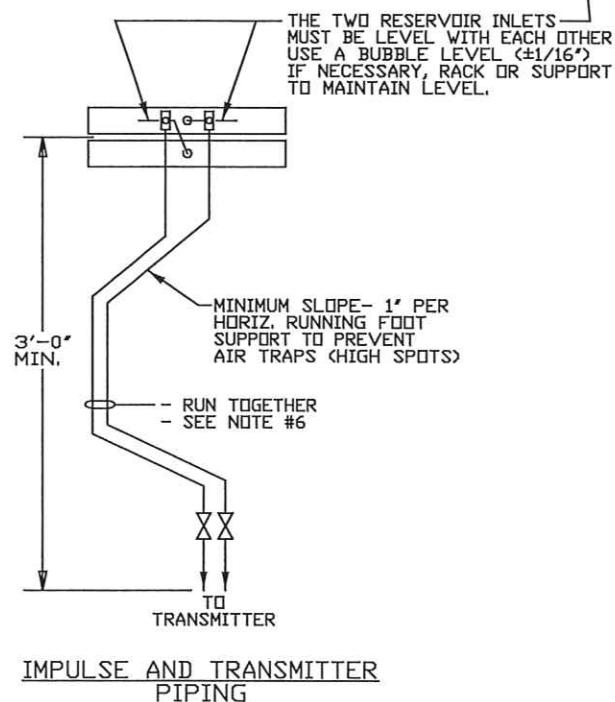
3. DIFFERENCE BETWEEN DIMENSIONS AT CORRESPONDING POINTS OF MEASUREMENT SHOULD BE THE SAME
A-E = B-F = C-G = D-H = CONSTANT VALUE

CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$

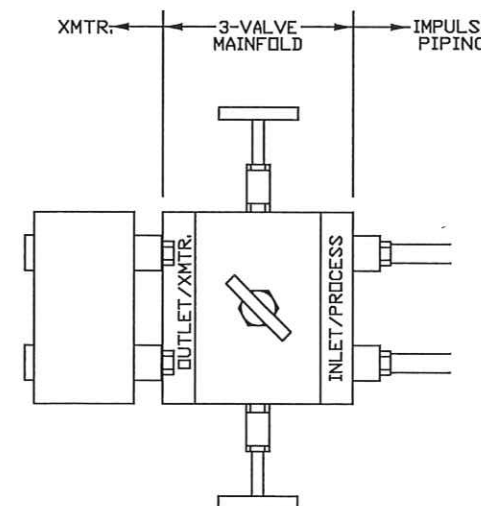


SIDE VIEW



- SEE NOTE #6
- NO INSULATION ON ANY IMPULSE PIPING UNLESS HEAT TRACING IS REQUIRED
- SEE NOTE #8 EXCEPTION
- XMTR. MUST BE BELOW STEAM LINE.
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW 3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____
SERVICE: _____
MAX FLOW: _____ lbs./hr.
NORMAL FLOW: _____ lbs./hr.
MIN MEASURABLE: _____ lbs./hr.
STEAM PRESSURE: _____ PSIG
STEAM TEMP.: _____ (SAT or °F)
NOMINAL PIPE SIZE: _____ inches
PIPE WALL: _____ schedule
PIPE I.D.: _____ inches
ORIFICE PL. BORE: _____ inches
XMTR. DIFFERENTIAL: _____ inches W.C.
MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches
MIN DNSTEAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

- IMPULSE PIPING MUST BE SLOPED TO ALLOW AIR BUBBLES TO BE PURGED FROM SYSTEM.
- CONDENSATE RESERVOIRS MUST BE LEVEL WITH EACH OTHER.
- WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
- REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
- INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
- BOTH IMPULSE PIPES MUST BE KEPT AT THE SAME TEMPERATURE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.
- SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
- MINIMIZE THIS LENGTH. FOR LENGTHS OVER 12', INSULATE FROM FLANGE TAP UP TO WITHIN 12' FROM RESERVOIR.
- 8" PIPES AND LARGER, ORIFICE PLATE MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.



PREFERRED INSTRUMENTS

31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.

ORIFICE PLATE INSTALLATION
DETAILS FOR VERTICAL
STEAM PIPES W/FLANGE TAPS

MODEL	SIZE	TYPE
SUPERSEDES		ASS'Y NO.
MATERIAL		SCALE: NONE
DRAWN: CFA 5/5/97		

FILE # S1802

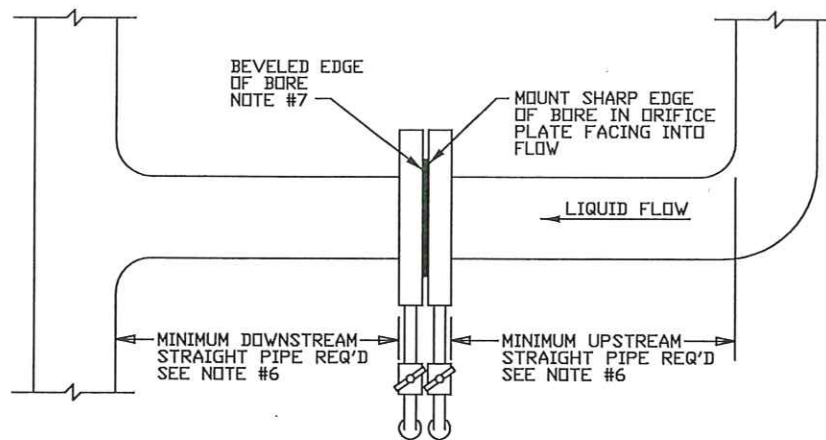
LET.

REVISIONS

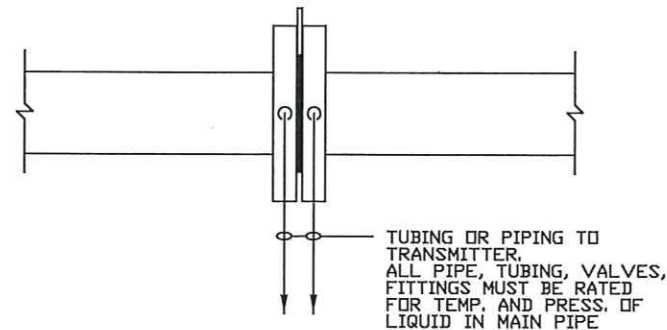
DATE OF CHANGE

APPR'D:

SDW-1802

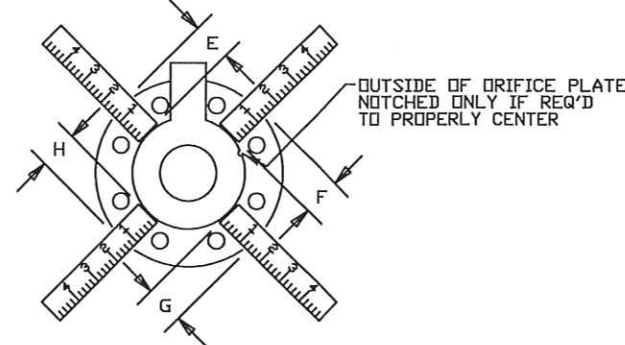
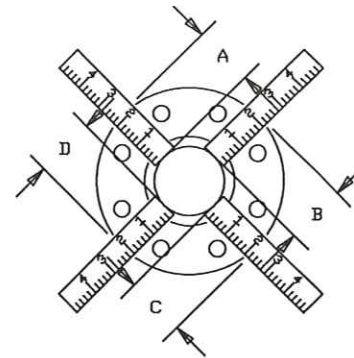


TOP VIEW



SIDE VIEW

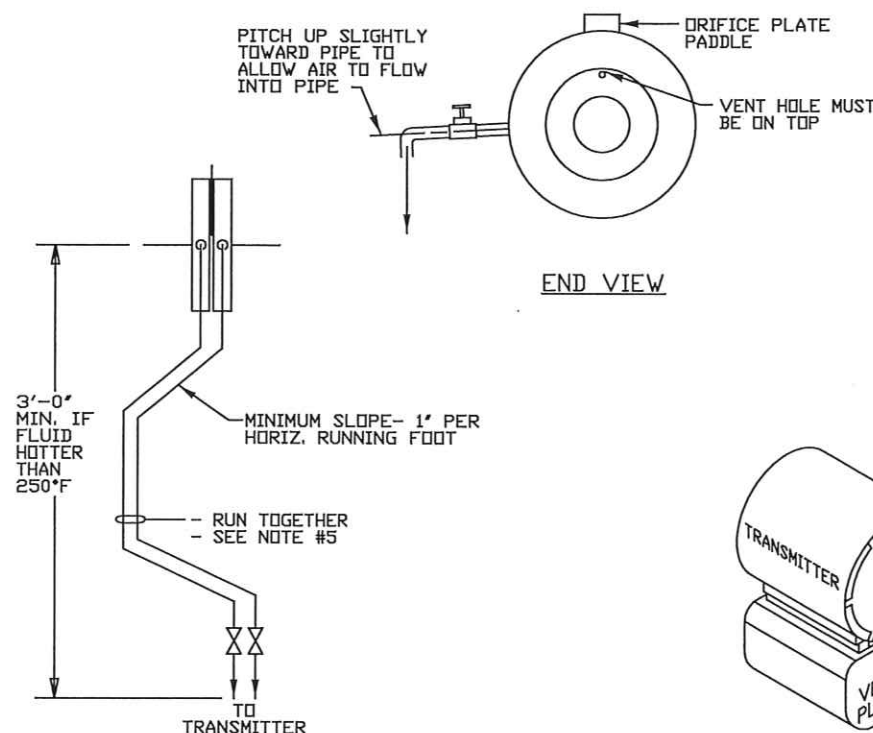
1. MEASURE CONCENTRICITY OF FLANGE TO PIPE I.D.



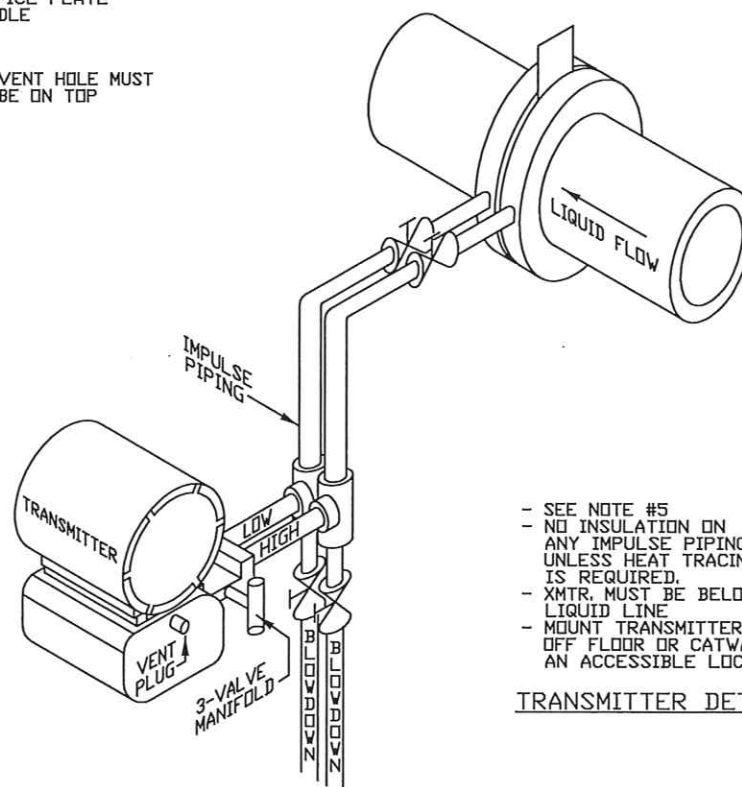
2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE
3. DIFFERENCE BETWEEN DIMENSIONS AT CORRESPONDING POINTS OF MEASUREMENT SHOULD BE THE SAME
A-E = B-F = C-G = D-H = CONSTANT VALUE

CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$

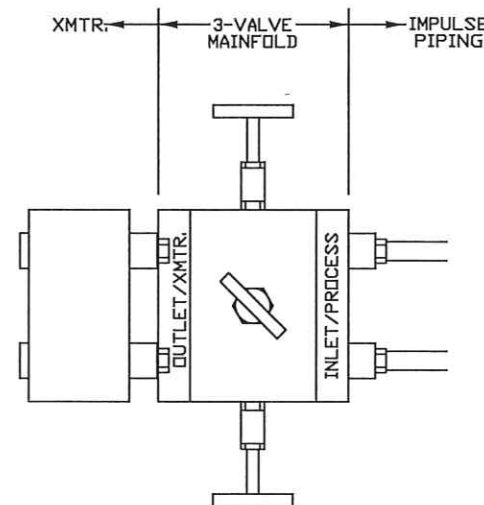


IMPULSE AND TRANSMITTER PIPING



- SEE NOTE #5
- NO INSULATION ON ANY IMPULSE PIPING UNLESS HEAT TRACING IS REQUIRED.
- XMTR. MUST BE BELOW LIQUID LINE
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW
3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____
SERVICE: _____
MAX FLOW: _____ GPM or lbs./hr.
NORMAL FLOW: _____ GPM or lbs./hr.
MIN MEASURABLE: _____ GPM or lbs./hr.
LIQUID TEMP: _____ °F
LIQUID DENSITY @70°F: _____ SP.GR.
NOMINAL PIPE SIZE: _____ inches
PIPE WALL: _____ schedule
PIPE I.D.: _____ inches
ORIFICE PL. BORE: _____ inches
XMTR. DIFFERENTIAL: _____ inches W.C.
MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches
MIN DNSTREAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

- IMPULSE PIPING MUST BE SLOPED TO ALLOW CONDENSATE TO DRAIN AWAY FROM TRANSMITTER.
- WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
- REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
- INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
- BOTH IMPULSE PIPES MUST BE KEPT AT THE SAME TEMPERATURE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.
- SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
- 8" PIPE AND LARGER, ORIFICE PLATES MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.



PREFERRED INSTRUMENTS

31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.
ORIFICE PLATE INSTALLATION
DETAILS FOR HORIZONTAL
LIQUID PIPES W/FLANGE TAPS

MODEL	SIZE	TYPE
SUPERSEDES		ASS'Y NO.
MATERIAL		SCALE: NONE
DRAWN: CFA 5/5/97		

FILE # S1803

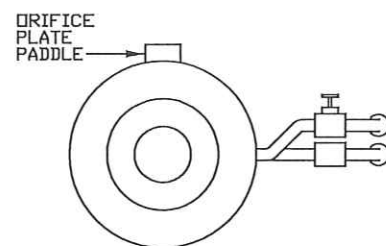
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REVISIONS

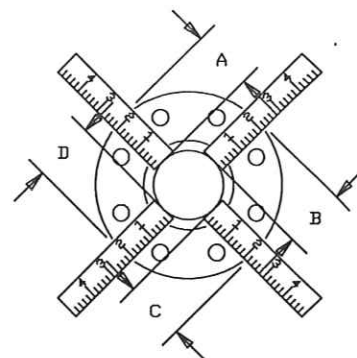
DATE OF CHANGE

APPR'D

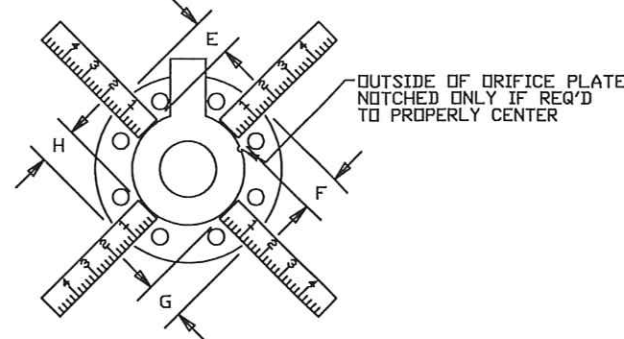
SDW-1803



TOP VIEW

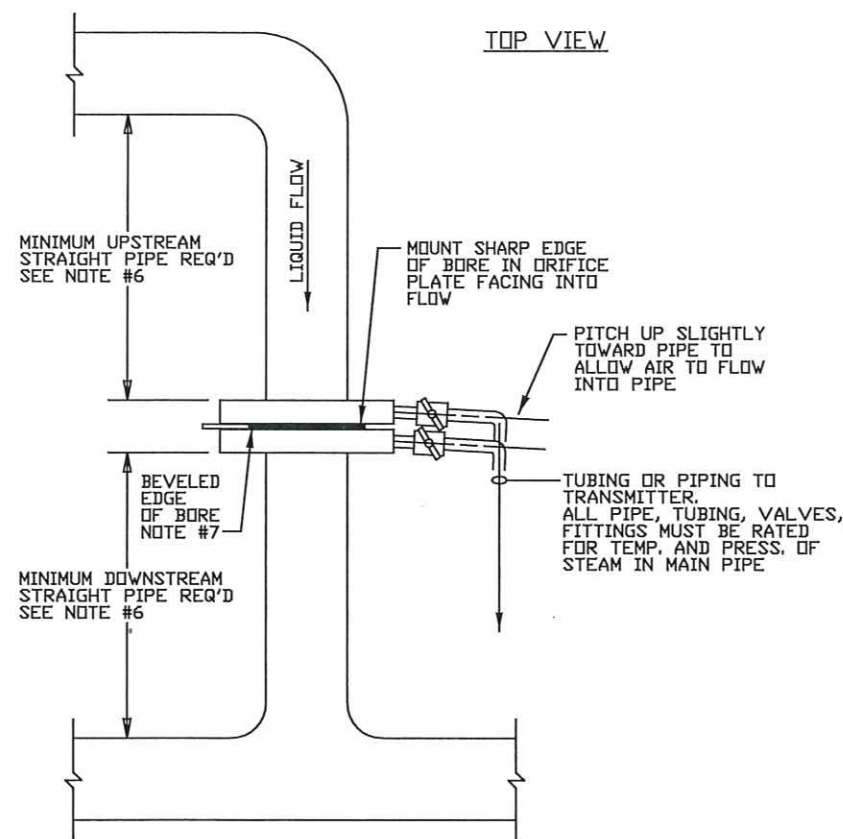


1. MEASURE CONCENTRICITY OF FLANGE TO PIPE I.D.



2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE

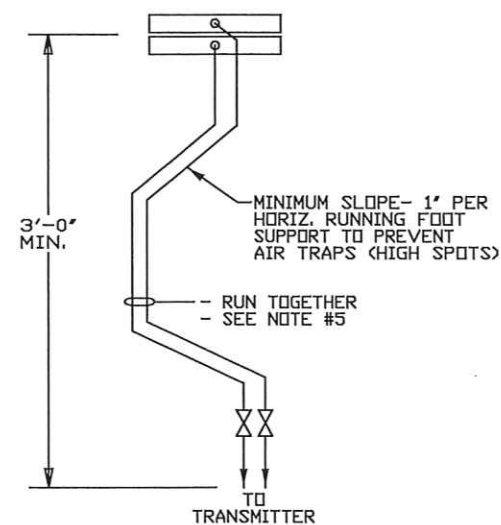
3. DIFFERENCE BETWEEN DIMENSIONS AT CORRESPONDING POINTS OF MEASUREMENT SHOULD BE THE SAME
A-E = B-F = C-G = D-H = CONSTANT VALUE



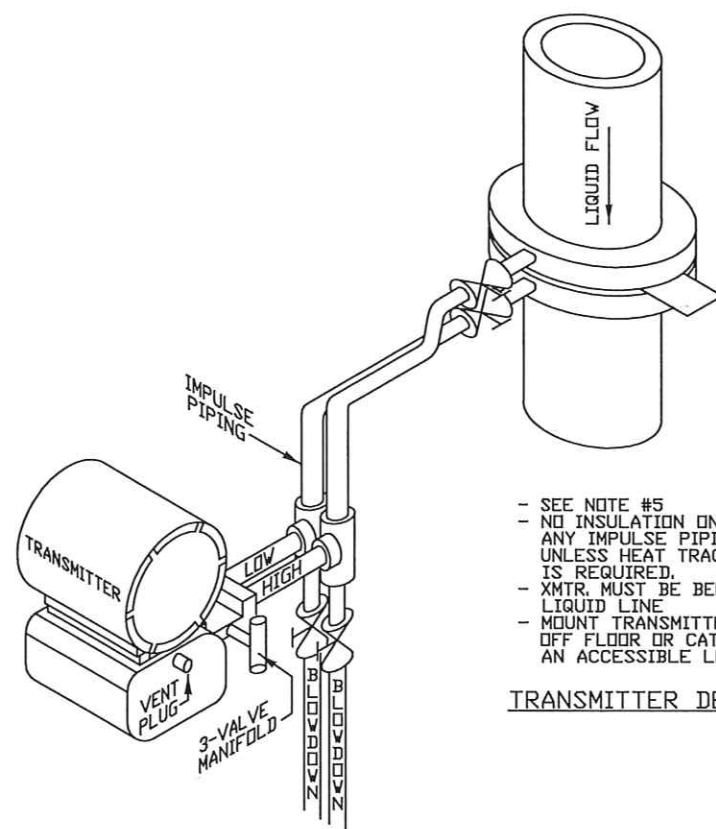
SIDE VIEW

CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$

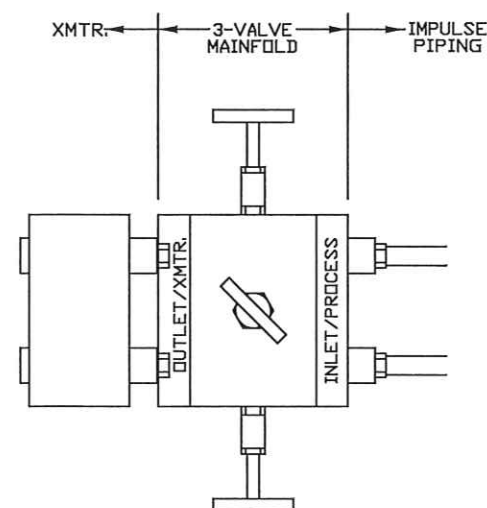


IMPULSE AND TRANSMITTER PIPING



- SEE NOTE #5
- NO INSULATION ON ANY IMPULSE PIPING UNLESS HEAT TRACING IS REQUIRED.
- XMTR. MUST BE BELOW LIQUID LINE
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW
3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____
SERVICE: _____
MAX FLOW: _____ GPM or lbs./hr.
NORMAL FLOW: _____ GPM or lbs./hr.
MIN MEASURABLE: _____ GPM or lbs./hr.
LIQUID TEMP: _____ °F
LIQUID DENSITY @70°F: _____ SP.GR.
NOMINAL PIPE SIZE: _____ inches
PIPE WALL: _____ schedule
PIPE I.D.: _____ inches
ORIFICE PL. BORE: _____ inches
XMTR. DIFFERENTIAL: _____ inches W.C.
MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches
MIN DNSTEAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

1. IMPULSE PIPING MUST BE SLOPED TO ALLOW CONDENSATE TO DRAIN AWAY FROM TRANSMITTER.
2. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A) HI & LO CLOSED - EQUALIZER OPEN B) OPEN LO C) CLOSE EQUALIZER D) OPEN HI
3. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
4. INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
5. BOTH IMPULSE PIPES MUST BE KEPT AT THE SAME TEMPERATURE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.
6. SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
7. 8" PIPE AND LARGER, ORIFICE PLATES MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.

PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Manufacturing Corp.
**ORIFICE PLATE INSTALLATION
DETAILS FOR VERTICAL
LIQUID PIPES W/FLANGE TAPS**

MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
APPR'D:		

FILE # S1804

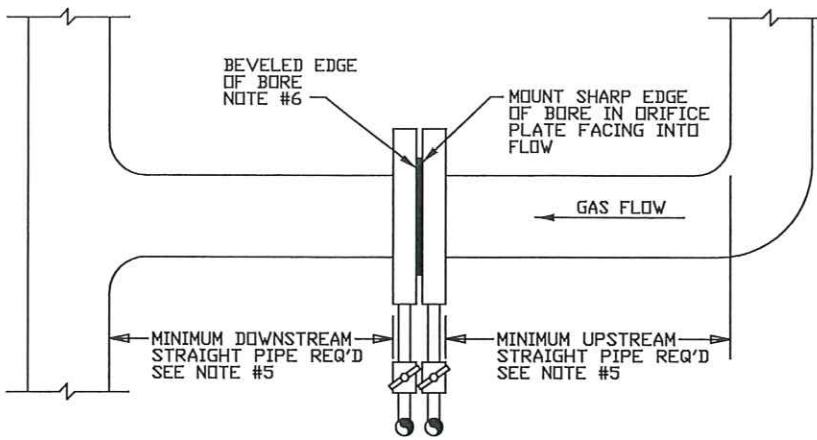
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REVISIONS

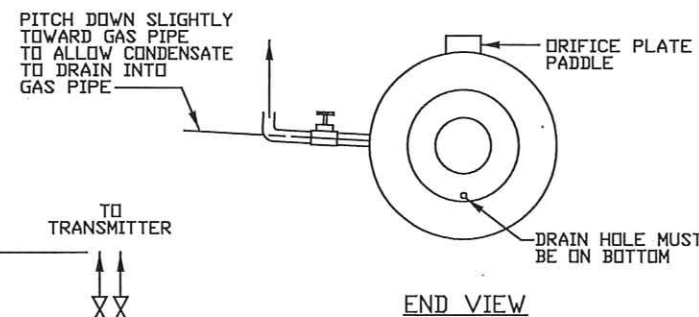
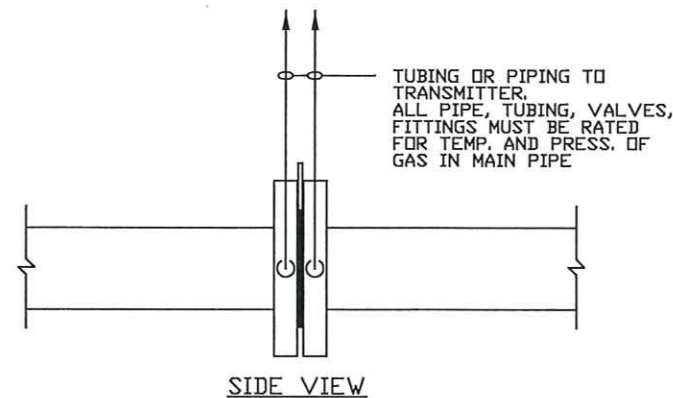
DATE OF CHANGE

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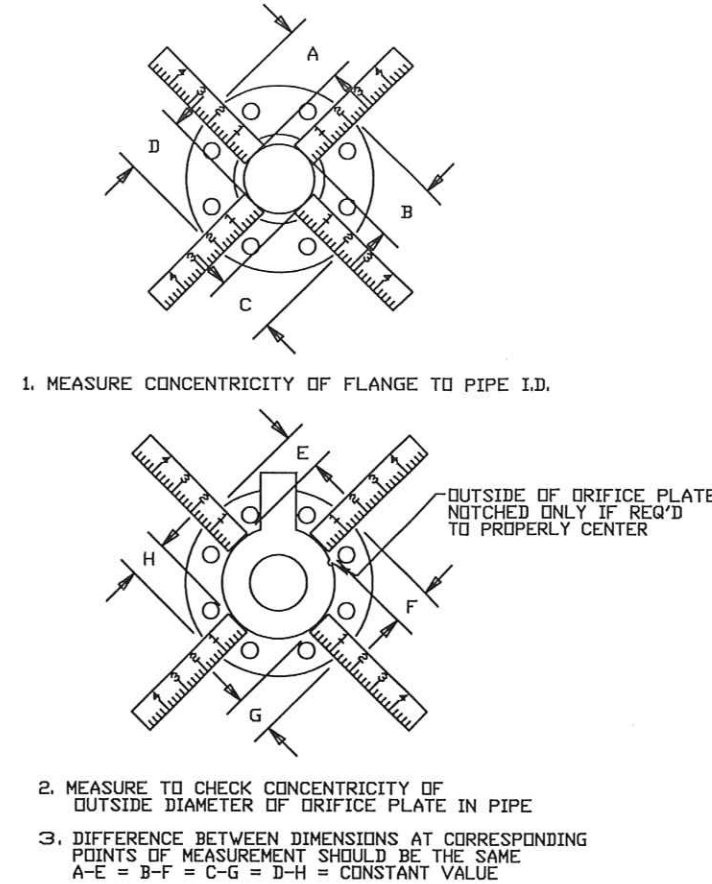
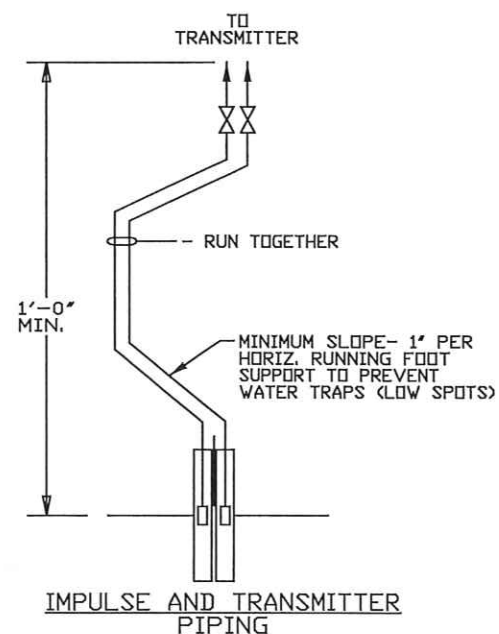
SDW-1804



TOP VIEW

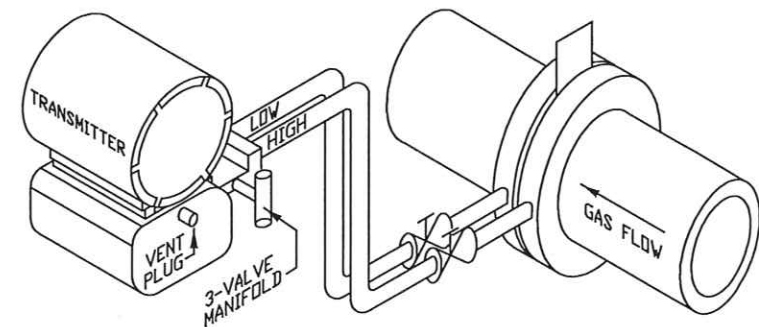


END VIEW



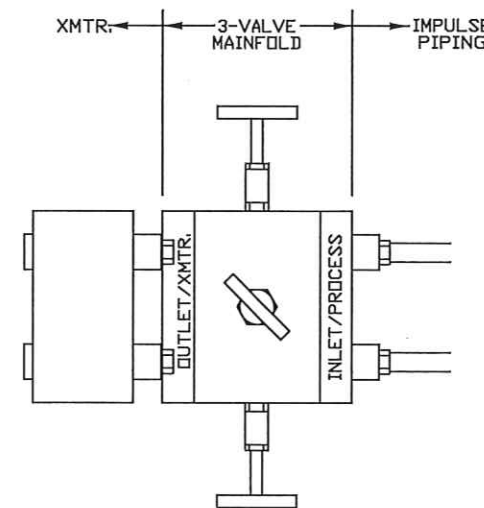
CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$



- XMTR. MUST BE ABOVE GAS LINE
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW
3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

SERVICE: _____

MAX FLOW: _____ SCFH

NORMAL FLOW: _____ SCFH

MIN MEASURABLE: _____ SCFH

GAS PRESSURE: _____ PSIG

GAS TEMP.: _____ °F

GAS DENSITY @70°F: _____ SP.GR.

NOMINAL PIPE SIZE: _____ inches

PIPE WALL: _____ schedule

PIPE I.D.: _____ inches

ORIFICE PL. BORE: _____ inches

XMTR. DIFFERENTIAL: _____ inches W.C.

MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches

MIN DNSTEAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

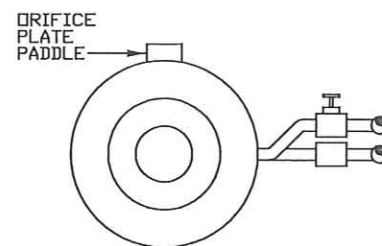
1. IMPULSE PIPING MUST BE SLOPED TO ALLOW CONDENSATE TO DRAIN AWAY FROM TRANSMITTER.
2. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
3. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
4. INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
5. SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
6. 8" PIPE AND LARGER, ORIFICE PLATES MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.

PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Manufacturing Corp.
**ORIFICE PLATE INSTALLATION
DETAILS FOR HORIZONTAL
GAS PIPES W/FLANGE TAPS**

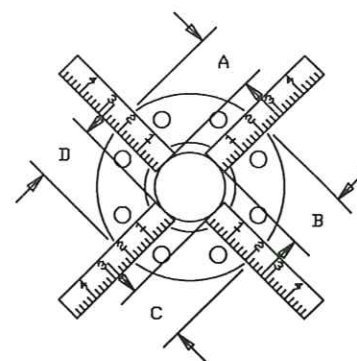
MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
APP'R'D:		

FILE # S1805

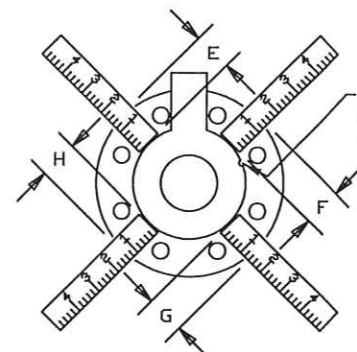
SDW-1805



TOP VIEW



1. MEASURE CONCENTRICITY OF FLANGE TO PIPE I.D.



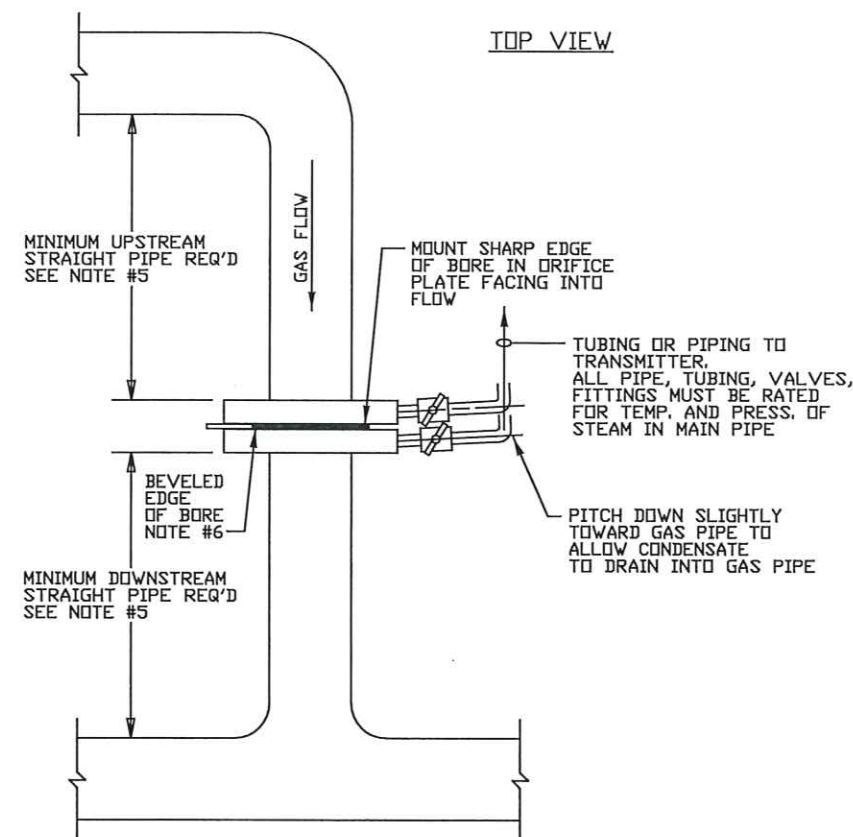
2. MEASURE TO CHECK CONCENTRICITY OF OUTSIDE DIAMETER OF ORIFICE PLATE IN PIPE

3. DIFFERENCE BETWEEN DIMENSIONS AT CORRESPONDING POINTS OF MEASUREMENT SHOULD BE THE SAME
A-E = B-F = C-G = D-H = CONSTANT VALUE

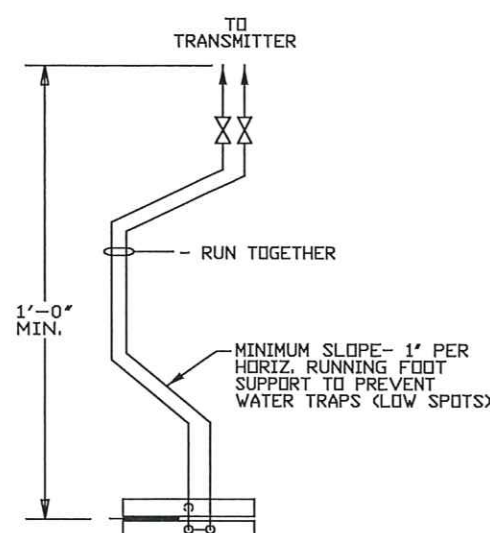
OUTSIDE OF ORIFICE PLATE NOTCHED ONLY IF REQ'D TO PROPERLY CENTER

CENTERING OF ORIFICE PLATE OR FLOW NOZZLE

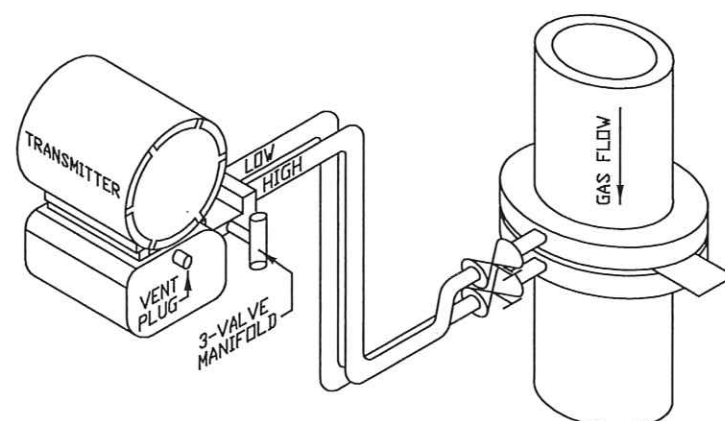
CONCENTRICITY TOLERANCE: 8" PIPE $\pm 1/32"$
6" PIPE $\pm 1/64"$



SIDE VIEW

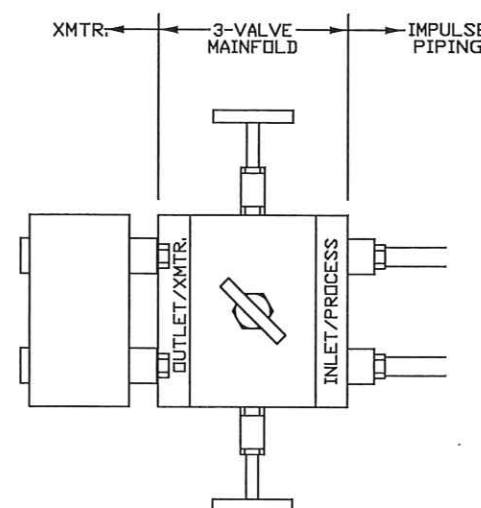


IMPULSE AND TRANSMITTER PIPING



- XMTR. MUST BE ABOVE GAS LINE
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

TRANSMITTER DETAILS



TOP VIEW
3-VALVE MANIFOLD MOUNTING DETAIL

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

SERVICE: _____

MAX FLOW: _____ SCFH

NORMAL FLOW: _____ SCFH

MIN MEASURABLE: _____ SCFH

GAS PRESSURE: _____ PSIG

GAS TEMP: _____ °F

GAS DENSITY @70°F: _____ SP.GR.

NOMINAL PIPE SIZE: _____ inches

PIPE WALL: _____ schedule

PIPE I.D.: _____ inches

ORIFICE PL. BORE: _____ inches

XMTR. DIFFERENTIAL: _____ inches W.C.

MIN UPSTREAM STRAIGHT PIPE REQ'D: _____ inches

MIN DNSTEAM STRAIGHT PIPE REQ'D: _____ inches

NOTES:

1. IMPULSE PIPING MUST BE SLOPED TO ALLOW CONDENSATE TO DRAIN AWAY FROM TRANSMITTER.
2. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
3. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
4. INTERIOR OF PIPE MUST BE FREE OF SCALE, PITS AND BUMPS, 2.5 DIAMETERS ON EITHER SIDE OF ORIFICE PLATE ALL WELDING FLUSH TO INTERIOR OF PIPE.
5. SEE CALIBRATION DATA TABLE FOR MINIMUM STRAIGHT PIPE. THESE PIPE RUNS MUST BE STRAIGHT, AND MUST NOT HAVE ANY VALVES, THERMOWELLS, TEES, WELDS, OBSTRUCTIONS, REDUCERS, ELLS, ELBOWS, OR ROUGH PIPE I.D. WHICH MIGHT CAUSE TURBULENCE. IF MORE THAN MINIMUM STRAIGHT RUN IS AVAILABLE, INCREASE UPSTREAM STRAIGHT RUN.
6. 8" PIPE AND LARGER, ORIFICE PLATES MAY NOT HAVE BEVEL, ORIFICE PLATE STAMPING SHOULD FACE FLOW.

PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.

ORIFICE PLATE INSTALLATION
DETAILS FOR VERTICAL
GAS PIPES W/FLANGE TAPS

MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
APPR'D:		

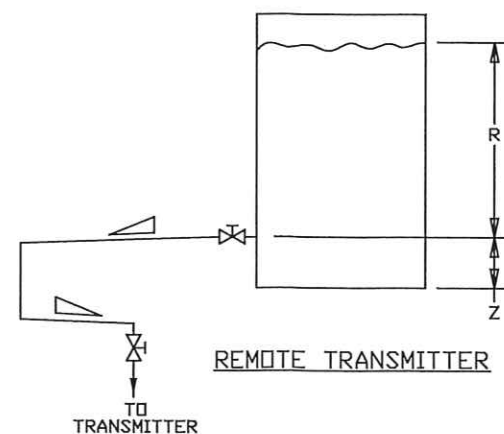
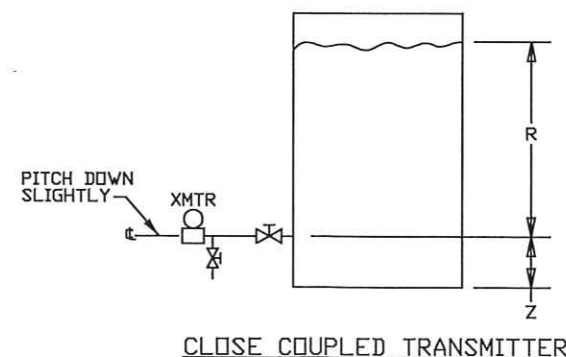
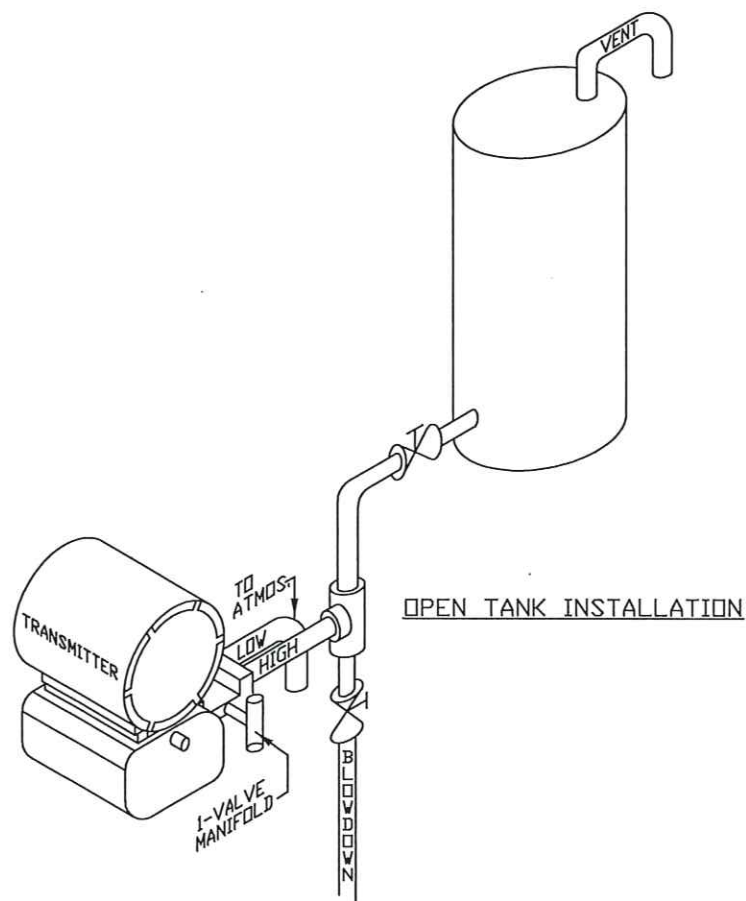
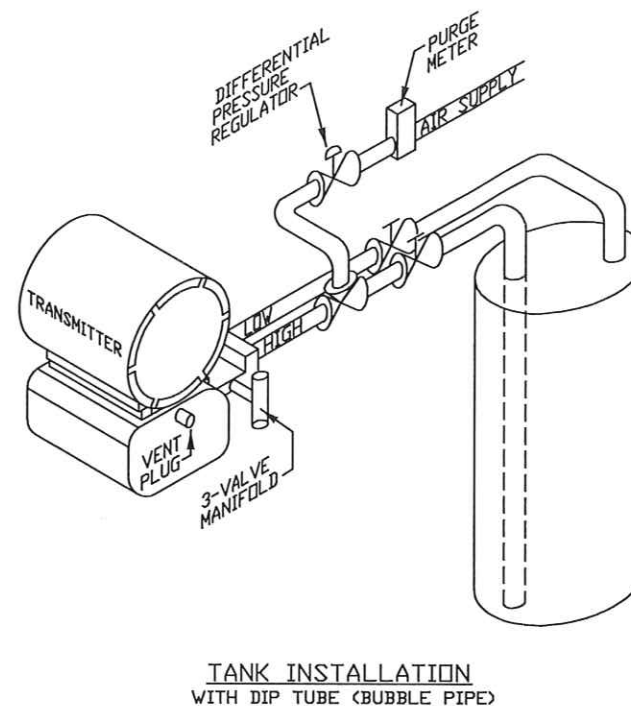
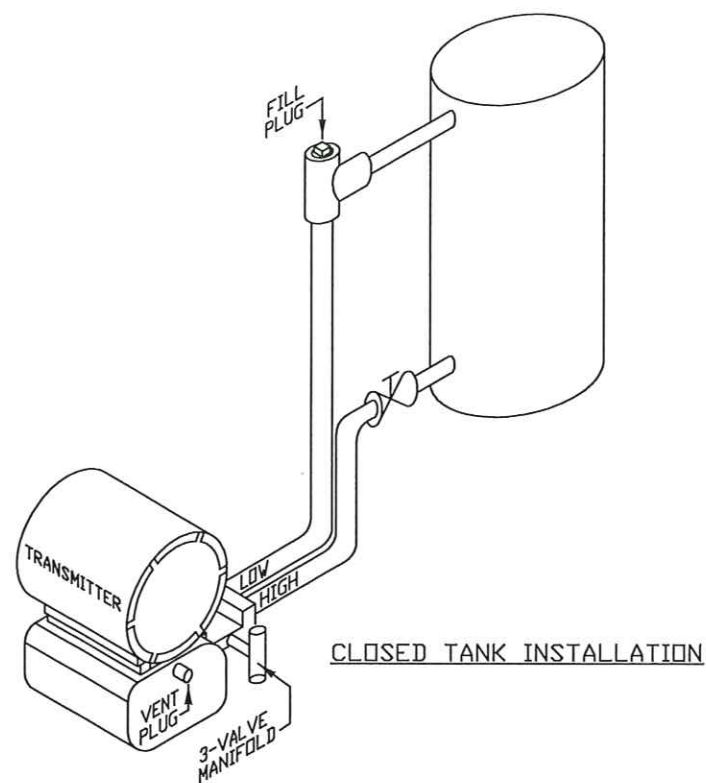
FILE # S1806

REVISIONS

DATE OF CHANGE

APPR'D:

SDW-1806



TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

SERVICE: _____

LIQUID TEMP: _____ °F

LIQUID DENSITY @70°F: _____ SP.GR.

LIQUID HGT. FULL (R): _____ inches

TAP HEIGHT (Z): _____ inches

XMTR. DIFFERENTIAL: _____ inches W.C.

4mA = _____ "W.C. ΔP = _____ "LIQUID HGT."

20mA = _____ "W.C. ΔP = _____ "LIQUID HGT."

NOTES:

1. IMPULSE PIPING MUST BE SLOPED TO ALLOW AIR BUBBLES TO BE PURGED FROM SYSTEM. 1/2" PER HORIZONTAL FOOT.
2. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS: A.) HI & LO CLOSED - EQUALIZER OPEN B.) OPEN LO C.) CLOSE EQUALIZER D.) OPEN HI
3. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
4. IMPULSE PIPING MUST BE KEPT AT A CONSTANT TEMPERATURE. DO NOT INSULATE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.

PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Manufacturing Corp.
LIQUID LEVEL MEASUREMENT
TANK INSTALLATION
CLOSED, OPEN AND W/DIP TUBE

MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
APPR'D:		

FILE # S1807

LET.

REVISIONS

DATE OF CHANGE

APPR'D:

SDW-1807

TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

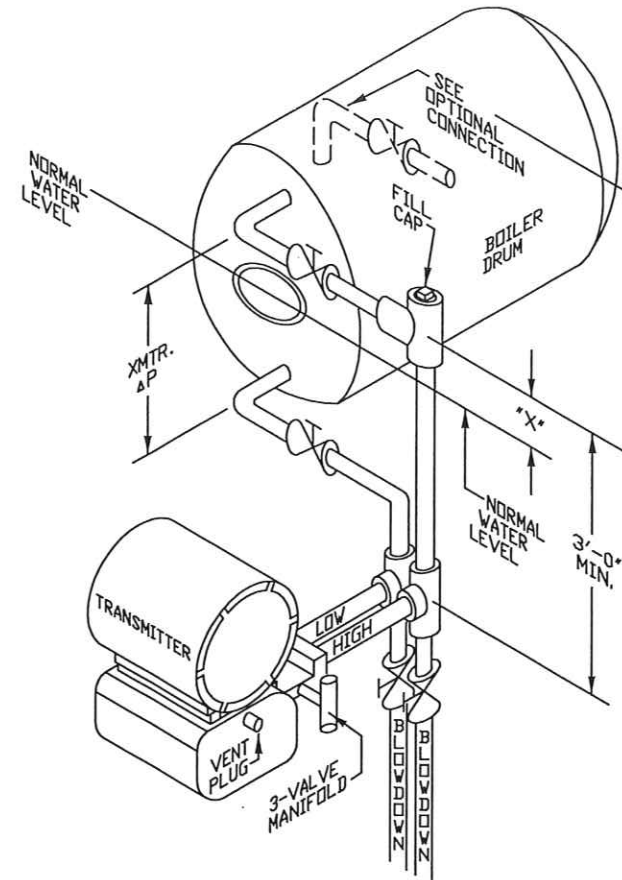
SERVICE: _____

DRUM PRESSURE: _____ PSIG

"X" (HALF GLASS OFFSET) _____ INCHES

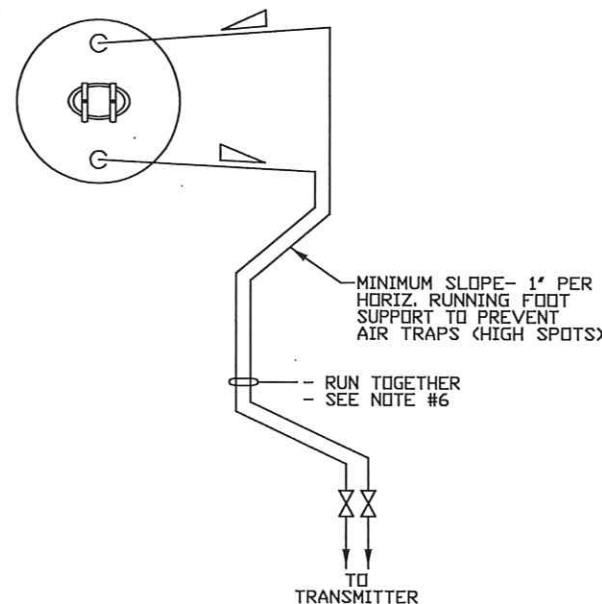
4mA= 0" " W.C.= + IN. ABOVE NORMAL WATER LINE

20mA= SPAN " W.C.= - IN. BELOW NORMAL WATER LINE

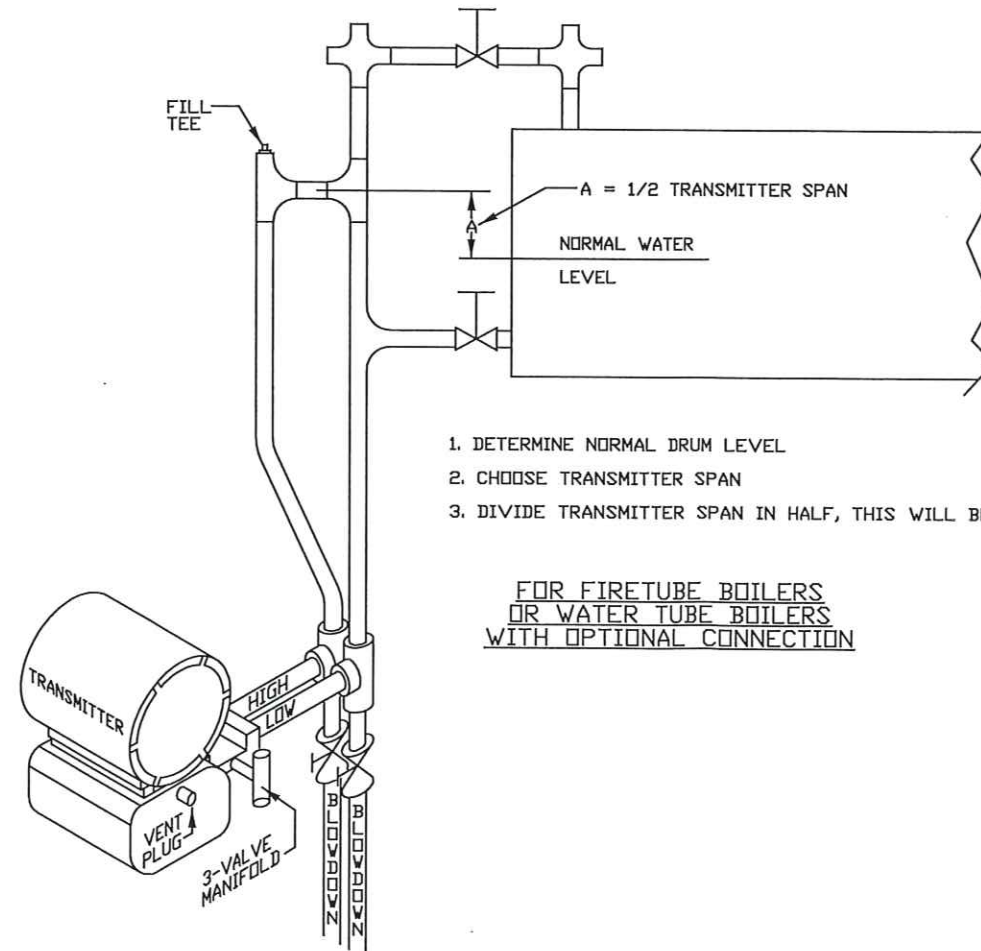


- SEE NOTE #4
- NO INSULATION ON ANY IMPULSE PIPING UNLESS HEAT TRACING IS REQUIRED.
- MOUNT TRANSMITTER 4'-6" OFF FLOOR OR CATWALK IN AN ACCESSIBLE LOCATION.

BOILER DRUM LEVEL



IMPULSE AND TRANSMITTER PIPING



1. DETERMINE NORMAL DRUM LEVEL
2. CHOOSE TRANSMITTER SPAN
3. DIVIDE TRANSMITTER SPAN IN HALF, THIS WILL BE DIMENSION "A"

FOR FIRETUBE BOILERS
OR WATER TUBE BOILERS
WITH OPTIONAL CONNECTION

NOTES:

1. IMPULSE PIPING MUST BE SLOPED TO ALLOW AIR BUBBLES TO BE PURGED FROM SYSTEM.
2. WHEN PUTTING TRANSMITTER IN SERVICE OPERATE 3-VALVE MANIFOLD AS FOLLOWS:
 - A.) HI & LO CLOSED - EQUALIZER OPEN
 - B.) OPEN LOW
 - C.) CLOSE EQUALIZER
 - D.) OPEN HI
3. REVERSE ABOVE PROCEDURE TO TAKE TRANSMITTER OUT OF SERVICE.
4. IMPULSE PIPING MUST BE KEPT AT A CONSTANT TEMPERATURE. DO NOT INSULATE. DO NOT RUN NEAR HOT OR COLD SURFACES. CONSULT FACTORY FOR HEAT TRACING INSULATION DETAILS.
5. FAIL SAFE STRATEGY: ON LOSS OF SIGNAL, OR WHEN TRANSMITTER IS OUT OF SERVICE, THE FEEDWATER VALVE WILL CLOSE.
6. WITHOUT PRESSURE COMPENSATED TRANSMITTERS, TRANSMITTER CALIBRATION MUST COMPENSATE FOR THE DIFFERENCE IN WATER DENSITY BETWEEN STEAM DRUM AND IMPULSE LINES.

PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT

A Division of Preferred Utilities Manufacturing Corp.

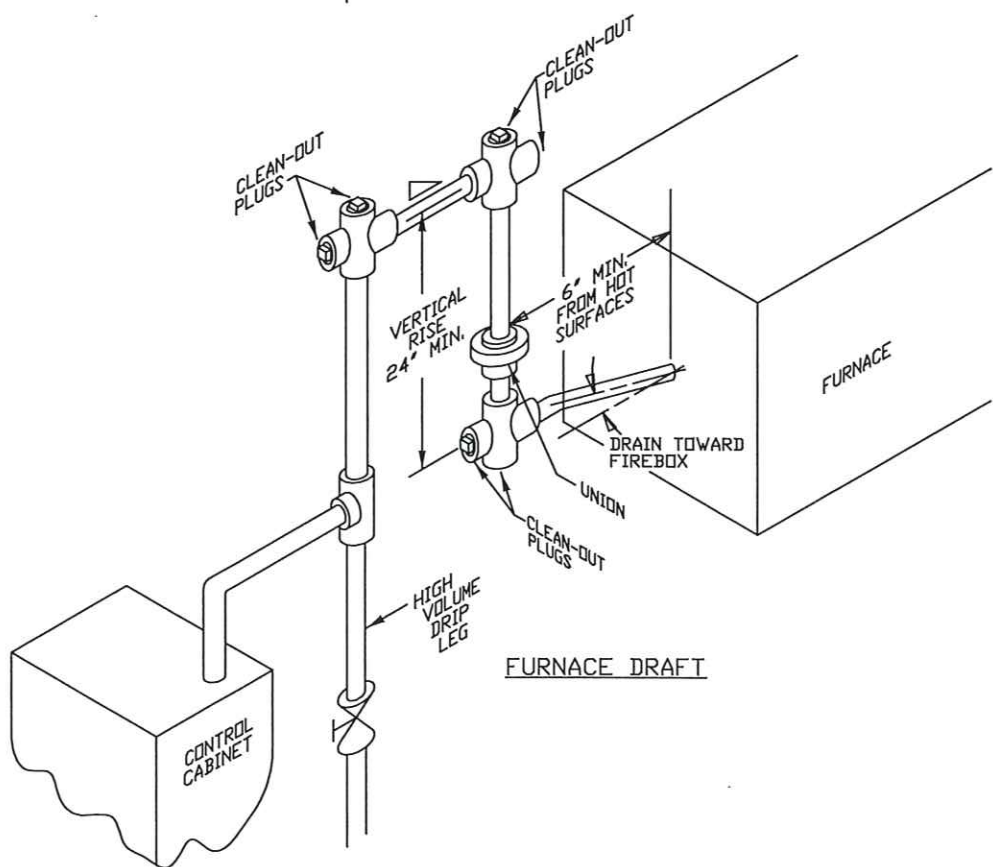
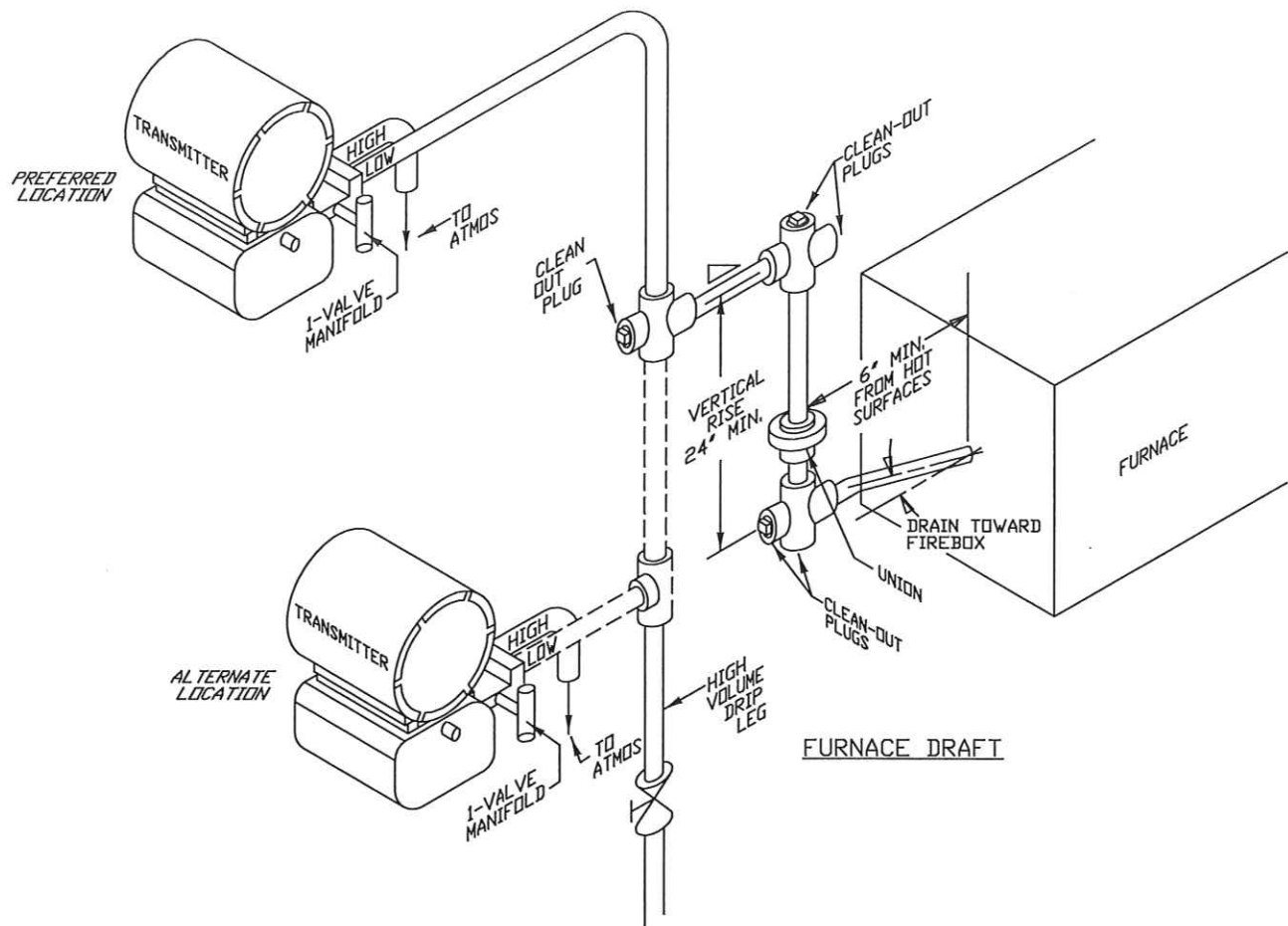
BOILER DRUM LEVEL
TRANSMITTER
CONNECTION DETAILS

MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
DATE OF CHANGE	APPR'D:	

FILE # S18081

LET.	REVISIONS	DATE OF CHANGE

SDW-1808



TRANSMITTER CALIBRATION DATA

DATE: _____

JOB NAME: _____

SERVICE: _____

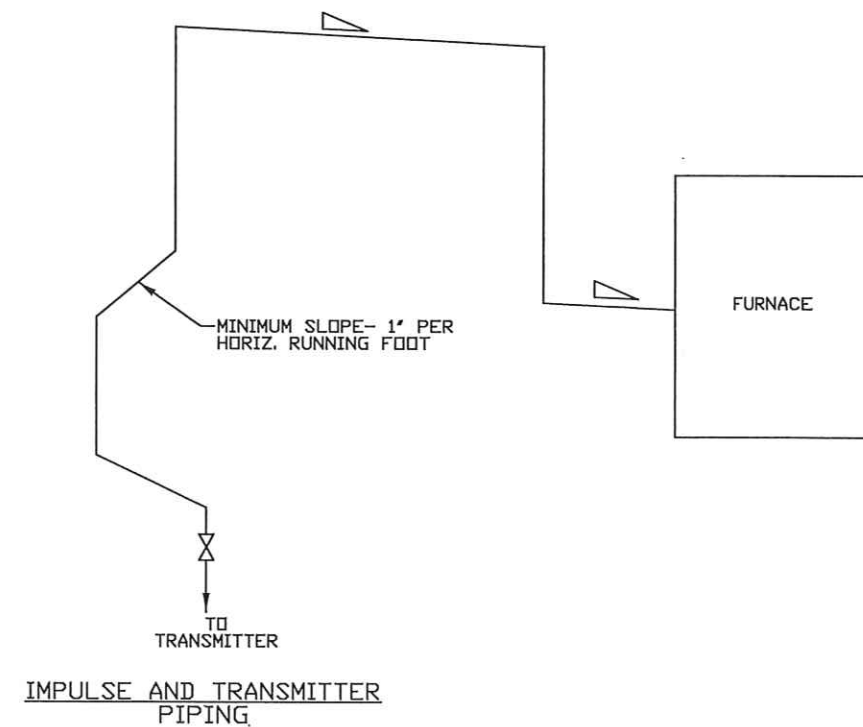
XMTR. DIFFERENTIAL: _____ inches W.C.

4mA = _____ + " W.C. ΔP = _____ " LIQUID HGT."

20mA = _____ - " W.C. ΔP = _____ " LIQUID HGT."

NOTES:

1. CONNECT DRAFT TAKEOFF TO INSTRUMENT WITH PIPE OR TUBING AS FOLLOWS:
PIPE SIZES:
UP TO 18 FT. USE 1/4" MINIMUM I.D.
UP TO 75 FT. USE 3/8" MINIMUM I.D.
ABOVE 75 FT. USE 1/2" MINIMUM I.D.
2. THE LARGER THE DIAMETER THE BETTER THE PERFORMANCE
3. WINDBOX OR ECONOMIZER OUTLET PRESSURE TRANSMITTERS MUST BE PIPED IN THE SAME MANNER AS THE FURNACE PRESSURE TRANSMITTER
4. FAIL SAFE STRATEGY: ON LOSS OF SIGNAL OR IF TRANSMITTER IS OUT OF SERVICE, THE BOILER OUTLET DAMPER WILL OPEN.



PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Manufacturing Corp.

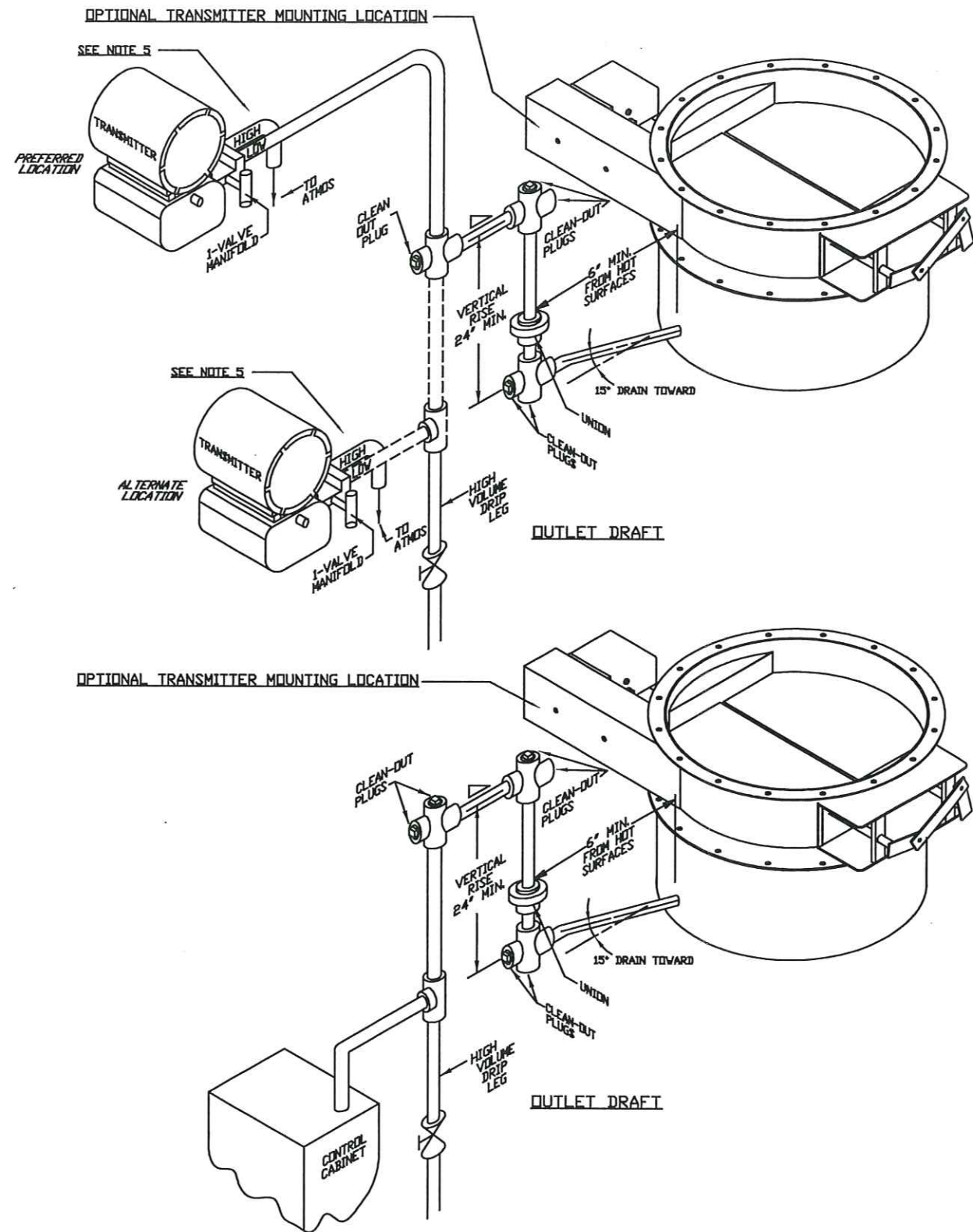
FURNACE DRAFT TRANSMITTER CONNECTION DETAILS

MODEL	SIZE	TYPE
SUPERSEDES	ASS'Y NO.	
MATERIAL	SCALE: NONE	
DRAWN: CFA 5/5/97		
APP'D:		

FILE # S1809

REV.	REVISIONS	DATE OF CHANGE

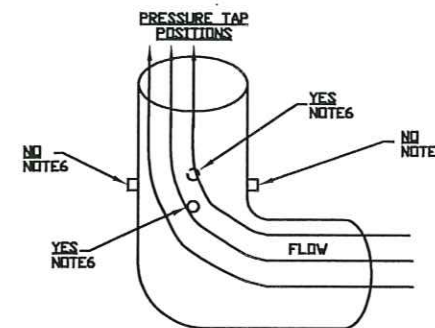
SDW-1809



TRANSMITTER CALIBRATION DATA

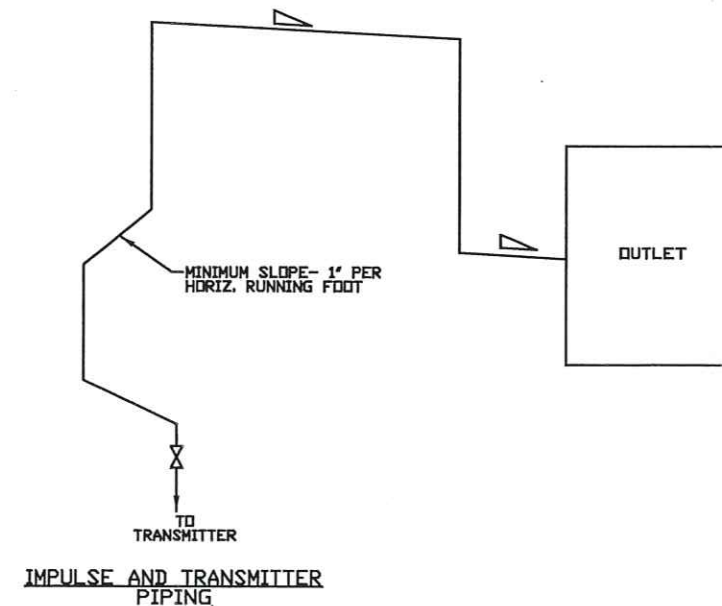
DATE: _____
 JOB NAME: _____
 SERVICE: _____ OUTLET DRAFT
 XMTR. DIFFERENTIAL: _____ inches W.C.
 4mA: - 1" W.C. (APPLIED TO 'HIGH' PORT)
 20mA: + 1" W.C. (APPLIED TO 'HIGH' PORT)

NOTE: CONNECT XMTR 'LOW' PORT TO DUCT
 (4mA = +1" W.C. IN DUCT, 20mA = -1" W.C. IN DUCT)

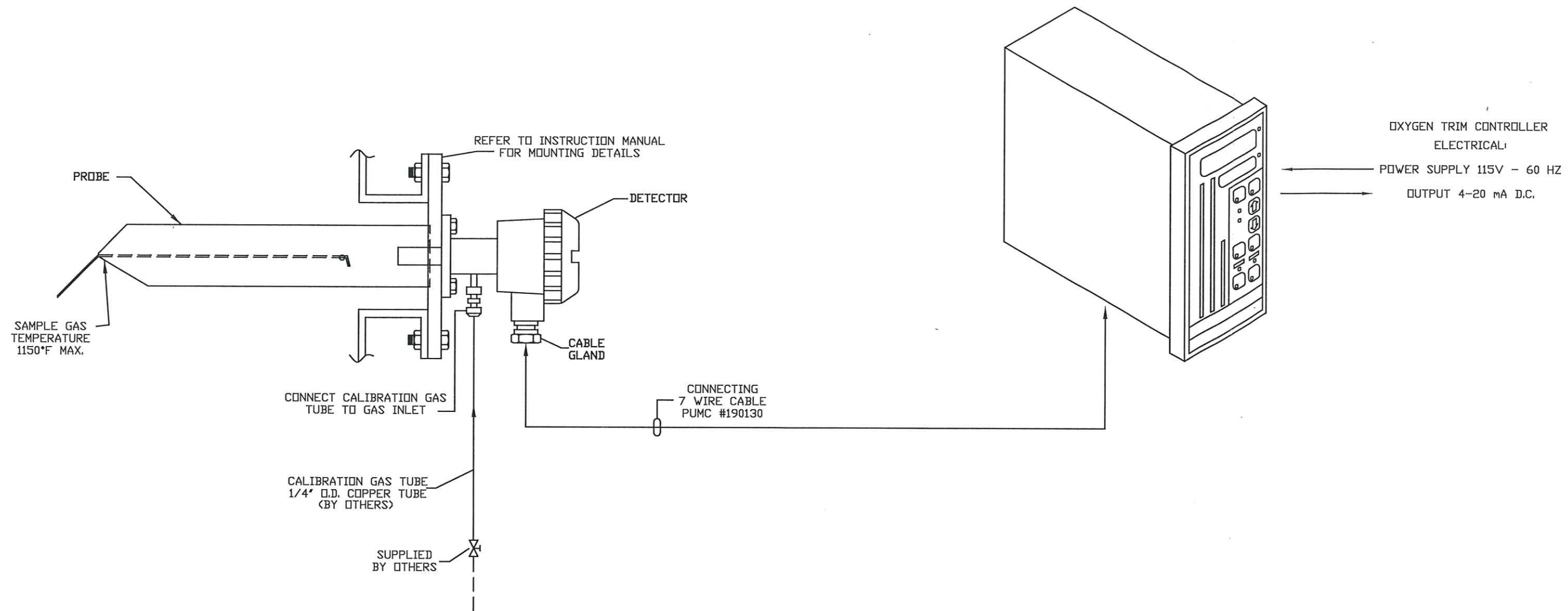


NOTES:

1. CONNECT DRAFT TAKEOFF TO INSTRUMENT WITH PIPE OR TUBING AS FOLLOWS:
 PIPE SIZES:
 UP TO 18 FT. USE 1/4" MINIMUM I.D.
 UP TO 75 FT. USE 3/8" MINIMUM I.D.
 ABOVE 75 FT. USE 1/2" MINIMUM I.D.
2. THE LARGER THE DIAMETER THE BETTER THE PERFORMANCE.
4. FAIL SAFE STRATEGY: ON LOSS OF SIGNAL OR IF TRANSMITTER IS OUT OF SERVICE, THE BOILER OUTLET DAMPER WILL OPEN. (4 mA = +1" W.C. WHICH DRIVES THE DAMPER OPEN)
5. CONNECT HIGH DRAFT PRESSURE SWITCH FOR FLAME SAFE GUARD SAFETY INTERLOCK.
6. DUCT TAP TO BE PERPENDICULAR TO FLOW PATTERN.



PREFERRED INSTRUMENTS 31-35 SOUTH STREET DANBURY, CONNECTICUT A Division of Preferred Utilities Manufacturing Corp.			
BOILER OUTLET DRAFT CONTROL TRANSMITTER CONNECTION DETAILS			
MODEL:	SIZE:	TYPE:	
SUPERSEDES:	ASS'Y NO.:		
MATERIAL:	SCALE: NONE		
DRAWN: JMC 5/24/01	SDW-1811		
FILE # S1811	LET.	REVISIONS	DATE OF CHANGE

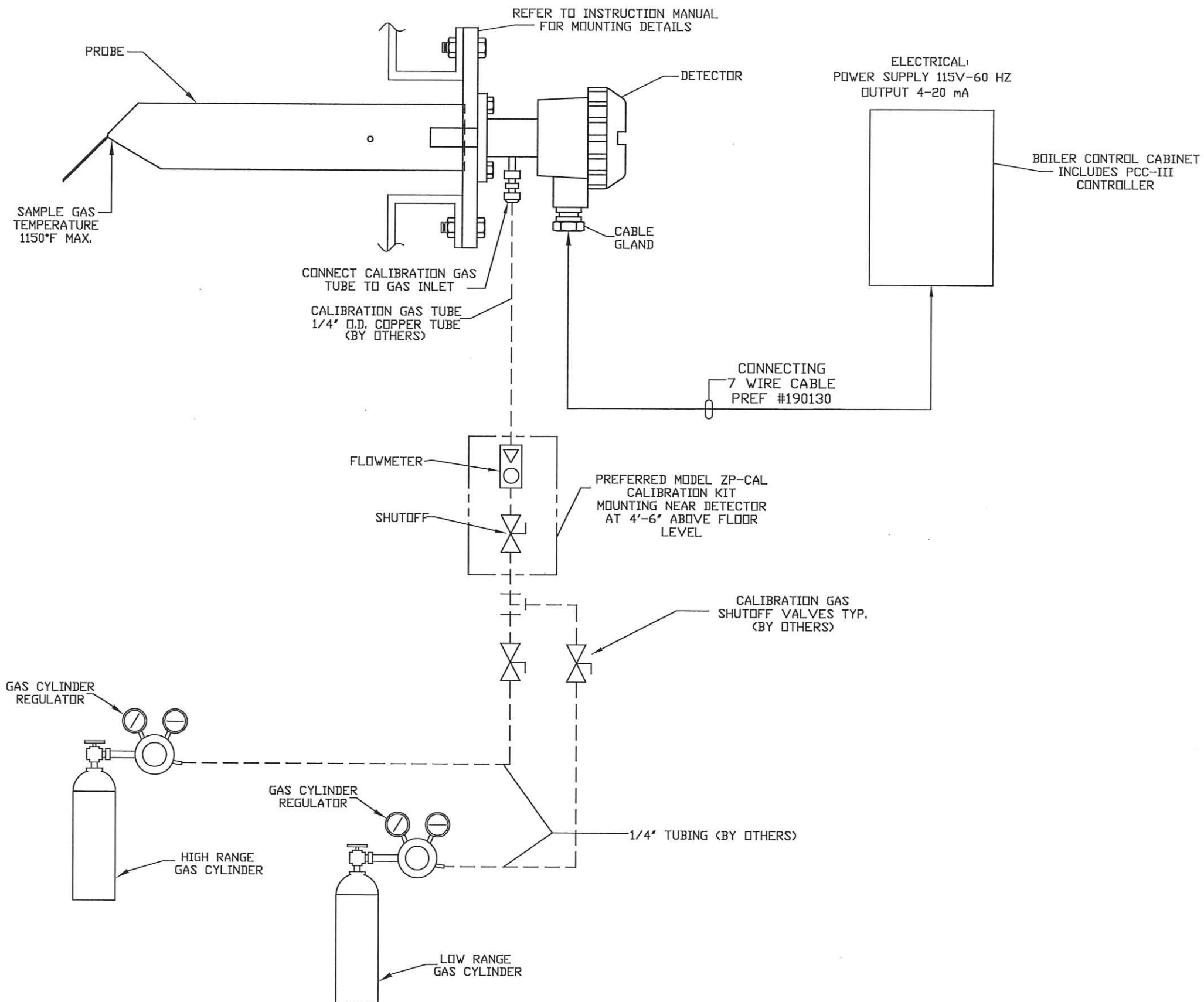


PREFERRED INSTRUMENTS
 31-35 SOUTH STREET
 DANBURY, CONNECTICUT
 A Division of Preferred Utilities Manufacturing Corp.
**OXYGEN ANALYZER
 CONNECTION DETAILS**

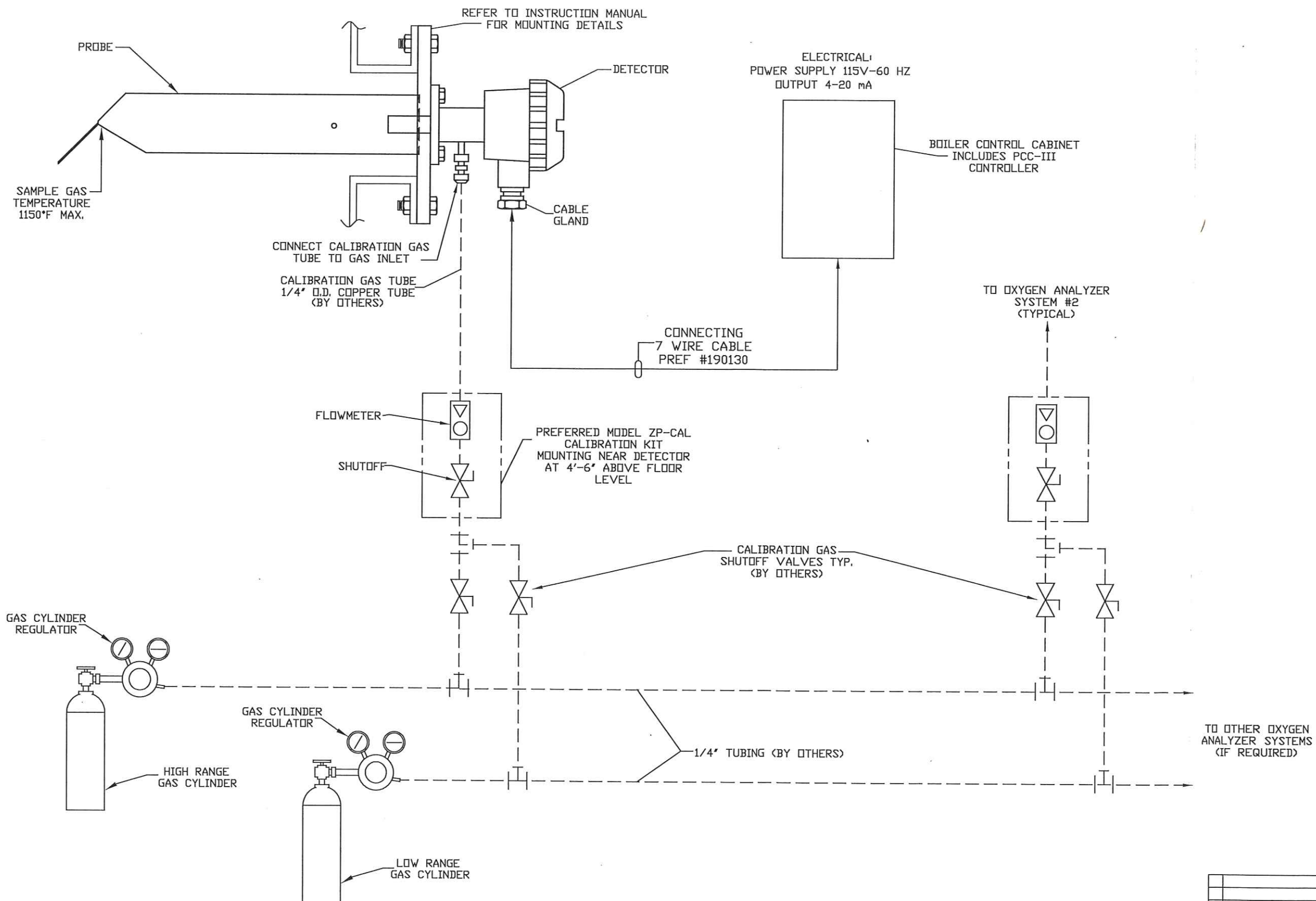
MODEL	SIZE	TYPE
SUPPLEMENT		ASST. NO.
MATERIAL		WELD NONE
DRAWN JMC 9/13/01		
REVISED	DATE OF CHANGE	APPROVED

FILE # S1812

SDW-1812



PREFERRED INSTRUMENTS 31-35 SOUTH STREET DANBURY, CONNECTICUT A Division of Preferred Utilities Manufacturing Corp.			
OXYGEN ANALYZER WITH CALIBRATION GAS			
MODEL	SIZE	TYPE	
SUPPLEMENT	ASSY NO.		
MATERIAL	SCALE		NONE
DRAWN JMC 9/20/01		APPROVED	
FILE # S18121	REVISE	DATE OF CHANGE	SDW-1812-1



PREFERRED INSTRUMENTS
 31-35 SOUTH STREET
 DANBURY, CONNECTICUT
 A Division of Preferred Utilities Manufacturing Corp.

**OXYGEN ANALYZER WITH
 HEADER CALIBRATION GAS**

REV.	REVISIONS	DATE OF CHANGE	APPROV.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

FILE # S1812A

SDW-1812-4



Preferred Services

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31-35 South Street, Danbury, Connecticut 06810



The following is from an email distributed to all sales and service personnel on May 25, 2006 relating to wiring practices that could result in electrical noise issues. It is as applicable today as it was then.

The R&D and engineering staff have made a major effort in providing installation instructions for most of the instruments and systems we provide. Too many jobs are being installed incorrectly by contractors that result in commissioning problems.

The contractors do not read the provided instructions. So the first thing we must do when we arrive at the job site we must perform a thorough review of the installation. If the installation is not correct we must warn the contractor that the installation is not correct and not to our recommendations and that problems may result.

Recommend that the installation be corrected but do not insist that they do or back charges can result. Electrical noise is not something you can hold in your hand and show the contractor, but, we know it exist and will come and go whenever. There may not be a problem at the moment but a couple of weeks down the road when the system starts acting erratic it's too late to ask the contractor to change the installation wiring nor will you be able to convince anyone that it is a noise issue if it has worked for two weeks.

Noise is something that can't be predicted and can happen anywhere at any time if the proper precautions were not taken at the time of the installation. Proper grounding, dedicated conduits, bonded conduit are all very necessary in a VSD installation. DC and AC wires run in separate conduit and remaining separated in the panel is a must.

Don't tell the contractor that you will try it first and he will only have to correct the installation if there is a problem. If there is a problem after you blessed the installation, the problem is now ours to correct. This goes for the proper installation of meters and transmitters as well.

The initial review of the installation is the only time we can stand firm on our position. Documentation of the installation errors are a must with copies sent to sales, engineering and the customer or contractor representative before work continues.



Preferred Services

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31-35 South Street, Danbury, Connecticut 06810



Field Wiring Requirements to Reduce or Eliminate Electrical Noise Issues

Our first recommendation is to always insure that the field wiring is installed in accordance with the National Electrical Code and any additional local requirements. However, in addition to code requirements there are numerous methods and practices recommended by most electrical engineers and product manufacturers that, if followed, can help to reduce nuisance start up and operation problems. The most notorious of these problems is electrical noise.

Noise is defined as unwanted or undesirable electrical signals in an electric circuit. Every electrical circuit has noise in it. The key is to reduce the noise level so that it does not adversely affect the desired signal.

Noise is usually found in one of two forms; transmitted radio frequency interference (RFI) and conducted electro-magnetic interference (EMI).

To reduce noise two general methods are used; reduce or suppress the noise at the source and reduce intrusive noise from entering the circuit. Fortunately, many of the accepted techniques employed today work for both methods.

Suppression of noise at the source should be looked at first because it reduces the total amount of noise in the circuit and will generally be the most cost-effective if the noise is affecting a number of instruments in the system. The most common methods for suppressing noise include arc suppression, arc removal (replacing electromechanical relays with solid state relays), isolation, proper grounding of both the power source and the drain wires of shielded cables, filtering and circuit redesign.

The following are a collection of articles, excerpts from instruction manuals and sections of electrical prints that focus on the correct wiring methods and recommendations that will help reduce electrical noise issues.

Recommended Field Wires to Help Suppress Electrical Noise Problems

1. All panel and field wiring must conform to national and local electrical codes.
2. All wiring (AC, DC, and shielded cable) should be copper, stranded, 150 volt minimum and rated to 60 degrees C minimum.
3. Wire Shielded Cable- Minimum 22 gauge, 100% foil shielded and has twisted pairs, Belden 8737 or equal.
4. Ignition Wiring- Must be a carbon-fiber ignition wire also referred to as "Resistance Core" ignition wire. Also use the PN 20177 resistor spark plug cap and a PN 20176 hex extender.
5. VSD to Motor wire- we now insist that a special shielded wire be used for this application. Alphawire (#V163xx) or Belden (#29520 through #29532) Preferred PN 70530-xxga (xx= 12,10,8,6,4,2)
6. ZP Oxygen Analyzer- must use PN 190130 specifically designed and manufactured for this purpose.
7. BMU Servos and LCD touch pad- must use the green multi-conductor BMU-CABLE-XX cable.



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31-35 South Street, Danbury, Connecticut 06810



Field Wiring Requirements to Reduce or Eliminate Electrical Noise Issues

Variable Speed Drives

The application of variable Speed Drives (VSD), sometimes referred to as variable Frequency Drives (VFD), are becoming more and more popular in the boiler rooms for reducing electrical energy consumption. A VSD works by modulating the pulse width of the voltage cycle. Unfortunately, this pulse-width modulation (PWM) is also a great generator of electrical noise. The instructions and practices related to VSDs must be followed or noise problems will result.

VSD Installations

1. Conduits: Metallic conduit or Type MC armored cable (continuous corrugated cable) must be used for all power wiring. The metal conduit acts as a shield to prevent the PWM output waveform from transmitting RFI or conducting EMI to other equipment. The output waveforms of a PWM drive consist of relatively high frequency components (typically up to 500 kHz) and if not properly installed will cause interference with power-line carrier systems. It is not uncommon to experience interference in which harmonic distortion is assumed to be the cause when in fact it is an EMI/RFI issue caused by improper installation practices and the absence of EMI/RFI filters in the VSD.

In addition to the high frequency on the output, it is important to know that the input power generates low frequency harmonics (typically 300-600 Hz). To avoid a vast majority of EMI/RFI issues, there must be three separate conduits to the VSD: output power to the motor, incoming power to the VSD and control wiring.

2. Grounding: It is important to have dedicated ground wires from the power source to the VSD frame and from the VSD frame to the motor frame. This is not a requirement for proper VSD operation but will greatly reduce electrical noise.

General Wiring Instructions and Recommendations

- The wiring from the VSD output to the motor must be in a dedicated conduit and must be separate from all other wiring including the power supply to the VSD. Do not run these wires through junction boxes that include any other wires.
- The VSD to motor conduit must be metallic and have either threaded or non-insulating compression fittings. PVC conduit and EMT set screw type hub connectors are not acceptable. This high level of noise generated by these wires is contained and shielded inside the metal conduit and connectors.
- Final flex connections: if the VSD to motor wire is a standard THHN wires then Seal-Tite should be used and never Greenfield. If the VSD to motor wire is the recommended Special Shielded Cable for VSD applications then Greenfield is acceptable.
- All AC and DC wiring must be in separate conduits to prevent noise pickup. If AC and DC wires are in the same wire trough they must be physically separated with partitions.
- When terminating field wires inside a control panel, every effort must be made to keep the AC and DC wires separated.
- Regarding shielded cables, the drain wire should be connected at one end only and only shown on the electrical prints. Generally, the shield is connected to the DC common of the power source for that circuit. All shield foils and drain wires must be insulated to prevent accidentally touching earth or power grounds. Shields connected at both ends or touching ground can actually add extra noise to a signal instead of reducing it.
- There are always exceptions to every rule.
 - 1) The drains of the control wires for a VSD should be connected to chassis ground at the VSD end as shown on the electrical prints.
 - 2) The drain wires of the ZP probe wires are connected to chassis ground at the control end as shown on the electrical prints.
 - 3) The BMU scanner cables direct the drain wire to earth ground at the scanner end. Scanners should be mounted on metallic pipe nipples to complete the ground circuit. If non-conducting pipe nipples are used then a jumper wire to ground from the scanner will be required. Do Not connect the cable drain wire at the BMU.

**The following is an article copied from HPAC Engineering magazine, April 2002.
Note that the author is from ABB, Inc.**

Applying VFDs to HVAC Systems

An overview of the design basics (in plain English)

By Jeff Miller

ABB Inc.

New Berlin, Wis.

With the technological advancement of variable frequency drives (VFD) over the past 5-10 years, it is surprising that one still hears of projects that are plagued by problems of one type or another. The intent of this article is to assist the designer who is applying VFDs to HVAC systems to avoid common pitfalls. There has been a growing sentiment that VFDs are turning into commodities. Certainly the technology has been drastically improved and many drives have more similar features, but the person applying the VFD must still understand the minimum application requirements.

With VFDs, the old adage "buyer beware" is still true. More importantly, it is vital to understand that VFDs are applied products. In other words, careful attention must be taken when applying a VFD to an HVAC system. A VFD that is not properly applied and programmed can cause considerable headaches. The following is a checklist of the important considerations when applying VFDs to typical HVAC applications.

ELECTRICAL INSTALLATION

Conduits.

There must be metallic conduit or armored cable (type MC cable, also continuous corrugated cable) used for all power wiring. The metallic conduit acts as a shield to prevent pulse-width modulation (PWM) output waveform from transmitting radio frequency interference (RFI) or conducting electromagnetic interference (EM) to other equipment. The output waveform of a PWM drive consists of relatively high frequency components (typically up to 500 kHz) and if not properly installed cause interference with power-line carrier systems (such as time-clock controls, closed-circuit cameras, security systems or any device that operates in the AM band). It is not uncommon to experience interference in which harmonic distortion is assumed to be the cause, when in fact it is an EMI/RFI issue caused by improper installation practices or the absence of EMI/RFI filters in the VFD. It is important to understand that VFDs generate high frequency noise on the output (due to the PWM waveform) and that harmonics (low frequency noise, typically 300-660 Hz) are generated by the input of the VFD. To avoid the vast majority of EMI/RFI issues, there must be three separate conduit entrances to the VFD: for incoming power, motor power, and control (low voltage) wiring. PVC conduits and wire troughs are the most common source of high frequency electrical noise interference problems as they do not provide any shielding for the motor wiring.

There are several applications where underground wiring is required and PVC conduit is hard to avoid, such as cooling towers (that are located far from the central plant) and submerged pumps. For these applications, one of two approaches should be utilized. If PVC conduit is to be used, parallel conduit runs for VFD motor wiring need to be physically separated by at least 18 in. The ideal condition is that metallic conduit or armored cable (as mentioned above) is utilized. This will go a long way toward preventing interference issues with building automations systems (BAS), security systems, power line carrier systems, etc.

Sizing.

In 1996, the NEC changed the requirements for sizing the wiring to the input of the VFD. The requirements used to be based on the full load amp rating of the motor. Per section 430-2, the new requirement is to size the wiring based on the input current rating for the VFD. For some VFD designs, a 10-hp, 460-v VFD with an output current rating of 14 amps, the input current of the VFD can be as high as 21-25 amps. This is due to the fact that some VFDs do not include a reactor in either the AC or DC section. Without the reactor, harmonic distortion increases and thus the RMS current increases. Be very careful with your VFD requirements here, on both new construction and retrofit projects. A three-percent impedance reactor goes a long way to reduce the input current to numbers very close to the output current (primarily due to harmonic distortion reduction), increase power factor, and greatly improve the VFD's ability to operate through poor power quality conditions.

Grounding.

It is important to have dedicated ground wires from the power source to the VFD and from the VFD to the motor. This is not a requirement for proper VFD operation, per se, but will greatly reduce electrical noise and help reduce the possibility of bearing currents in the motor. For three-phase VFD applications, merely follow the standard code requiring ground wire sizing guides, as oversized grounds are not required.

Control wiring.

Used twisted, shielded control wires for all analog and serial communication wiring. The shield should be grounded at one end only. This greatly reduces the potential for noise issues with the BAS. The digital input and output signal wires do not require shielded wires.

MECHANICAL INSTALLATION

Ambient Temperature.

Pay attention to the ambient temperature where the VFD is to be located. The vast majority of these drives are rated 32 F to 104 F. On the lower end of the scale, it is not too critical, but if you have a VFD mounted in an unconditioned penthouse, outdoor enclosure (either a NEMA 3R or NEMA 4), and the drive is in Alaska, installing a strip heater with a thermostat would be prudent. High ambient condition is more of a concern. VFDs are designed and rated based on current, voltage and temperature. The vast majority of drives can be slightly derated (in rated output current) to accommodate 122 F. This is recommended for applications such as boiler rooms, rooftop units, outdoor applications, and unconditioned equipment rooms. Projects that are installed over 3,300 ft. altitude also require slight derating due to the reduced cooling capacity of the VFD at high altitudes.

Enclosures.

The appropriate enclosure rating is also important. NEMA 1 enclosures are intended for clean, indoor applications. For environments that have dust, falling dirt, or dripping water, NEMA 12 may be the best choice. For outdoor applications, either a NEMA 3R (weatherproof, but ventilated) or a NEMA 4 (weatherproof, hose-directed water proof) should be used. Understand that a NEMA 4 poses a heat problem for the VFD. A NEMA 4 enclosure requires cooling by either a heat exchanger or self-contained air conditioner. (This dramatically increases the cost of the project.)

An addendum to the UL508C standard for VFDs with regard to mounting plenums now exists. It does not dictate the type of enclosure, but places requirements for flame spread ratings and smoke

generation. The VFD's UL file number can be investigated to determine if it passes the plenum rating requirements. One must also look to local codes. For example, in Chicago a VFD mounted in a plenum (including an equipment room that serves as return air) must be placed in a NEMA 12 enclosure.

Condensation.

Pay attention to VFDs mounted in the supply air where condensation is a real concern. I have seen several inches of water in a CFD due to condensation. There was no question regarding the cause of failure in this investigation. Panels mounted on cold exterior concrete walls in warm humid equipment rooms can pose serious condensate problems. Other mechanical considerations are excessive vibration (when mounted on the outside of a large air handler) and corrosion due to the VFD being mounted next to cooling tower water treatment chemicals or water softener chemicals. Another problem is a penthouse with fresh air intakes in locations near to oceans where fog is common. This can create real problems for the electronics of a NEMA 1 enclosed VFD. The use of a NEMA 12 enclosure is recommended for these types of applications at a minimum.

CONTROLS

Damper control interface with VFDs is typically not considered until after the VFD is installed and the control contractor begins design for the hardware and software to satisfy the required sequence of operation. Damper control typically consists of a requirement to open a damper (such as an outdoor air damper, fire damper, isolation damper, etc.) before the motor is to operate in any mode (drive or bypass). This means that a "start" or "run" command can come from the BAS, an operator at the VFD provides a local "start" command at the VFD keypad, or the command can come from the serial communication connection. After a run command is received, but before the VFD actually runs the motor, the VFD needs to close a relay contact to actuate the damper. When the damper is fully open, an end switch from the damper will close and then the VFD will be allowed to operate the motor. There is also a common requirement for an additional input to the VFD package for smoke detectors, fire alarms, etc. When an alarm occurs, the motor must stop and the damper is to close. This sequence is even more important when a bypass is utilized, as it will also need to operate in the same manner. The damper end-switches should be mounted such that they can be adjusted during start-up so the open indication is only provided when the damper is in the fully open position. Also ensure that the VFD has an input that when activated, will stop the motor in any VFD operating mode as well as bypass. There are many projects that have experienced damaged duct work because the VFD either did not include this feature, or was not properly interfaced with the safeties (freezestats, high static switches, etc.).

Life safety requirements.

These should always be one of the first control sequences investigated when applying a VFD. The fire department's override requirement can be an override of all controls and run at 60 Hz (such as an exhaust fan), or run at a preset speed (i.e., for stairwell pressurization), and/or override off. The keypad may be required to be removed after programming for some of these applications as most VFD designs do not have an option to disable to "off" button on the keypad. The sequence of operation always needs to include the bypass, if provided.

BAS

The trend toward serial communications with the BAS is fast and furious. The benefits are reduced installation cost (a twisted pair of wires compared to six or seven sets of twisted pairs) and much more information and control is available to the user. With the typical analog and digital I/O used to control drives, the owner would be able to start and stop the VFD, control its speed, and monitor its speed and load and whether or not it is running or faulted. With serial communications, the user can adjust parameters, monitor all of the operating conditions such as operating frequency, current, voltage, VFD temperature, kilowatt consumption, run time, etc. If the VFD experiences a trip (or fault), the owner can determine the cause of the fault, and if appropriate, can reset the VFD from the computer. Alarms can be set for the VFD over temperature, for example, to send an alarm if the VFD temperature reaches a certain level (this typically indicates that a cooling fan has failed). This is especially useful for the multiple-building operator. Enhanced energy savings strategies can be employed with the additional information provided by a serial communications.

A thermal storage retrofit project in Dallas uses the kilowatt information from the VFDs to determine when to reset the chilled water temperature, thus satisfying the cooling requirements faster and allowing the VFD fan speed to be reduced, which is a larger energy consumer than the chilled water pumps. For many applications, the process transducer (such as a static pressure transducer) is wired directly into the VFD. It operates with the internal PID set-point controller. The actual set-point is provided over the serial communications link. This reduces the amount of traffic on the serial communications bus as the VFD is performing the PID algorithm, not waiting for the information to pass from the transducer to the unitary controller, and then sending a speed signal to the VFD. This benefit allows for distributed control without sacrificing performance. Some VFD manufacturers allow the serial communications link to monitor and control the analog and digital inputs and outputs. These become "free" points for the mechanical room that needs to monitor or control devices when the local DDC panel is full.

Protocols.

Be cautious with all of the different protocols. Verify with the VFD and controls manufacturers that they not only support your protocol of choice (i.e. LonWorks, BacNet, N2, FLN, Ethernet, Modbus, etc.), but also support all of the information (or points of information/data) that you require.

VFD SELECTION

VFDs, as mentioned above, are basically designed around amperage, temperature, and voltage. With this in mind, selection of the appropriate VFD is simple if you pay attention to the subtleties. The UL? NEC table 430-150 states that a standard efficiency 50-hp, 640-v motor should have a full-load amp rating of 65 amps. Most VFD manufacturers design the VFD rating around this table. If the motor is a standard 4-pole (1,800 rpm synchronous) for new construction, you will probably receive a 50-hp motor with a FLA around 50 amps due to high efficiency motors. If the motor is 50-hp, 8-pole (900 rpm, synchronous), the FLA may be 72 amps. The safest method to size a VFD is to size it based on voltage and full load amps. This is especially true for multiple motor applications where you size the VFD based on the sum of all the motors' FLA ratings.

BYPASS

Bypasses were considered an absolute requirement when VFDs were introduced due to the level (or lack) of reliability they initially provided. With the current technology, bypasses may not be a requirement, but if the designer plans on utilizing one, there are several important considerations.

What happens to the system when the motor is placed in bypass (full speed) operation? Will the

system simply shut down on a high static pressure trip? Will you not be so lucky and damage duct-work or unseat your two-way valves? Operating the motor at full speed in a variable-volume system requires a control scheme such as monitoring a contact that indicates to the BAS that the system is in bypass and is to reset the VAV box minimum setting, add a mechanical dump damper that opens if the pressure raises to a dangerous level or at the minimum, have a high static switch that will stop the motor when the pressure exceeds a safe level. Some people have attempted to "over-speed" (above 60 Hz) the motor with the VFD to reach designed flow levels, so when the motor is placed in bypass; the potential for over-pressurization is greatly reduced. This is not an efficient method of addressing this problem. A 10 percent (66 Hz) over-speed is the maximum recommended high-frequency setting when required for an efficient pump or fan selection, not to accommodate bypass operation.

SUMMARY

Review your application before specifying the VFDs for requirements such as BAS interfaces, harmonic distortion limits, the ability to start into spinning loads (especially with parallel fans feeding a common plenum), qualified local support for application assistance, local start-up and service and warranty terms (on-site coverage, duration), and owner/operator training. Overall, contemporary VFDs are more reliable, cost effective, and include far more capabilities than VFDs of several years ago. When problems do occur, the vast majority of the time they are generated by an application issue such as installation, lack of the proper accessories, or programming issues. The devil truly is in the details.

Preferred Instruments

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Important Installation Notes for Danfoss Variable Speed Drives

Read the entire Danfoss Instruction Manual before Installing the Variable Speed Drive (VSD).

Grounding of the Motor and the VSD with grounding conductors is very important for Safety AND to prevent electrical noise. Do NOT rely on building steel for grounding.

The wiring from the VSD to the motor should be run in rigid conduit or EMT with compression fittings, or in armored shielded power cable to prevent electrical noise interference problems. Do NOT use PVC conduit or EMT with set screw hub fittings.

See the Danfoss manual for the proper method to terminate the shields of the 4-20 mA shielded cables (to prevent electrical noise interference problems).

Install the VSD in a location that minimizes vibration, exposure to water, and heat. The VSD should NOT be mounted directly on the burner or boiler due to the typically high levels of vibration, water splashing, and heat.

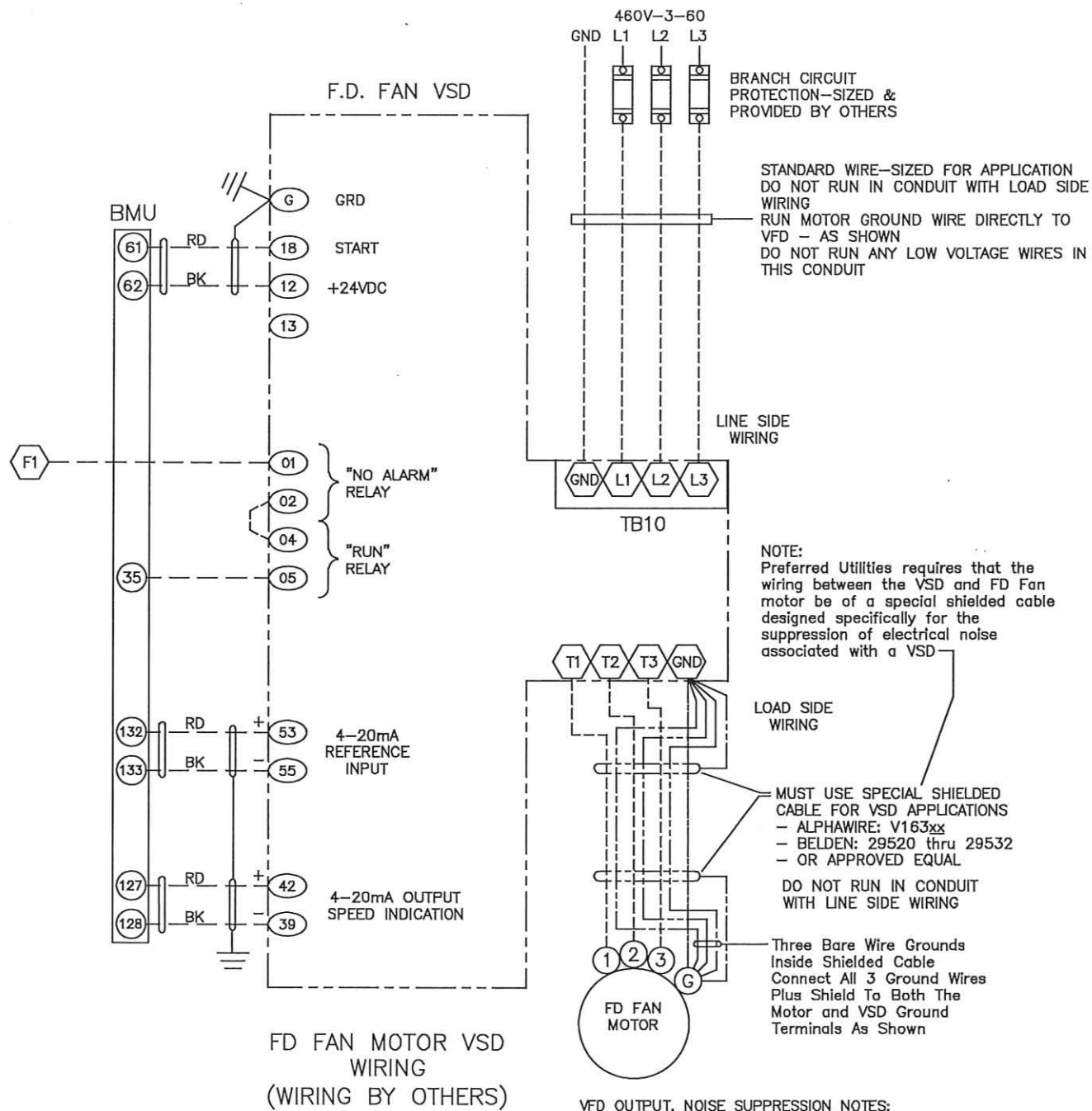
The VSD should be mounted vertically. A 10" (minimum) air space ABOVE and BELOW the VSD is required for proper cooling air circulation.

The VSD is designed to mount flush on a wall (or other flat surface). The cooling fins and cooling fan are on the rear of the VSD. The wall acts as the backplate of the cooling fins and forms a duct to force the cooling air over the cooling fins and up through the cooling fan.

If the VSD is NOT mounted flush against a wall, provide a plate or other flat surface to mount the VSD against to insure proper cooling air flow over the fins.

The VSD will not be damaged (or trip) due to excessively high ambient temperatures, or improperly restricted cooling air flow. However, the VSD will automatically reduce the maximum permissible speed (and heat output) if the drive starts to overheat.

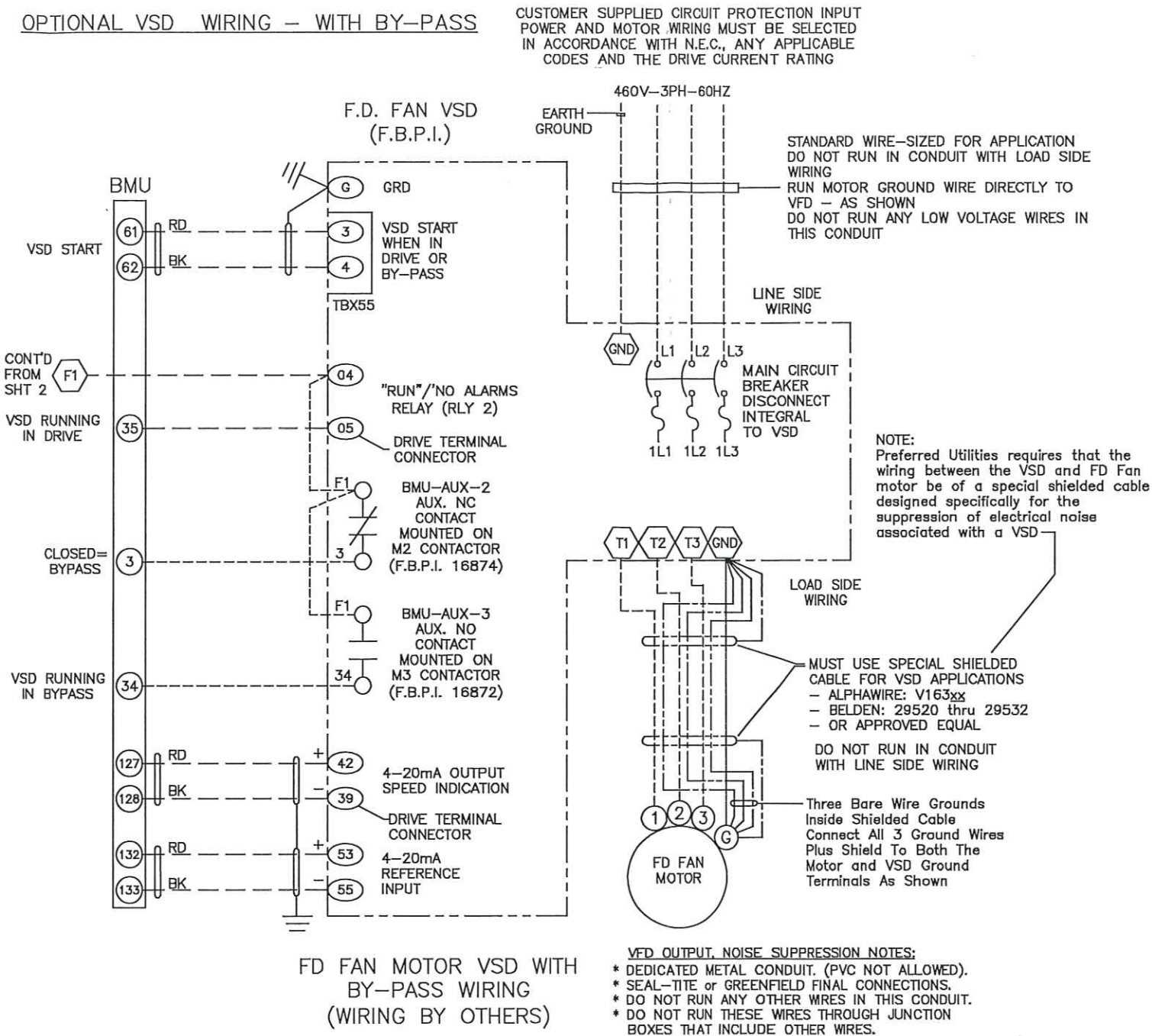
OPTIONAL VSD WIRING - WITHOUT BY-PASS



VFD OUTPUT NOISE SUPPRESSION NOTES:
* DEDICATED METAL CONDUIT. (PVC NOT ALLOWED).
* SEAL-TITE or GREENFIELD FINAL CONNECTIONS.
* DO NOT RUN ANY OTHER WIRES IN THIS CONDUIT.
* DO NOT RUN THESE WIRES THROUGH JUNCTION BOXES THAT INCLUDE OTHER WIRES.

ATTENTION:
NOISE SUPPRESSION NOTES MUST BE FOLLOWED!!!

OPTIONAL VSD WIRING - WITH BY-PASS



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ATTENTION:
NOISE SUPPRESSION NOTES MUST BE FOLLOWED!!!

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PREFERRED INSTRUMENTS
31-35 SOUTH STREET
DANBURY, CONNECTICUT
A Division of Preferred Utilities Mfg. Corp.

BURNERMATE UNIVERSAL
FIELD WIRING
STANDARD

F	Revised IDF Wiring-Sht 2	Re	9-18-09		
G	Revised Scanner Notes	Re	1-18-10	SUPERSEDES:	ASS'Y:
H	Rev'd VSD-Bypass wiring	Re	4-28-10	SCALE:	SHT 7 OF 8
J	Updated VSD-Bypass wiring	Re	11-18-10	DRN: WFL 9/20/07	
LET	REVISIONS	INIT	DATE	APPR'D:	BMU-FW-STD

Darrel Scribner

From: Peter Lavelle
Sent: Tuesday, January 20, 2015 9:49 AM
To: Rob Frohock; Larry Creagh; Dan Wallace; Peter Cantatore; Gary K. Rice; Michael D. Elswick
Cc: Darrel Scribner
Subject: Please add VSD-motor shielded cable to BOM's (quotes and Production)
Attachments: MotorAmps - Wire Size Data.xlsx

Hi Guys

Darrel and myself are tired of a few jobs per year turning to garbage due VSD electrical noise interfering with electronic controllers, 4-20ma xmtrs, t/c's, etc, etc....

We are spending field service \$\$ that we almost never get paid for and we are annoying end users with intermittent trips.

Whenever a VSD is used on a job...please include the 70530-xxga 3 phase shielded cable in our scope of supply (Proposals AND production BOM's).

It doesn't matter if we are supplying the VSD OR if someone else is supplying the VSD.

This applies to burners, ID fans, feedwater pumps, condensate pumps, oil pumps,... whatever.

If we are buying a DA skid from someone else with VSD's, we should also insist that they use this type of cable (or equal).

Please see attached Motor Hp vs Voltage vs Motor wire Gauge chart.

You need to know both the motor Hp and Voltage in order to select the proper wire gauge.

You will also have to guesstimate a wire run length, and include a clause for the cost extra for additional feet of cable.

Pumc p/n 70530-xxga is the p/n for the VSD-Motor shielded cable (Belden or Alpha Omni)

(xx = 12, 10, 8, 6, 4, 2 gauge)

We don't much stock this cable, it is generally purchased for each job.

I believe that there are MRP Estimating ID's for this cable also.

If the VSD is being shipped loose, or if the VSD is being supplied by others, I believe that we should still supply the VSD cable and tie-wrap it to the motor that we ARE supplying.

You will need to know a conservatively long cable length in advance.

Too many of our Rep's and small installers aren't bothering to order this special cable and just use regular wire (ignoring our drawing comments)

That's why I want it on our burner, etc production BOM's.

This cable has (4) grounds/shields !!

All (4) need to be grounds at BOTH ends!!

In the Motor Hub and to the VSD Ground/Shield terminal/clamp.

This is shown on our standard drawings, make sure it is shown on custom jobs as well.

VSD electrical noise is a well known issue and shielded motor power cabling is a well known solution.

Installers who say they don't need VSD-motor shielded cable are WRONG.

DO IT !!!

Please forward this email to anyone else that needs to see it.

DC Commons and AC Neutrals Isolation

The drawing on page 2-19 shows the relationships between the various "Grounds" and "Commons" within the PCC III.

A thorough understanding of these relationships will prevent unintended "Ground Loops" in the DC and AC field wiring. "Ground Loops" is a general term to describe unintended current flows via AC Ground or DC Common circuits, which generally are NOT drawn on a schematic as a distinct field wiring connection.

DC Ground Loops can cause lower than expected 4-20 mA values due to a portion of the current bypassing the intended circuit path and traveling through some unintended parallel path. AC "Ground Loops" can cause Ground Fault Interrupter Circuit Breakers to trip if current returns via a "Neutral" that is not protected by the GFCI breaker.

Green Wire Ground: The incoming AC power Ground (the "Green" wire) is only connected to Case Ground (ie, the metal enclosure). Case Ground is isolated from all Neutrals and all DC Commons. Case Ground should always be connected to the appropriate power supply Ground, per NEC.

Line: The CPU AC Power "Line" Input (Terminal 2U) is internally connected to CPU terminals 2L and 3L. CPU Terminal 2U is NOT internally connected to any of the option boards. If a connection is desired, external wiring is required.

Hot: The "Hot" Power Inputs to the "G" and "S" Triac Output Option Boards are isolated from the CPU "Line" Input. Each Option Board "Hot" is isolated from the "Hot" of the other Option Boards. If a connection is desired, external wiring is required. The "Hot" Input for a particular Triac Option Board is a common input that feeds all Triacs on that board.

Neutral: The CPU AC Power "Neutral" Input (Terminal 1U) is internally connected to CPU terminal 1L. CPU Terminal 1U is NOT internally connected to any of the option boards. If a connection is desired, run a field wire from the CPU board to the Option Board.

CPU Terminal 1U is the return path (or Neutral) for all current that enters any of the CPU 120 Vac Discrete Input channels (Terminals 4L – 8L). The "Hots" and "Neutral" of all "J" Option Board 120 Vac Discrete Input channels are isolated from the CPU Board "Line" and "Neutral". Each "J" Board Input channel is isolated from each other "J" board channel. The "J" Board is provided with jumpers to allow connecting the Neutrals of the channels together if desired.

DC Common: The DC commons ("-") are isolated from case ground. All Signal Commons on the CPU board are interconnected, and are also connected to the Signal Commons on the "A", "F", and "G" Option Boards. Specifically, the following terminals are all internally connected to each other:

CPU:	9, 12, 14, 18, 20, 22, 24, 26
"A":	x-41, x-43, x-45, x-47, x-49, x-51
"F":	x-41, x-43, x-45, x-46, x-47, x-49, x-51
"G":	x-51

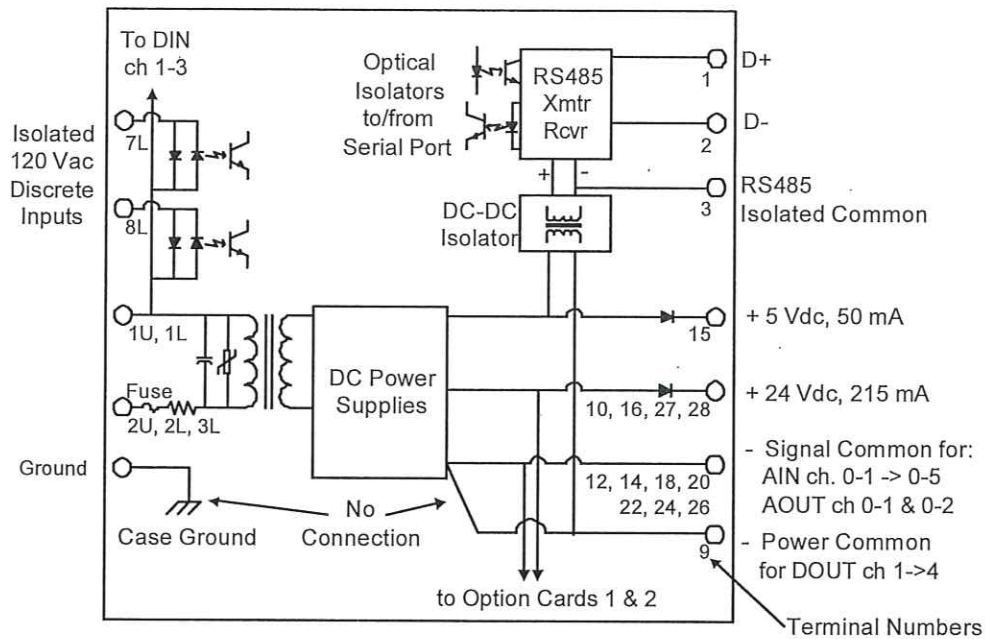
Power Common (PC): Terminal 9 on the CPU Board is reserved for "noisy" electrical loads such as external relay coils, and solenoids.

Signal Common (SC): Except for Terminal 9 (Power Common), all other DC Commons are referred to as Signal Common, and should be connected to low noise 0-5 Vdc and 4-20 mA circuits.

Isolated Signal Commons: The "-" terminal of each channel of a "B" Option Board is isolated from all other channels on that Option Board and from the CPU Board. The "+" terminals are also isolated channel to channel and from the CPU.

Isolated RS485: Terminal 3 ("COM") is the isolated DC Common of the isolated power supply that powers the field wiring portion of the Isolated RS485 Communications Link. The RS485 Data "+" and "-" (terminals 1 & 2) are also isolated from the CPU Board.

CPU Board AC to DC, and DC to DC Isolation

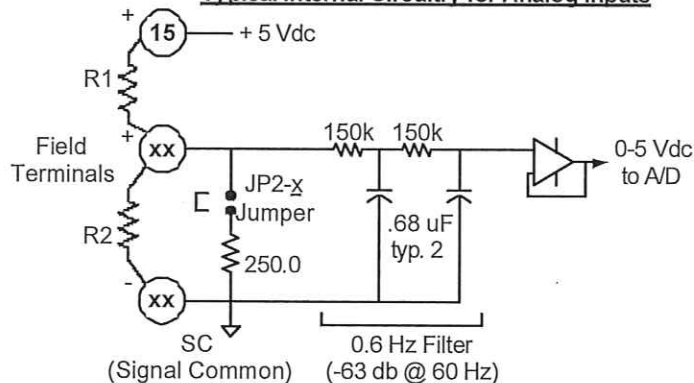


Pull-Up/Down Resistor for Voltage Inputs

This Sub-Section does NOT apply to 4-20 mA Inputs; that is, Inputs with the 250 ohm Resistor connected.

The 250 ohm resistor is never connected for: 1-5 V, 0-5 V, 0-10 V, and Potentiometer Inputs.

Typical Internal Circuitry for Analog Inputs

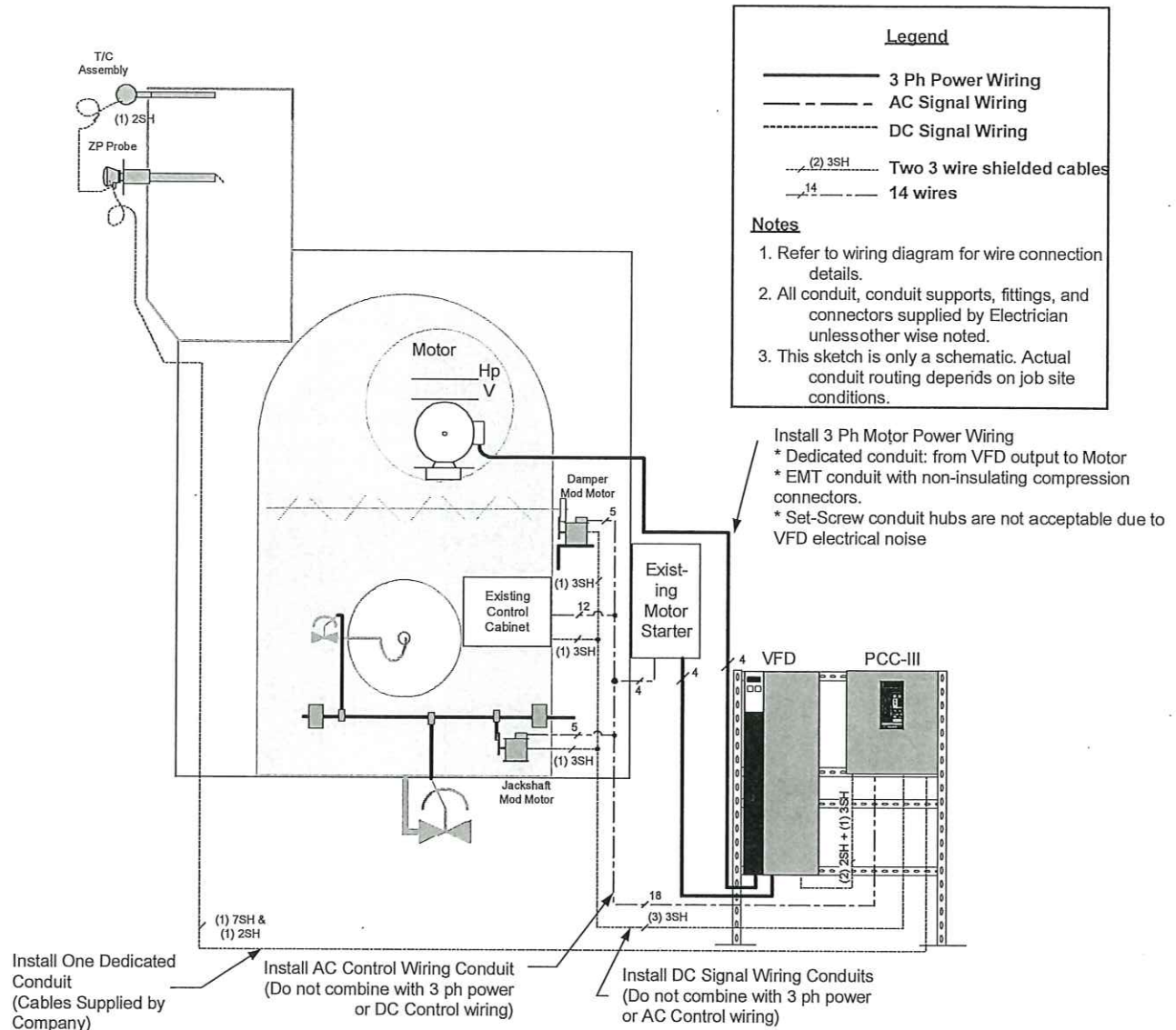


Each Analog Input has a low pass noise filter with high quality, low leakage capacitors for 60 Hz noise rejection. If the field wiring breaks, a pot wiper gets dirty, or is otherwise disconnected, the A/D Input Voltage will remain at the last value for several hours due to the capacitors in the filter.

In many applications it is desirable for the Input to fail to either 0V or 5V after the Input becomes disconnected.

INSTALLATION PROCEDURE

Conduit and Wiring To Be Installed



READ ALL NOTES ON THE UTILITYSAVER WIRING DIAGRAMS.

NOTE IN PARTICULAR:

- The wiring to the ZP oxygen sensor and flue gas temperature thermocouple must be in a dedicated conduit and separate from all other wiring.
- The wiring from the VSD output to the fan motor must be in a dedicated conduit and must be separate from all other wiring. Do not run through junction boxes that include any other wiring.
- The VSD to motor conduit must be metallic and have either threaded or compression fittings. PVC conduit, and EMT set screw style hub connectors are not acceptable. This wiring generates high levels of electrical noise. The metal conduit and connectors contain the noise inside the conduit.
- A dedicated ground wire must be run from the VSD frame to the motor within the motor conduit for safety, and to reduce electrical noise. A second ground wire must be run from the VSD frame to the AC power source for NEC safety grounding.
- The DC and AC wiring must be in separate conduits. However, all DC wiring can be combined into one conduit (except the ZP cable), and all AC wiring can be combined into a second conduit (except the motor power wiring).

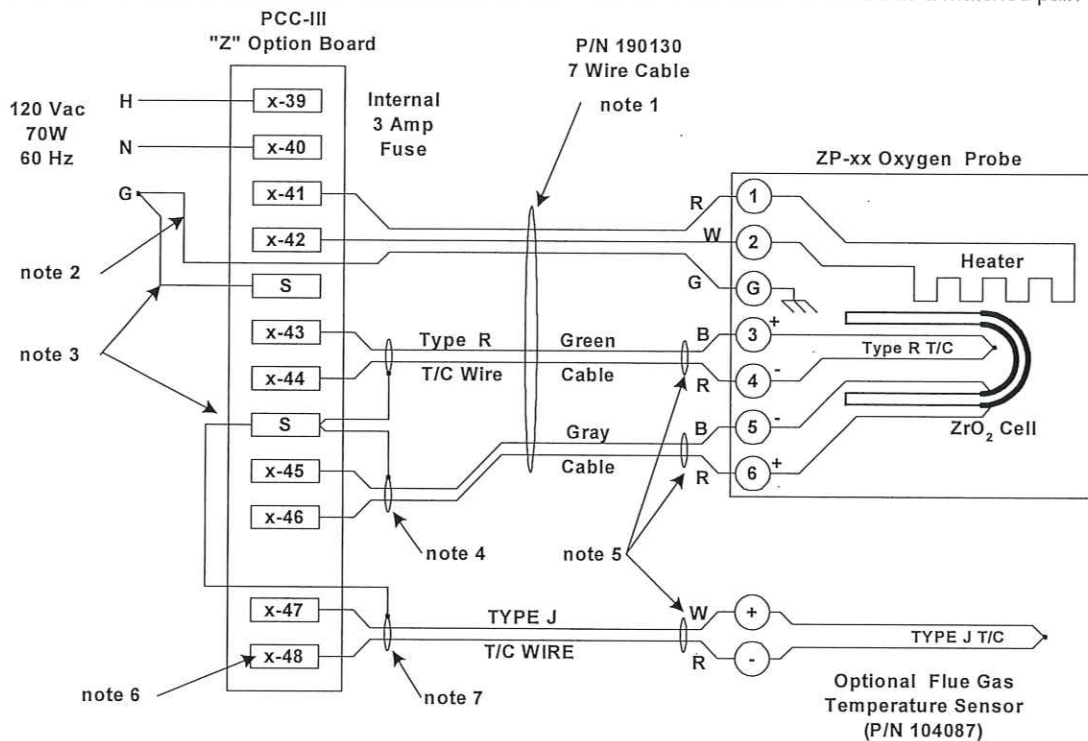
Mount PCC-III Controller

Mount the PCC-III Controller in a location that is easily accessible to the operator and no more than 500 ft of wiring distance from the ZP Sensor. The location must be free from vibration, extreme temperatures (32 - 122 F), and condensing humidity. The PCC-III Controller front panel is rain proof but should not be subjected to prolonged direct sun light. Use the full size panel cut-out template provided to help cut the hole in the panel.

Wiring

The PCC-III and ZP 120 Vac power supplies should only be turned off for ZP maintenance or for extended Boiler shutdowns. The 120 Vac power should NOT be turned off every time the burner is shut down. Excessive power cycling can shorten the life of the ZP detector. Provide a "service loop" in the flex conduit at the Detector to allow removal disconnecting the wiring. Note: The Terminal Screws in the Detector head are M4x0.7 metric screws.

The ZP Sensor and the "Z" option board are factory calibrated as a matched pair. The Sensor and "Z" board are marked with the same serial number. Install and wire the ZP Sensor and PCC-III "Z" board as a matched pair.



Wiring Practices and the Suppression of Electrical Noise

In addition to safety code requirements, there are numerous methods and practices that help to reduce nuisance start-up and operational problems due to electrical noise. Variable Speed Drives (VSD) and ignition transformers are the major electrical noise generators on a boiler system, and their installation should be closely scrutinized.

General Wiring Requirements

1. Physically separate AC wiring from DC wiring. Do not run AC and DC wiring in the same conduit or trough. When necessary, AC and DC wiring should cross at a 90-degree angle.
2. DC shielded cables: The drain/shield should be connected at one end only, and only as shown on the electrical drawings that follow. Generally, the shield is connected to the DC common of its power supply (not to earth ground). All shield foils and shield wires should be insulated (taped or heat shrink) to prevent accidental connection to earth or power ground. Shields connected at both ends, or unintentional second grounds, can actually add extra noise to a signal instead of reducing noise.

Ignition Transformer Wiring / Mounting

1. Ignition transformers should be mounted as close to the spark electrode as possible to keep the igniter lead wire short and to make the return current path through the burner steel to the transformer as short as possible. Igniter spark gaps should be as small as possible but within the burner manufacturing recommendation.
2. Ensure there is good grounding contact of the transformer and of the igniter assembly (use star washers).
3. Use only automotive style "Resistance Core" ignition wire. Do not use copper core ignition wire.

VSD Wiring

1. The wiring from the VSD output to the motor must be in a dedicated conduit and must be separate from all other wiring. Do not run the VSD input wiring in this conduit. Do not run through junction boxes that include any other wiring.
2. VSD outputs generate high levels of electrical noise. The metal conduit and conduit connectors contain the noise inside the conduit. The VSD to motor conduit must be metallic and have either threaded or non-insulating compression fittings. PVC conduit and EMT set screw-style hub connectors are not acceptable.
3. A dedicated ground wire must be run from the VSD frame to the motor frame within the motor conduit for safety and to reduce electrical noise. A second ground wire must be run from the VSD frame to the AC power source for NEC safety grounding.
4. All DC wiring conduits should be kept as far away from VSD-to-motor conduits as possible.
5. Preferred Utilities strongly recommends that the wiring between the VSD and the motor be of a special shielded cable specifically designed for suppression of the electrical noise associated with the VSD (available from Alpha Wire or Belden).

Wiring Practices and the Suppression of Electrical Noise

Oxygen Analyzer Wiring

1. See Note below. Use only P/N 190130 cable for O2 detector wiring. Run this cable in a separate conduit from the detector back to the control panel. Avoid splices. Only a shielded thermocouple wire used for flue gas temperature can be run with the O2 cable. No other wires, AC or DC, are allowed in this conduit.
2. Maximum wiring length is 500 feet.
3. Connect the detector ground wire directly to the BMU power supply ground.
4. Do not connect any shield drain wires at the detector. Insulate shields to prevent shorts to ground or to other shields.
5. Connect the O2 cable shield drain wires to the (S) terminals as shown on the drawings.

Note: To assure that the integrity of system communications is maintained and that the adverse influence of "electrical noise" is minimized, it is required that the "BMU-CABLE-XX" for interconnection of the BurnerMate Universal to the LCD and Servos and Catalog Number 190130 ZP O2 Analyzer to **BurnerMate Universal** interconnecting cable is used in the interconnection of these devices. Preferred Utilities will not warranty the operation of the **BurnerMate Universal** system if wired in any other form.

Scanner Wiring

1. If a BMU Scanner with the included cable is used the connecting field wiring must be installed exactly as shown on the "BurnerMate Universal Field Wiring Standard" drawing page 1 of 8. The wire shield is connected to earth ground at the scanner via the prefabricated cable and must be insulated at all other locations to prevent accidental grounding. Do not connect the shield wire to terminals **T102** or **T105**.
2. For all other scanners, the **BurnerMate Universal** requires a 120 VAC input on terminals **T30** for Flame Scanner 1 and **T31** for Flame Scanner 2.
3. For all other scanners where the Flame Intensity inputs will be utilized, contact Preferred Instruments Technical Support for the proper wiring requirements.

Maintenance of Instruments & Systems

2nd Edition

Lawrence D. Goettsche, Editor

***Practical Guides
for Measurement and Control***



Noise

Noise is defined as unwanted or undesirable electrical signals in an electrical circuit. Every electrical circuit has noise in it. Noise in a circuit becomes noticeable when the noise level approaches the wanted or desired signal level. Noise in a circuit may come from the outside via conduction or field radiation or from the circuit itself, which also generates noise. The key is to reduce the noise to a level that does not adversely affect the desired signal. The reduction of noise uses two general methods: reduction of noise from the source and reduction of intrusive noise into circuits. Fortunately, many of the techniques available for the reduction of noise work for both methods.

Noise generation can be reduced by preventing the noise from leaving the equipment that is generating the noise or the actual suppression of the noise. The prevention of noise from leaving a noise generator uses the same shielding techniques used for prevention of noise intrusion. These methods put some form of grounded metal shield between the noise generator and the outside world or some device that prevents noise from being conducted via wires to the outside world. Suppression of noise methods include arc suppression, arc removal (replacing electromechanical relays with solid-state relays, for example), separation, circuit redesign, equipment selection (use of zero-crossing firing SCRs instead of phase angle firing, for example), filtering, and isolation. Suppression of the source of noise should be looked at first because it reduces the total amount of noise propagating in the system and will generally be the most cost-effective method if the noise is affecting a number of instrument systems. Suppression of the noise may

also reduce the mysterious or “things that go bump in of the night” types of problems.

Noise can enter a system by being conducted through wires or metal or coupled through electromagnetic fields (capacitively, inductively, or plane wave (radiated) coupled).

CONDUCTED NOISE

Conducted noise is noise that is conducted into the system via wires or metal surfaces and comes from sources such as switching transients, nonlinear devices such as switching power supplies and SCR drives, and noise coupled into the external system that enters the system through the system’s connections with the external world (power, signal, communication circuits, etc.). Conducted noise is reduced by filtering or suppressing the noise that is entering on the incoming or outgoing wires. The filter may be as simple as a shunt capacitor or as complex as an active filter. Ferrite beads, common mode chokes, isolating transformers, power conditioners, optical isolators, and fiber optics are just a few of the methods that are used. Distance from the noise source also affects the strength of the conducted noise; i.e., the further from the noise source, the more the noise is reduced by the impedances between the source and the circuit in question. Many times, separate branch circuits are provided for sensitive equipment to take advantage of this effect. The key to successful reduction of conducted noise is to identify the type and strength of the noise that is causing the problem. If the noise generator(s) cannot be suppressed, the most cost-effective method of prevention of the noise entering the sensitive system should be supplied.

Interrupting the noise path is a common troubleshooting method for determining whether the problem is conducted noise. Changing the power source for a device, disconnecting a signal or communications path, or disconnecting a ground (note that a safety ground should not be disconnected without providing equivalent protection) are some of the ways to break the conducting path.

One of the computers in a system was experiencing mysterious resets and lockups. Investigation showed that one of the printers was connected to the same UPS that the computer used. Removing the printer from the UPS solved the problem, which was conducted noise from the printer into the UPS system and on to the computer system.

COUPLED NOISE

Coupled noise enters the system via the electromagnetic fields by capacitive, inductive, or plane wave coupling. Capacitive coupling can be viewed as being similar to a capacitor and is electric field-based. Inductive coupling can be viewed as being similar to a transformer and is magnetic field-based. Plane waves are both electric and magnetic field-based and are waves (for example, radio waves).

Capacitive coupled noise can be reduced by placing a grounded metal shield between the noise source and the protected circuit. Aluminum and copper are commonly used materials.

Inductive coupled noise can be reduced by placing a magnetic material shield between the noise source and the protected circuit. Carbon steel is a commonly used material, and a number of special magnetic materials are available for this purpose.

PLANE WAVE NOISE

Plane wave noise or radiated noise occurs when the coupled noise source is more than $1/6$ of a wavelength away from the circuit in question. Common sources of this are walkie talkies, radio base stations, and high speed and high frequency circuits.

Plane wave noise can be reduced by placing a metal shield with no hole larger than $1/20$ of a wavelength between the noise source and the protected circuit. It should be noted that antennas that are $1/4$ wavelength long serve as effective antennas for that frequency, and as frequency goes up, wavelength and, hence, the antenna length goes down. Wires that are just wires at low frequencies become more effective antennas at high frequencies. Generally, the effectiveness of shielding is related to how good a conductor the shield is and the thickness of the shield. Generally, any metal instrument enclosure provides sufficient thickness for protection against plane waves.

A cable shield for high frequencies was run into an enclosure, and the shield was opened and the drain wire run down two feet to a ground bus. The shield was ineffective because the drain wire served as an high impedance inductor at the frequencies involved. The drain wire should have been connected, with a path as short as possible, to a low inductive ground return path.

SHIELD GROUNDING

Shield grounding, many times presented as a complex subject, can actually be simple in practice. By following these rules, most loops can be protected by shielding:

Rule #1 — Shields at frequencies below 1 MHz should be grounded only at one point: the zero potential point of the circuit.

Rule #2 — Shields at frequencies above 10 MHz should be grounded in multiple points.

Rule #3 — Nonmagnetic materials such as aluminum foil are effective only against electrostatic (capacitive coupled) noise and provide limited protection against plane wave noise (a function of thickness of the shield).

Rule #4 — Magnetic material is effective against both electrostatic and magnetic (inductive coupled) noise.

Rule #5 — Twisted pairs are effective against magnetic noise and are a general good practice. The tighter the lay (more twists per inch), the more effective the twist.

Rule #6 — Standard grounded metallic instrument enclosures with no opening larger than $1/20$ of the wavelength for the highest frequency involved will provide adequate protection against plane wave noise.

Rule #7 — Inductive effects become significant when the length of the wire is longer than $1/20$ of the wavelength of the frequency in question.

Rule #8 — In an ungrounded instrument loop, Rule #1 should be followed. Earth grounding the shield does not improve the effectiveness of the shield; if anything, it decreases the effectiveness of the shield.

Rule #9 — The vulnerability of a circuit to coupled noise is related to the circuit loop exposed to the noise. Reduce the loop, reduce the noise.

Note that aluminum foil or copper braid shields used for cable shields do not provide any protection from magnetic-based noise. Aluminum conduit, aluminum conduit fittings, aluminum or 304 or 316 stainless steel enclosures, and copper MI cable also do not provide any protection against magnetic-based noise.

For multiconductor shielded cables, the shield drain wire length should be kept to a minimum. This requirement, however, many times causes logistics problems for cables that are connected to a single ground or common bus in a cabinet. This may be overcome by connecting the shield drain wires together at the cable (using a compression terminal block) and then running the drain wires to the ground or common connection located as close as possible. This method creates a lower inductive path; i.e., multiple wire returns instead of single wire returns.

Twisted pair cable with individual foil shields and an overall shield run in steel conduit provides excellent noise protection.

Isolation

Isolation is a technique that is used as a means to segregate and protect sensitive electronic equipment. Transformers are used to provide power isolation. These can be standard transformers or can be specially designed isolation transformers that have additional shielding built in. These isolation transformers are used when the isolation is also used to minimize noise and transient intrusion. Isolation of ground return paths via a separately derived system can be accomplished with a standard transformer.

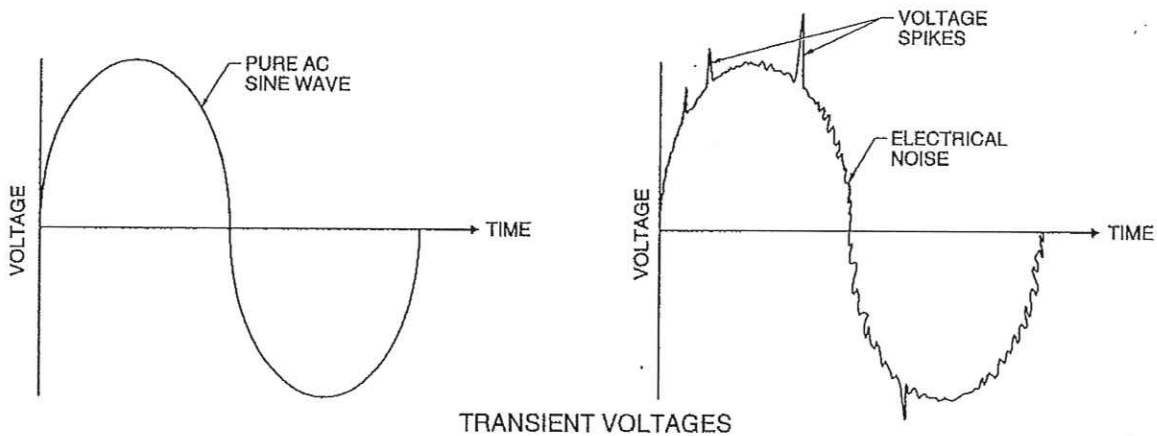
Signal isolation can be very important. Signal isolation is used to eliminate ground loops or to isolate one system from another. Common uses are to isolate grounded thermocouples, to isolate computer systems from the instrument system, to isolate two different systems that are communicating with each other, and to isolate two separately grounded systems. Experience indicates that using isolated transducers is a good practice and is seldom regretted.

A computer was talking via an RS-232 serial port to an RS-232/RS 485 converter and then to a group of controllers. The system exhibited intermittent bizarre behavior. A check with a line monitor indicated that the computer was sending and receiving correctly. A grounding problem was suspected, but the system did not appear to be incorrectly grounded. A check of the RS-232/RS-485 converter showed, however, that it was a non-isolated type. The converter was replaced by an isolated type and the problem cleared up. The computer was providing a ground, and the controllers provided a different ground, creating a ground loop that caused the problem. Moral of the story: since you have little control over how computers are built, it is good practice to provide isolation for your computer I/O from the real world.

Transient voltages caused by lightning strikes must be considered in all electrical applications since lightning may strike at almost any place. Low-level transient voltages are produced on indoor power lines when most loads are switched OFF. Transient voltages may be continuously produced when using:

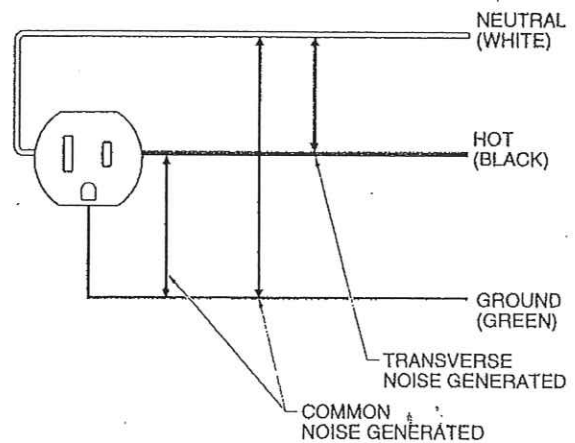
- Single-phase switched mode power supplies
- Fluorescent lighting using electronic ballasts
- Variable-speed motor drives
- Soft-start motor starters
- Electronically controlled welding equipment
- Motors that include brushes (DC and universal)

Transient voltages include voltage spikes and electrical noise, or both. A *voltage spike* is an increase in voltage (typically several thousand volts) that lasts for a very short time (microseconds to milliseconds). Voltage spikes are shown as sharp peaks on the AC sine wave. *Electrical noise* is any unwanted disturbance that interferes with a signal. Electrical noise is shown as jagged lines on the AC sine wave. An oscilloscope or scopemeter may be used to detect voltage spikes and electrical noise. See Transient Voltages.



Electrical noise is produced on power lines from two different points. *Common noise* is noise produced between the ground and hot or the ground and neutral lines. *Transverse noise* is noise produced between the hot and neutral lines. In most electrical systems, common noise occurs more frequently than transverse noise. See Electrical Noise.

Common noise is caused by arcing at motor brushes, ground faults, poor grounds, radio transmitters, ignition systems, and the opening of electrical contacts. The opening of electrical contacts generates noise because an arc is produced across the contacts as they are pulled apart. The higher the current in the circuit being opened, the larger and longer the arc. Transverse noise is caused by welders, switched power supplies, and the firing of silicon-controlled rectifiers (SCRs) in electrical equipment.



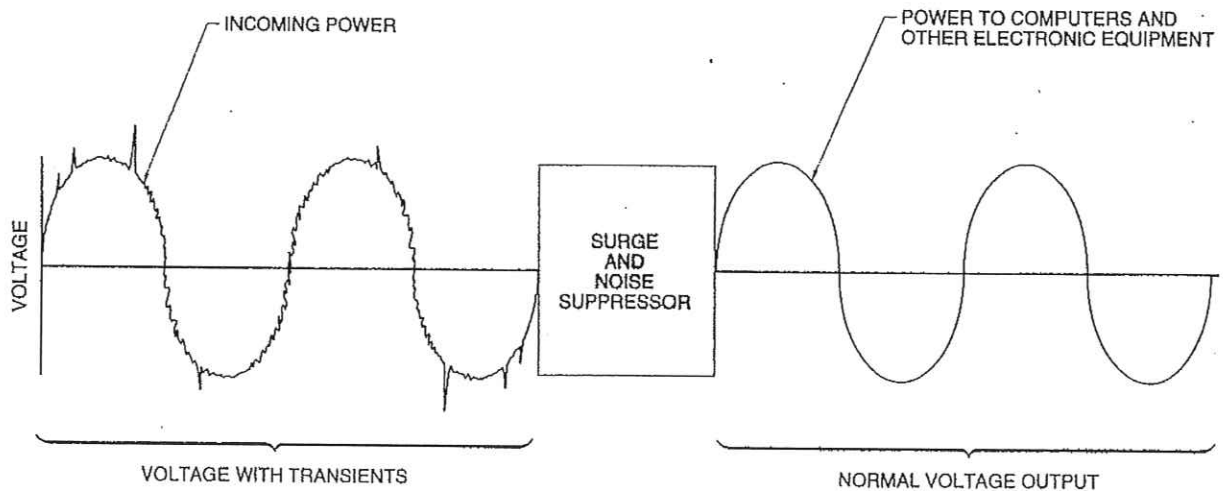
ELECTRICAL NOISE	
COMMON NOISE	GROUND AND HOT OR GROUND AND NEUTRAL
TRANSVERSE NOISE	HOT AND NEUTRAL

ELECTRICAL NOISE

Voltage Spike and Electrical Noise Protection

Computers, electronic circuits, and specialized equipment require protection against voltage spikes and electrical noise. Protection against voltage spikes and electrical noise includes:

- Proper wiring, grounding, and shielding of the power lines. Proper wiring, grounding, and shielding include the use of a proper grounding system (See NEC® 250.) and also ensure the proper use of the ground and neutral conductors. The neutral conductor should always carry the normal load current. The ground conductor should only carry fault current. The ground conductor should never carry the normal current drawn by a load. The amount of current carried on the hot, neutral, and ground conductors is measured with a clamp-on ammeter. The current measured on the neutral conductor should equal the current measured on the hot conductor under normal operating conditions. The current measured on the ground conductor should always equal zero under normal operating conditions.
- Proper sizing of neutral and ground conductors.
- Ensuring that all wire connections are tight. Loose connections cause noise and arcing which may damage computer and other electronic circuits.
- Proper selecting and applying of surge suppressors and noise suppressors. A *surge suppressor* is a protection device that limits voltage surges which may be present on power lines. Surge suppressors limit voltage surges by discharging or bypassing the damaging voltage. Surge suppressors may be installed separately or may be included with a noise suppressor. See Surge and Noise Suppressor.



SURGE AND NOISE SUPPRESSOR

System Protection

An electrical system is protected at several points along the distribution system. An electrical system is normally protected at the main entrance into a plant, at the distribution panel, and at the individual circuits. See System Protection.

Main entrance protection devices protect against major surges and reduce transient voltages in the main entrance to an electrical distribution system. Main-entrance protection should include surge suppressors, such as lightning arresters that are large enough to dissipate a lightning strike or major utility fault. A major utility fault occurs when two power lines come in contact during a storm.

**VHA Boiler Plant Safety Device Testing Manual
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All safety testing described in this text involving such switches centers around making sure that all these requirements are met. The most common failure in this regard is a failure to insure that the switch has the proper set point which requires measuring operating parameters in order to determine the proper set point.

1.3.2 Confirming That All Devices Actually Function for Intended Purpose

In testing any interlock device that operates through the automatic control system, it is paramount that the testing procedure verifies compliance with the four requirements listed above.

1.3.3 Lockable Valve Requirements

In order to facilitate testing of some types of interlock devices, it is sometimes convenient to temporarily isolate the interlock device and provide test ports by means of manual valves. However, these modifications cannot be allowed to increase risk by locking out a safety device during normal operation and should clearly indicate test and normal position. Any such manual valve that could isolate a safety device from its normal operating circuit should be lockable and the lock should be lockable only in the correct operating position.

1.3.4 Confirming That Jumpers Are Removed and Valves Properly Locked

In many cases in order to test a device, it will be necessary to either electrically jumper (bypass) a device or to valve out the device. The safety testing personnel should only carry a fixed number of jumpers and should make sure that at the end of a test that all jumpers being used are accounted for and that all lockable valves are locked in their correct position.

1.4 NOMENCLATURE

AFOSV	Automatic Fuel Oil Shutoff Valves
ALWCO	Auxiliary Low Water Cutoff
APFGSOV	Automatic Pilot Fuel Gas Shutoff Valves
APFGSVV	Automatic Pilot Fuel Gas Solenoid Vent Valve
CAPI	Control Air Pressure Interlock
CAPS	Combustion Air Pressure Switch
DA	Deaerator
DAODS	Deaerator Overflow Drain System
DASV	Deaerator Safety Valve
FDDWOPS	Forced Draft Damper Wide-Open Pre-Purge Proving Switch
FDMIS	Forced Draft Motor Interlock Switches
FGRDI	Flue Gas Recirculation Damper Interlock
AFGSOV	Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve
AFGSV	Automatic Fuel Gas Shutoff Solenoid Vent Valve
FPI	Furnace Pressure Interlock
FSMFO	Flame Scanner-for main flame out
FSNSIS	Flame Scanner Not Sensing Igniter Spark
HFGPCS	High Fuel Gas Pressure Cutoff Switch
HFOPCS	High Fuel Oil Pressure Cutoff Switch
HWAB	High Water Alarm on Boiler
HWACT	High Water Alarm on Condensate Tank
HWADT	High Water Alarm on Deaerator Tank

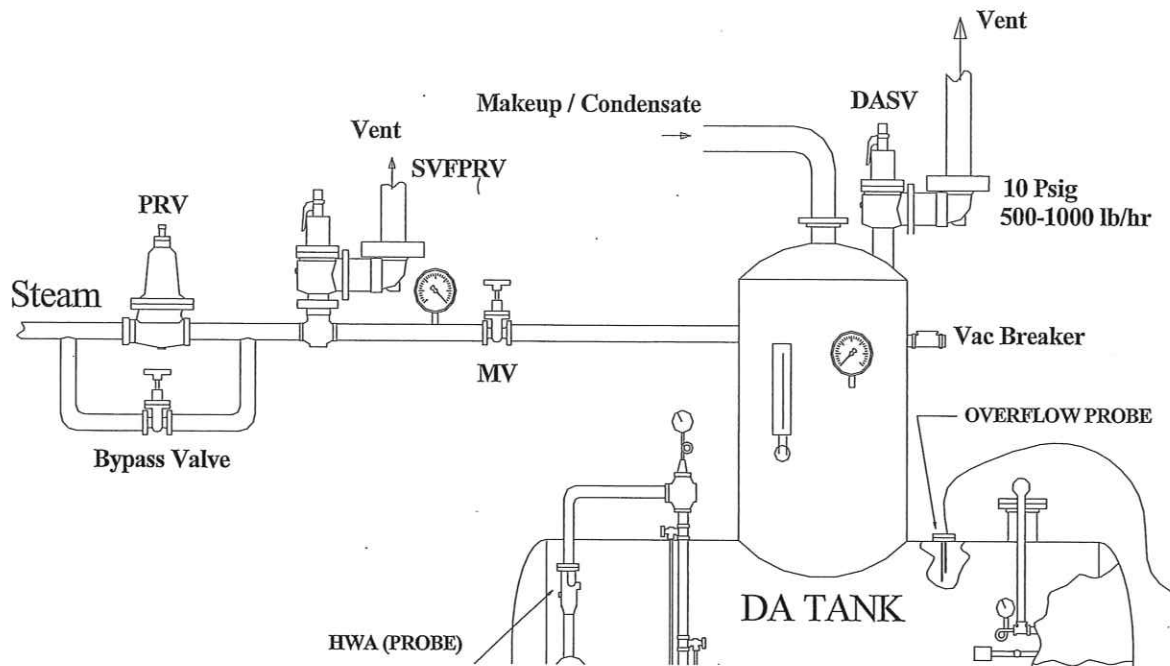


Figure 1.1 Safety Valve Following a PRV

1.5.2 Setup for testing a combustion air switch, purge air switch, furnace pressure switch, control air pressure switch, and high pressure switches for main gas and pilot.

In order to test these switches it is convenient to be able to temporarily isolate these switches from the normal pressure source and to apply test pressures that can be accurately measured. At the same time the piping should be such that the actual pressure that the switch senses can also be measured. The arrangement that is pictorially shown in Figure 1.2 for testing the combustion air pressure switch allows this objective to be met for all switches covered in this section.

Not applicable. No changes to this portion of the system not in the project scope of work.

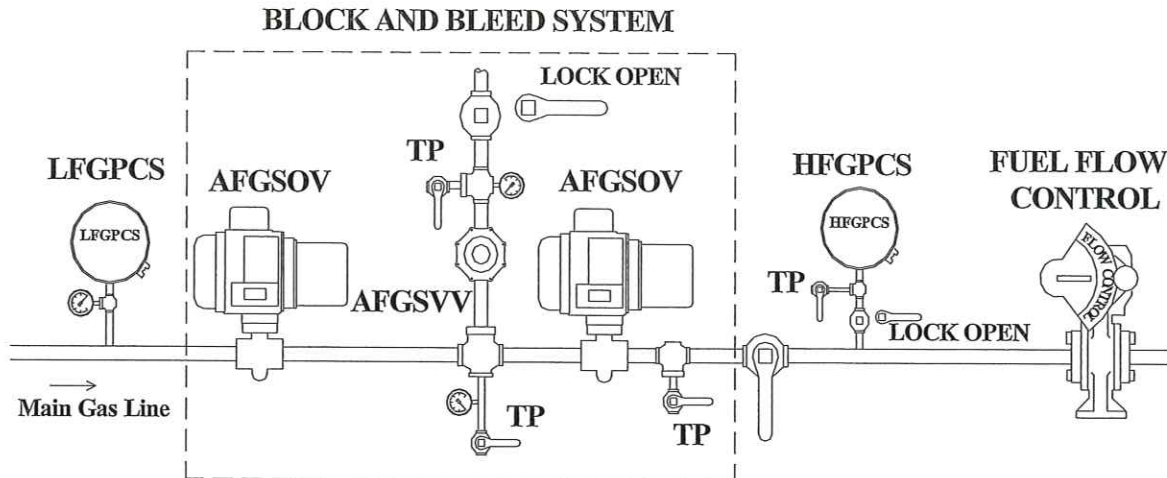


Figure 1.3 Leak Checking Automatic Shutoff Valves

1.5.4 Setup for Checking Dangerous Gas Detection System For the Building

Sample gas with a level of CO and combustibles slightly exceeding the sensor set points should be available with a means to supply the gas to the sensor per the manufacturers test procedures.

1.5.5 Setup for Checking the Deaerator Overflow System and Oil Liquid Relief Valve

A sight glass with turbine wheel should be installed downstream of the valve in order to visually confirm that flow exists. The oil liquid relief valve also requires a pressure gage at the pump discharge.

1.5.6 Setup for Checking Proof of Closure Switches, Low Fire Proving Switch, Force Draft Damper Vane Interlock, Outlet Stack Damper Interlock, Recycle Steam Pressure Switch, Non-recycle Pressure Switch, Primary Low Water Cutoff, and Recirculation Damper Interlock

It is necessary to electrically isolate these switches for testing. The two electrical leads from each of these switches should be wired into an electrical control panel and the terminals to which they run should be clearly identified. Only one wire should be under a given terminal.

1.5.7 Setup for Hydrostatic Testing

In order to hydrostatically test any device it is necessary that valves are available to isolate the device, a test port is available to apply the test pressure, and a pressure gage is available to monitor the pressure in the device (See Figure 1.4). All devices that could be damaged by the test pressure must be removed prior to conducting the hydrostatic testing.

2 WATER LEVEL CONTROL

2.1 LOW WATER CUTOFFS

2.1.1 Description

A low water cutoff is a device that causes the automatic fuel safety shutoff valves to close if the water level in the boiler drops below a pre-set safe level. Low water causes about 50 percent of all boiler incidents. Low water can cause the boiler to overheat which could lead to the failure of the pressure vessel with enormous potential damage (explosion). Two low-water cutoffs are required. Low-water cutoffs operate either on a "float" system or electrode system. In the float system there is a cross arm connection to the boiler (high and low connection points). Between these connection points there is a vertical section containing a volume sufficient to house the float. If the water level falls below a prescribed level, the falling float will cause a switch to actuate causing the automatic fuel valves to close. (See Figure 2.1)

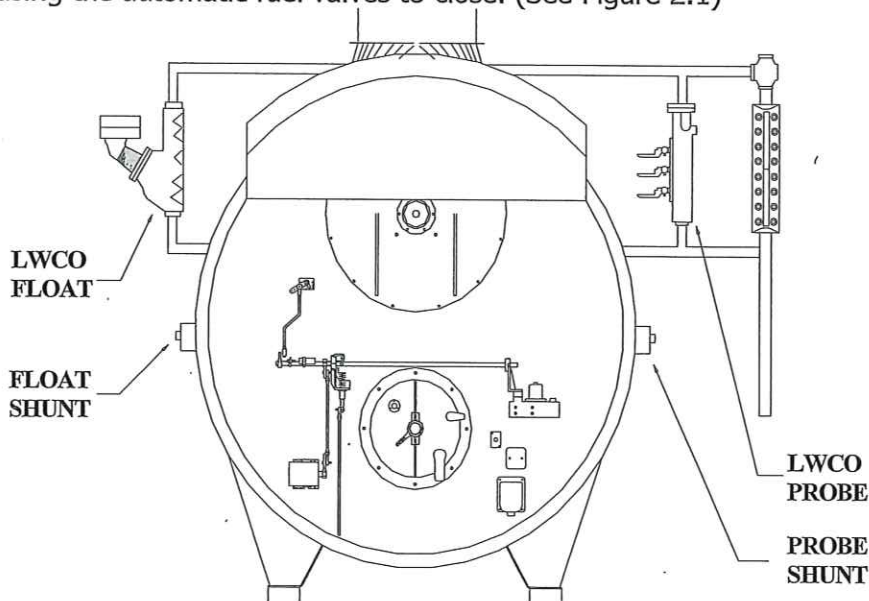


Figure 2.1 Low Water Cutoff

In the electrode system, there is a similar cross arm arrangement as in the float system. Probes extend vertically downward into the vertical pipe connecting the cross arms. The electrodes are located at the bottom of the probe and are used to measure the conductivity of the media in which the electrodes are immersed. The conductivity of water is much higher than steam. Hence, if the water level drops below the probe, a drastic change in conductivity occurs. This change is used in an electrical circuit to cause the automatic fuel shut-off valves to close. Most safety codes require at least one float system be included to protect against low water. This is shown in Figure 2.1. The VA requires one float and one probe. True redundancy requires two separate cross arm arrangements. Use of a single cross arm could lead to a situation in which blockage in the cross arm renders both level control safety devices useless.

Some low-water cutoffs are provided with non-latching "shunt" switches by which the cutoff switch is bypassed. Arrangements for shunt switches include individual shunt

condensate transfer or boiler feed pump from running dry. A low water alarm on a boiler is a warning to operators of an impending potential problem of a "boil out" of water.

2.2.3 Testing Low Water Alarms

This alarm is tested by causing a drop in water level in the vessel being tested. The alarm should activate at the desired setpoint (the setpoint must be above the level at which dangerous operations will occur, at a level allowing operators to restore the proper level, and visible in the appropriate sight glass).

A step by step procedure is given in Appendix A for three situations: boilers, deaerators, and condensate tanks.

2.3 HIGH WATER ALARM

2.3.1 Description

A high water alarm is used on a boiler, deaerator, and condensate tanks to aid in preventing overfilling. Due to the failure rate of float type devices used for this purpose, high water alarms should always be a conductivity probe type device.

2.3.2 Consequence of High Water Alarm Failure

High water in a condensate tank could lead to backup of condensate in condensate lines. High water in a deaerator will result in poor deaeration but also leads to violent shaking of the vessel. High water in a boiler could result in pushing liquid into the steam line. Slugs of water in the steam system can move at high velocity due to the motive force of steam causing water hammer. Water hammer can cause valves and other fittings to explode and steam piping to rupture. Death and injury from these events is a regular occurrence. This same effect could produce high water levels in the steam supply to a steam powered appliance connected to the system with detrimental effects on the process.

2.3.3 Testing the High Water Alarm

The high water alarm can be tested off-line. Slowly fill the vessel with water, observe the water level in the sight glass, and note the point at which the alarm sounds. Be careful not to overfill the system, above the level at which the alarm should actuate.

A step by step procedure is given in Appendix A for three situations: boilers, deaerators, and condensate tanks.

2.4 OVERFLOW DRAIN SYSTEM

Not applicable. No changes to this portion of the system not in the project scope of work.

2.4.1 Description

Deaerator tanks and condensate storage tanks have overflow systems to prevent overfilling. The deaerator overflow is shown in Figure 2.2. The overflow system on the condensate tank also helps guarantee that the condensate tank remains at atmospheric pressure and consists of a drain line connected to the vessel. The drain line from a deaerator includes a normally closed device that opens if the water level is too high and allows water to drain either to sewer or into the condensate tank. Three different types of overflow control valve systems have been utilized on deaerator tanks:

deaerator. Observe the water level in the sight glass. Use the sight glass to confirm that the drain system is capable of maintaining the water level at the drain level.

A step by step procedure is given in Appendix A.

- Is the safety valve properly drained?
- Can the safety valve be safely checked?

Some authorities recommend doing all safety valve testing on a test stand. However, there is a chance that the valves could be mixed up or damaged in installation so that this test method is not as reliable as testing the valves in situ. Also some authorities check a safety valve by lifting the handle. This test does not confirm that the valve opens at its setting. It does confirm that the valve can vent steam (is not blocked). This test should never be performed at a working pressure less than 75 percent of the safety valve setting.

A detailed test procedure which allows the 7 points enumerated above to be checked is given in Appendix A for three situations: boilers, deaerators, and piping following a PRV station.

3.2 RELIEF VALVES

3.2.1 Description

Relief valves are spring-loaded valves that open if the liquid pressure in the system that they protect increases above a pre-set limit. They are similar to safety valves with the exception that they do not exhibit "popping" action or blowdown. (Relief valves do not incorporate the "huddling" chamber found on safety valves). These valves are connected to an exhaust pipe that conveys the fluid to the building exterior or storage tank. Two important pieces of equipment requiring relief valves in boiler applications are economizers and oil pump sets

3.2.2 Consequences of a Relief Valve Failure

Failure of a relief valve could lead to a pressure vessel explosion with serious consequences. For example, there are several cases yearly in which the relief valve on domestic water heaters fail with the result that an entire house is "leveled". A even more devastating event could result from the explosion of an economizer. Failure could also lead to equipment damage due to overheating-e.g. in operation of an oil pump.

3.2.3 Checking a relief valve

There are several aspects of a safety or relief valve that must be checked. These include:

- Is the valve vented with proper piping?
- Is the lift pressure correct?
- Does the valve open at correct pressure?
- Will the valve handle the maximum capacity of the device that it protects?

Testing procedure for the relief valve on an oil pump set and economizers are given in Appendix A.

3.3 HIGH STEAM PRESSURE LIMIT SWITCHES

3.3.1 Description

A boiler should be fitted with two, high-steam-pressure-limit switches (HSPLS). Both switches have the function of causing the two automatic fuel shut off valves to close if a

In applying the hydrostatic pressure, care must be exercised not to overpressure the vessel. If the vessel were pressurized above its elastic limit, the vessel would not be fit for further use and should be scrapped!

4.2 HIGH PRESSURE FUEL CUTOFF SWITCH

4.2.1 Description

The high fuel pressure cutoff switch is used to cause the automatic fuel shutoff valves to close if fuel pressure is above a given the higher limit for safe operation. These switches are used for both the main gas and main oil fuel supply systems (See Figure 4.2). In both of these applications the switch senses the supply fuel pressure after the pressure regulating valve and upstream of the fuel control valve. The switch is in continuous operation once the boiler is in the run mode.

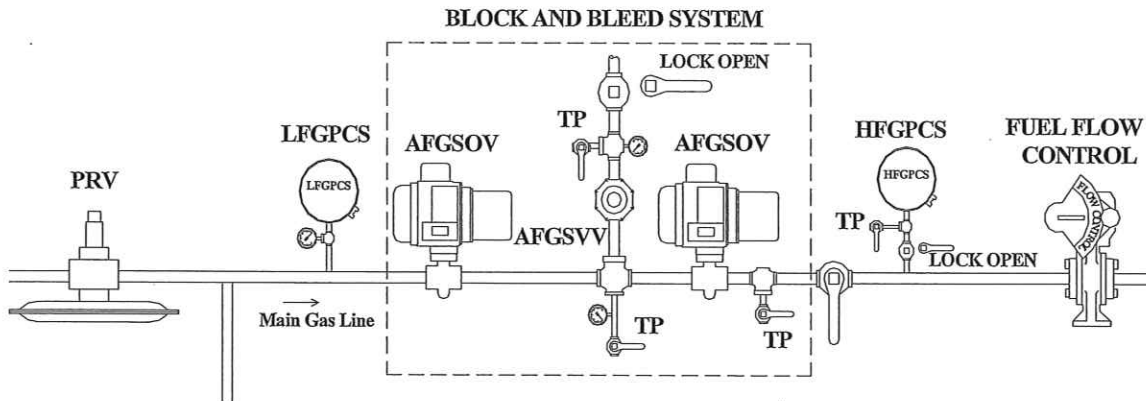


Figure 4.2 High Pressure Fuel Cutoff

4.2.2 Consequences of High Pressure Fuel Cutoff Switch Failure

High fuel pressure can cause unstable flame conditions but more importantly it can result in over-firing the boiler. Over-firing can damage burner/boiler materials to the point of meltdown and explosion. The generation of steam can be so intense that a pressure vessel explosion can occur. High fuel pressure can easily occur if a pressure regulator and high-pressure cutoff switch were to fail.

4.2.3 Checking the High Pressure Fuel Cutoff Switch

The checking procedure for this switch is designed to answer three questions:

- Is the switch in correct place?
- Are its limits correctly set?
- Does the switch work?

The switch should never be located upstream of the pressure regulating valve and should never be located downstream of the fuel flow control valve. The high pressure limit should be 120% of the normal regulated supply pressure for natural gas and 110% for light oil.

A step by step test procedure for the high pressure fuel cut out switch for the main gas and main oil supply systems is given in Appendix A.

4.3 VENTING BETWEEN AUTOMATIC GAS SHUTOFF VALVES

4.3.1 Description

The volume between the automatic fuel shutoff valves for gas should be vented to the atmosphere with a system as shown in Figure 4.3 for both the main gas and pilot line automatic shut off valves. While the boiler is running the solenoid valve is shut and gas

used in either case are the means by which the boiler is automatically shut down in case any operating limit is not satisfied. It is absolutely essential that these valves do not leak when closed. For both oil and gas, applicable codes require two automatic shut off valves. It is that important.

4.4.2 Consequences of Leaking Automatic Shut off Valves

There is a slight probability that one or more of the automatic fuel shut off valves would leak. If both valves leaked and the vent system did not function in the case of gas, fuel would be introduced into the burner and into the boiler furnace while the boiler is off. This fuel would produce a combustible mixture in the boiler. Fuel leaks into the boiler are obviously dangerous because it allows the presence of a combustible air-fuel mixture that could explode when the fuel is ignited on startup. This combustion explosion could easily wipe out all property and personnel within several hundred feet of the boiler.

4.4.3 Testing the Automatic Fuel Shut off Valves for Leaks

The testing for leaks can be done when the boiler is off. The best test procedure for gas is a situation in which the leak could be measured with a "bubble test". This method involves connecting a tube to a confined space downstream of the valve being tested with positive pressure on the upstream side of the valve. The tube is placed approximately 1/16th of an inch below a water surface. Any leak will show up as a bubble generated in the water at the tube exit. Any testing by watching pressure fall is difficult to evaluate because generally there are many potential sources for leaks in the system which will obscure the results. For oil a test port can be provided to visually observe whether oil drains from the test port.

A step by step procedure is given in Appendix A.

4.5 OIL LOW ATOMIZING MEDIA PRESSURE SWITCH

4.5.1 Description

An atomizing fluid (compressed air or steam) is usually used to aid in the combustion of the oil fuel (See Figure 4.4). A safety switch is required that shuts the boiler off in case of low atomizing pressure. This switch measures pressure in the atomizing fluid line immediately after the pressure regulating system and causes the automatic fuel control valves to close if the atomizing pressure falls below its setpoint. If there is a differential pressure regulator, the sensor should be located upstream of that regulator.

4.6.1 Description

The function of an automatic fuel shutoff valve is absolutely essential. All safety devices that require fuel shutdown rely on the two automatic fuel shutoff valves to perform this task. Proof of Closure switches must be present in both automatic shut off valves. Both oil and gas automatic shut off valves require proof of closure switches. The switches in the two valves should be wired in series so that an indicated failure in either valve will prevent the boiler from starting. The proof of closure switch is an integral part of the automatic fuel shutoff valve. It has a simple function to guarantee that the automatic fuel shutoff valve is closed before allowing the boiler to go through the burner startup sequence. If the automatic fuel shutoff valve is not closed, the proof of closure switch will be open, breaking the circuit and not allowing the burner to start. The proof of closure switch is active only during the startup sequence.

4.6.2 Consequences of a Failed Proof of Closure Switch

If the proof of closure switches fail, they could "stick" closed even with the valve open. This malfunction would present a false signal to the burner management system indicating that the valve is closed when it might not be closed. This malfunction could allow the fuel to be ignited with a large quantity of fuel in the furnace. Under this scenario, a horrible combustion explosion would occur. The result could be a tremendous loss of property and death as well as physical harm to personnel within several hundred feet of the boiler.

4.6.3 Testing the Automatic Fuel Shutoff Valve (Proof of Closure) Switch

In order to test a proof of closure switch one must demonstrate the following:

- That the switch is closed when the valve is closed.
- That the switch opens immediately once the valve starts to open.
- The boiler will not start with the switch open.

A detailed step by step procedure to determine whether the proof of closure switches meet the above requirements is given in Appendix A.

5.2.1 Description

In the startup procedure for the boiler, the safest way to light the main burner is with a minimum of fuel input. There are electrical position switches located on the control systems for the fuel flow control valves and the combustion air damper that activate when the damper is at low-fire position. These low-fire proving switches have the function of not allowing the main flame to be ignited if the firing position is not a minimum. In some electronic control systems a potentiometer is used to determine the position of the inlet damper by the output of a voltage level to the controller. The required V.A. system is position switches actuated by the fuel control valves and the damper themselves rather than at some point nearer the drive motors that operate the valves and damper. Parallel position systems require separate proof of the low fire position for air and fuel.

5.2.2 Consequences of a Failed Low Fire Proving Switch

Failure of the low-fire proving switch could allow the boiler to start in a high fire position. This result could easily lead to a violent combustion explosion with property loss as well as injury and death to individuals within a few hundred feet of the boiler.

5.2.3 Testing the Low-Fire Proving Switch

The low-fire proving switch should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch the right type and located correctly?
- Is the switch "activated" at any position other than "low fire"?
- Does the switch in the non-activated position prevent the boiler from firing?

A detailed step by step procedure for testing the low fire proving switch is given in Appendix A.

5.3 COMBUSTION AIR FLOW SWITCH

5.3.1 Description

A combustion airflow switch is used for the purpose of causing the two automatic fuel shutoff valves to close if the forced draft fan is not producing airflow (See Figure 5.1). Typically, this switch uses a pressure measurement across the fan. The switch is in the safety control circuit anytime the boiler is in the run position. A set point for the switch is established by measuring the minimum pressure rise seen by the switch over the firing range and setting its value at approximately 80% of the minimum pressure rise. For the combustion air flow switch one desires that the pressure rise being measured is as large as possible and is "flat" i.e. independent of firing rate.

the purge (high fire) position. Typically this pressure should be measured across the boiler bank without variable restrictions. The proper set point for the switch is approximately 80% of the maximum pressure change sensed by the switch.

5.4.2 Consequences of a Failed Purge Airflow Proving Switch

If this switch were to malfunction, it would be possible to ignite the pilot and or main flame with combustible gas mixtures present in the boiler. This could lead to a terrible combustion explosion with serious loss of property and life.

5.4.3 Testing the Purge Airflow Proving Switch

The purge air flow proving switch should be tested during the boiler startup sequence. There are basically three things that should be tested:

- Is the switch located correctly (i.e. pressure taps across right element)?
- Is the switch setpoint correct?
- Does the switch in the non-activated position stop the boiler from leaving purge?

A detailed step by step procedure for testing the purge air flow proving switch is given in Appendix A.

5.5 BURNER POSITION SWITCH

5.5.1 Description

Some manufacturers of oil burners require a position switch to indicate that the burner is in the correct position before firing. The switch is generally a simple proximity switch that is electrically closed by depression of the switch by the burner as it is fully inserted into the boiler. For those boilers utilizing this switch it must be tested.

5.5.2 Consequences of Burner Position Switch Failure

If the boiler could fire on oil with the burner partly retracted, fire, production of carbon monoxide, flame instability, and combustion explosions could result. This could lead to serious loss of property and injury/death.

5.5.3 Testing the Burner Position Switch

The switch must be periodically tested to determine if the boiler would fire on oil with the burner partially retracted. If the switch is properly set up, the boiler control will not allow the boiler to leave purge with the burner out of position. A detailed step by step testing procedure is give Appendix A.

5.6 FORCED DRAFT MOTOR INTERLOCK

5.6.1 Description

The forced draft motor interlock provides an extra level of safety relative to proving "purge air flow" and "combustion air flow" and protects the fan motor from running with an inadequate power supply. There are three types of interlocks currently being used. The simplest interlock is an auxiliary contact which is a single pole switch that "makes" when the main switch supplying 3-phase power to the fan is closed. One could cut any or all of the power leads going to the motor and this switch would indicate acceptable operation. Clearly, this interlock is not acceptable. A second design utilizes phase monitors on all three legs which looks at the incoming power characteristics which will work if one loses incoming power to the panel. However, the fan motor could be

causes the boiler to shut down. The proper set point for the switch is approximately 120% of the actual furnace pressure at high fire condition.

5.7.2 Consequences of Low Furnace Pressure Interlock Failure

A blockage in the exit portion of the boiler combustion gas circuit, leads to high furnace pressure and incomplete combustion. Under this condition carbon monoxide is generated and the combustion gases are potentially highly explosive. If the FPI were to malfunction two highly undesirable consequences might occur. First, high furnace pressure would cause incompletely combusted gasses internal to the boiler furnace to be expelled into the boiler room. Carbon monoxide levels in the boiler room could reach a point where occupants would be killed. Secondly, these incomplete combustion gases could explode if a supply of oxygen became available (For example the flame might be temporarily extinguished, and the explosively re-ignited by a "hot spot" in the boiler.) Therefore, the consequences of a failed FPI could be the loss of life of many people from carbon monoxide poison and flying debris from a boiler explosion.

5.7.3 Testing the Furnace Pressure Interlock

The FPI can be tested by first determining the furnace pressure at high fire in order to establish a proper setpoint for the interlock. It can then be tested offline by pressurizing the interlock with air. There are basically four items that need checking;

- Is the switch located correctly (i.e. pressure taps between the internal volume of the boiler furnace and atmosphere)?
- Is the interlock set point correct?
- Does the interlock break at the correct set point?
- Does the interlock in the open position stop the boiler from operating?

A detailed step by step procedure for testing the FPI is given in Appendix A.

5.8 OUTLET DAMPER POSITION INTERLOCK

5.8.1 Description

The purpose of the outlet damper position interlock (ODPI) is to insure that the outlet damper is open during purge. This interlock is a part of the safety system to insure that adequate purging has occurred prior to the ignition sequence. Therefore, it is a pre-ignition interlock. The ODPI is a displacement electrical switch that should be activated by movement of the outlet damper into the correct position for purging. (In many cases this interlock is on the jackshaft drive motor that is linked to the damper, but this arrangement does not meet VA specifications.) If the interlock is not "made", the safety controller for the boiler does not allow the boiler to leave purge.

5.8.2 Consequences of Outlet Damper Position Interlock

A blockage in the exit portion of the boiler combustion gas circuit due to a closed or partially closed outlet damper, leads to inadequate flow of combustion air. Under this condition there is the potential for highly combustible gases to be present in the boiler furnace after purging is complete because the air flow restriction reduces the volume of purge gases to the point that combustible gases remain in the boiler or exhaust system. If the ODPI were to fail, these incomplete combustion gases could explode when the igniter attempts to light the pilot. This explosion would cause boiler parts to fly hundreds of feet leaving anyone in its path badly injured or dead.

5.10.2 Consequences of Improper Purge Timing

If the timer does not function correctly, the boiler and stack could contain a highly explosive mixture of combustible gases due to inadequate purge. This gas mixture could explode when either the pilot or main flame are operated. The massive explosion that results would likely cause severe property damage and personal injury and death in an area several hundred feet from the boiler.

5.10.3 Testing the Pre and Post Purge Timer

The test is simple in that the duration of purge can be measured simply with a stop watch. The amount of purge air actually moved is more difficult to determine. An approximate calculation for the cubic feet of air moved is given by the following formula:

$$\text{Standard Cubic Feet of Air} = \frac{[(\text{boiler steam capacity in lb/hr})/3600] \times [\text{purge duration in seconds}]}{.075}$$

This amount of cubic feet of air should exceed four times the fireside volume of a firetube boiler and eight times the fireside volume of a water tube boiler. A detailed step by step test procedure is given in Appendix A.

5.11 IGNITER TIMER AND MAIN FLAME IGNITION TIMER

5.11.1 Description

The igniter serves as a spark to light the pilot flame. Moving quickly from an ignition source to pilot light to main flame does not allow a large amount of combustible gas in the boiler without the presence of an ignition source at anytime during light off. The igniter and main flame ignition time is controlled by the burner management system and should not be adjustable by operators. NFPA currently sets the maximum igniter spark duration of 10 seconds. For natural gas or light oil, the time allowed from the time that the two automatic shut off valves open until they close is 14 seconds (this is 10 sec for main flame ignition and 4 seconds for valves to close).

5.11.2 Consequences of Excessive Igniter or Main Flame Ignition Timing

If the igniter stays on too long and the pilot flame fails to ignite, an excessive amount of pilot gas could enter the boiler leading to a boiler explosion. Similarly if the trial time for main flame ignition is excessive, large amounts of fuel could enter the boiler and subsequently explode. Such explosions would likely cause severe property damage and personal injury and death in an area several hundred feet from the boiler.

There is an electronic timing mechanism that regulates the duration of time that the igniter produces a spark. If the trial for ignition (igniter or main flame) is too long, it allows time for a large amount of combustible fuel to enter the boiler. Then if ignition does finally occur the massive explosion described above will take place

5.11.3 Testing the igniter timer

The test of igniter time requires that one close both the main and pilot fuel supplies and measure the time the igniter is on during start up of the boiler. To test the time for trial for main flame, pilot gas is supplied to the boiler with the main fuel line manual valve closed. With this set up a stop watch can be used to measure the time that the main fuel valves remain open during an attempt to start the boiler. A detailed step by step procedure for these tests is given in Appendix A.

pilot fuel train. This set point should be about 80% of the regulated pilot gas pressure. The shortest pilot flame that will reliably ignite the main flame occurs at this minimum pilot gas pressure. Hence, a test to determine if the pilot length is adequate should be done at this minimum pilot gas pressure.

A complication exists in many situations for the backup fuel source for the pilot. Many systems normally use natural gas for the pilot fuel with propane or propane-air mixtures as the back up fuel. Natural gas and propane-air mixes should exhibit about the same burning characteristics. Propane has more energy per unit volume than natural gas and hence will have a different flame shape. If the situation being tested may involve both natural gas and propane as the pilot fuels, testing should be done to prove that the pilot flame is acceptable with either fuel. This test will also verify that the pilot can be successfully operated on either fuel.

5.14.2 Consequences of Inadequate Pilot Flame

Accidents commonly occur when boiler operators make multiple unsuccessful tries to ignite the fuel. Typically, these accidents involve introducing significant amounts of fuel into the boiler in several attempts to fire the main burner. If purging is not adequate, a point can easily be reached in which an explosive mixture of fuel is ignited. The massive explosion that often results usually causes severe property damage and personal injury and death in an area several hundred feet from the boiler. Even in the case of one try for main flame ignition, it must be remembered that if the igniter duration is too long, failure to quickly ignite the flame because of inadequate pilot flame length can cause a devastating explosion.

5.14.3 Testing for minimum pilot flame

The test involves setting the pilot gas pressure to a level just above the set point pressure on the low pilot gas cutoff switch. Then trials are made to see if the pilot can smoothly light both gas and oil. A detailed step by step procedure is given in Appendix A.

5.15 CONTROL AIR PRESSURE INTERLOCK

5.15.1 Description

Some older control systems use compressed air to operate various boiler controls. If air pressure is lost, the ability to regulate air and fuel flow into the boiler, feedwater flow, etc is lost. A control air pressure interlock switch that continuously measures air pressure in the air supply lines to the boiler controls is required. If the air pressure drops below a level necessary to operate the controls, the switch will trip and not allow the boiler to start, or if the boiler is running, will shut the boiler down. The person testing this switch should know the required air pressure specified by the control manufacturer and should adjust the setpoint pressure on the interlock to 120% of the minimum allowed pressure. An alarm to indicate problems at a pressure higher than the interlock setpoint is desirable.

5.15.2 Consequences of Failed Control Air Pressure Interlock Switch

Low control air pressure could easily result in a situation in which the air/fuel ratio moves into a situation where a furnace explosion could occur or dangerous levels of carbon monoxide is generated.

combustibles being present in the exhaust gas from the boiler. This interlock is electronically integrated into the burner management system for the boiler.

5.17.2 Consequences of a Failed Low Oxygen Alarm and Interlock

Insufficient combustion air results in flue gas with low oxygen and high combustibles which represent two very significant safety hazards. First, carbon monoxide will be a significant portion of the combustibles and can be fatal if breathed by humans at a sufficient level. Second, these combustible gases can produce a violent explosion if air is introduced. The explosion and toxic fumes that can be generated in this way could easily damage property and injure/kill people within hundreds of feet from the boiler.

5.17.3 Testing a Low Oxygen Alarm and Interlock

To properly test the alarm or cutoff it is necessary to know three things:

- Does the zirconium oxide sensor read the correct value?
- Has the trip point of the low oxygen interlock been set at the oxygen level at which the combustion is safe?
- Does the alarm interlock work? (i.e. provides an alarm and shuts the boiler down if levels below setpoint exist).

A detailed step by step procedure for the required test is given in Appendix A.

5.18 INTERLOCK OF OUTSIDE AIR DAMPER WITH BURNER MANAGEMENT SYSTEM

5.18.1 Description

Air for combustion must be available from the outside atmosphere (outside air) in the amount necessary to burn the fuel. Natural gas and oil require about 15 lb of air to burn 1 lb of fuel. The safety issue in this situation involves a scenario in which the outside air openings are closed to the point that insufficient air is supplied to the boiler. Boiler rooms can be placed into two distinct categories in terms of outside air supply. One type boiler room has so many leaks, open windows/vents/doors that there is no chance of starving the boiler for outside air. A second type boiler room is one in which normally there are a lot of openings to the outside but the possibility exists that these openings could be closed to a point where the boiler would be starved for air.

In the first type boiler room there is no need for an interlock because it is not possible to starve the boiler for air. In the second type boiler room there is generally no control to prevent the boiler from operating even though a potential danger exists. In this case, consideration of some method to prevent operation of the boiler with insufficient outside air should be given. Since generally there are several openings that must be closed to produce insufficient combustion air, no one position switch mounted at one of these openings will suffice to prevent the problem for all boilers. In some cases each boiler is provided combustion air through adjustable louvers with an interlock switch that prevents that boiler from being operated with the air intake louver closed. A cheaper solution is to permanently install sufficient area to provide the necessary outside air for all boilers by either welding or locking windows open or replacing windows with fixed air intake louvers.

Appendix A STEP BY STEP TEST PROCEDURES

Appendix A.1 INTRODUCTION

This appendix presents step by step test procedures for each safety device. The appendix provides forms for obtaining and recording all necessary data for each safety device being tested. It begins with tables that allow a thorough definition of the testing agency/personnel, responsible parties at the site, and boiler/burner data. This base data is followed by overarching requirements for safety testing. This information is then followed by one sheet for each device being tested to be used by the testing agency personnel as a check list and data form.

Appendix A.2 BASIC INFORMATION

VISN: _____
VA Medical Center: _____
Contact Name: _____
Phone: _____
Email: _____
Evaluators: _____
Date: _____

Individuals in Attendance:

Boiler and Burner Description

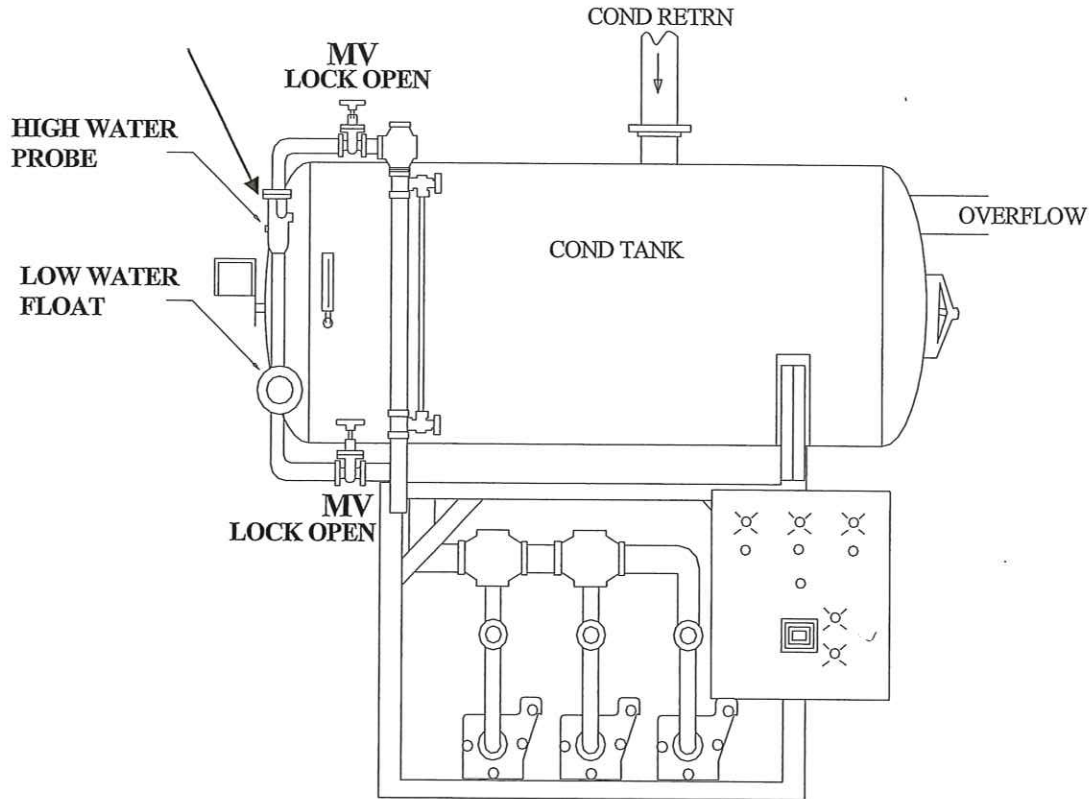
Boiler #	
Manufacturer:	
Model and Capacity:	
Serial #: National Board No.:	
Typical Operating Pressure:	
Design Pressure:	
Date of Manufacture:	
Boiler Controls:	
Burner	
Manufacturer:	
Type of burner:	
Fuels:	
Date of Manufacture:	

Checklist for High Water Alarm on Condensate Tank (HWACT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
HWACT					

*Alarm setpoint should be below 2/3rds of tank height & at least 4" below the overflow.

*Alarm type should be a probe sensor.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Use bypass valve to add water to the condensate tank at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. **DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.**
- Put maximum water supply to condensate tank and verify overflow is adequate.

Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Is overflow adequate?		
Can the switch be isolated with manual valves		

Comment:

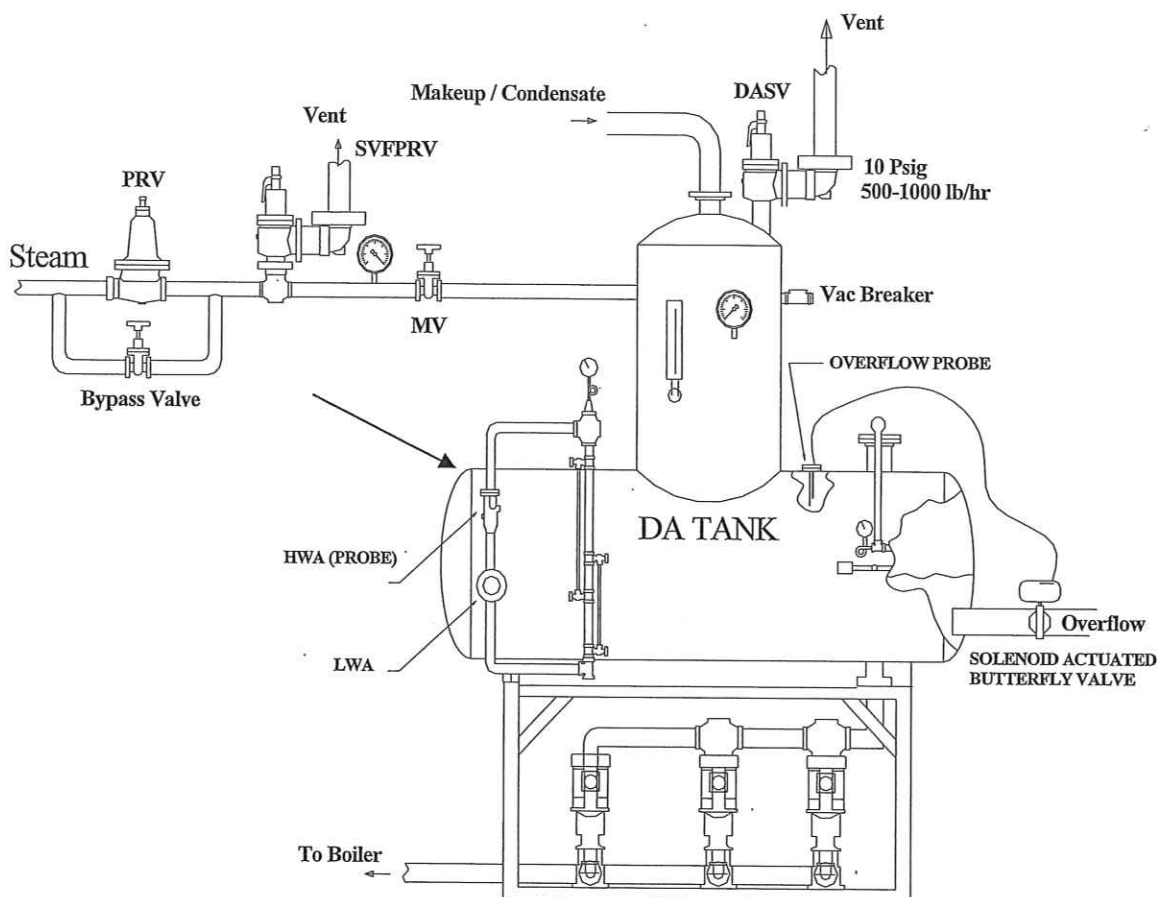
Not applicable. No changes to this portion of the system not in the project scope of work.

Checklist for High Water Alarm on Deaerator Tank (HWADT)

Item	Make	Float / Probe	Alarm Setpoint	Correct Device Type Y / N	Correct Location Y / N
HWADT					

*Alarm setpoint should be below 2/3rds of tank height & at least 4" below the overflow.

*Alarm type should be a probe sensor.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Use bypass valve to add water to the deaerator at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		
Can the switch be isolated with manual valves		

Comment:

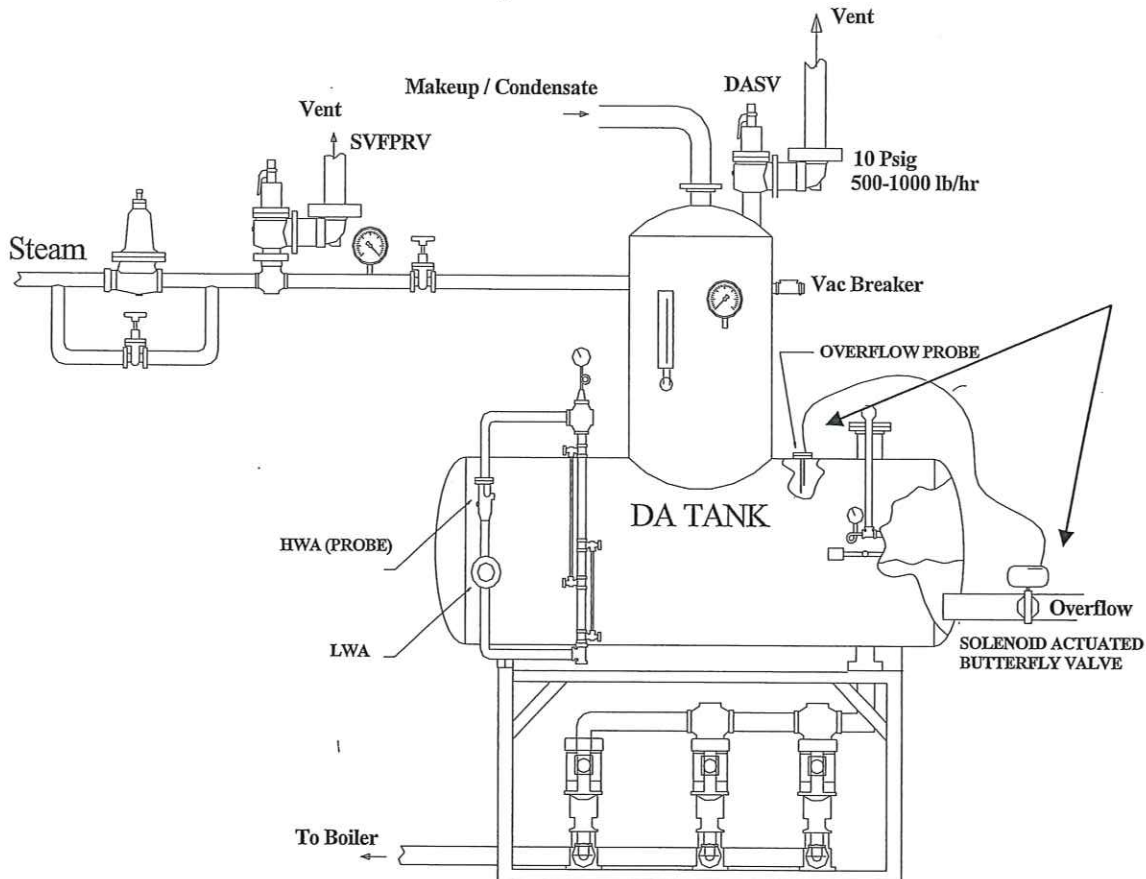
Not applicable. No changes to this portion of the system not in the project scope of work.

Checklist for Deaerator Overflow Drain System (DAODS)

Item	Make	Float / Probe	Overflow Setpoint	Correct Device Type Y / N	Correct Location Y / N
DAODS					

*Overflow type should be a conductivity probe connected to electronic valve.

*Setpoint should be at least 4" below top of tank.



- Drain the sight glass and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Open manual bypass valve to supply feedwater at maximum rate.
- Use sight glass in drain system to determine that dump valve has opened. Use water level sight glass to observe whether dump valve maintains water level visible in sight glass. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

Result	Y/N	Water Level
Did the overflow valve work correctly?		
Was the water level maintained in sight glass.		
View port in place to view overflow?		

Comment:

Not applicable. No changes to this portion of the system not in the project scope of work.

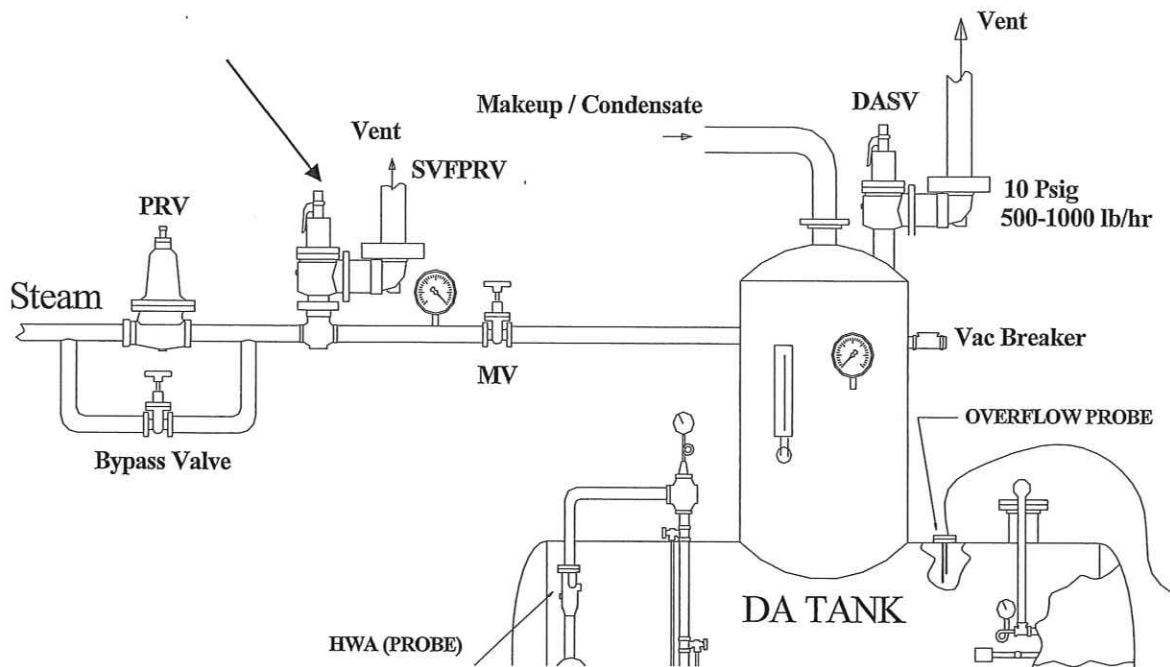
Checklist for Safety Valve Following PRV (SVFPRV) - Steam

Item	Make	Capacity (lb/hr)	Range	SVFPRV Setpoint	DA PRES (psig)	Correct Installation
SVFPRV						
Pressure Gage						

*Setpoint should be about 5 PSIG higher than DA safety lift point.

Item	Make/Type	Size (in)	Pressure upstream	Pressure downstream	Wide Open Flow Capacity lb/hr
PRV					
Bypass					

*SVFPRV must relieve largest wide open flow capacity, PRV or bypass valve.



- Pour water into drip pan ell drain and confirm that it is open.
- Close the manual valve in steam line following the safety valve.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SETPOINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- Open lager of the bypass valve or PRV completely and perform accumulation test. The pressure should rise no more than 6% above the setpoint pressure.
- After lifting valve, close bypass valve, open manual valve in steam line after PRV and allow safety to reseat.

Result	Y/N	Pressure
Did the safety valve work correctly?		
What was the safety valve relief pressure?		
What is the re-seat pressure?		

Comment:

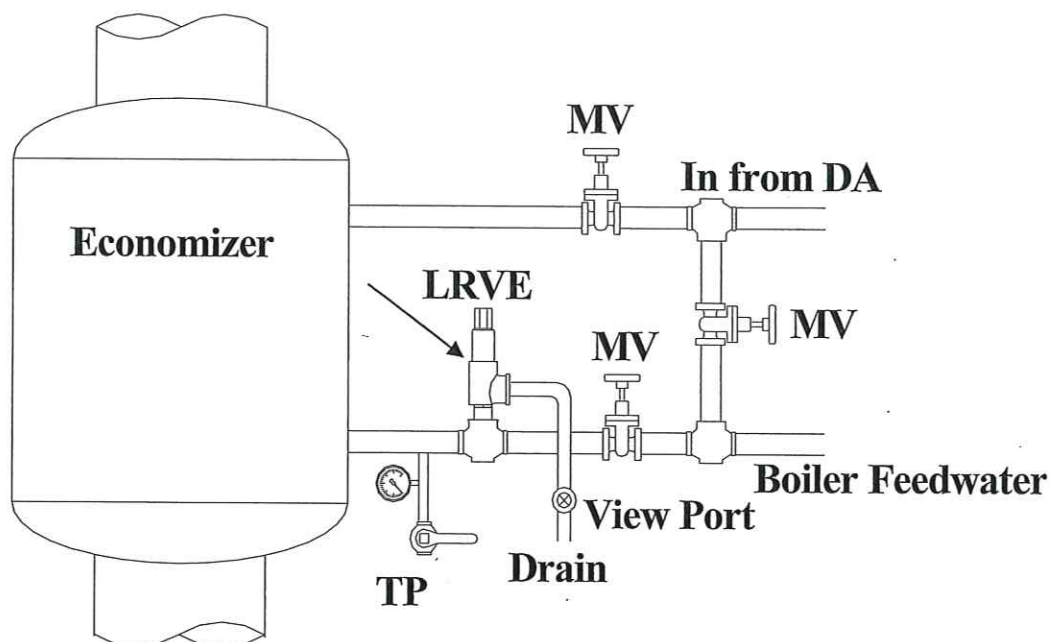
Not applicable. No changes to this portion of the system not in the project scope of work.

Checklist for Liquid Relief Valve on Economizer (LRVE)

Item	Make	Capacity (gal/hr)	Range	LRVE Setpoint	Feedwater Pressure	Correct Installation
LRVE						
Pressure Gage						

*Setpoint should be less than the max allowable economizer pressure and more than maximum feedwater pressure.

Item	Make	Max Stack Temp	MAWP
Economizer			



- With boiler offline use manual valves to isolate economizer and relief valve. Use hydrostatic tester to raise pressure and open relief valve (use view port to determine when valve is open). DO NOT RAISE PRESSURE MORE THAN ALLOWABLE ECONOMIZER PRESSURE!
- An alternate method is to raise economizer pressure by operating boiler with isolation valves closed.

Result	Y/N	Pressure
Did the LRVE work correctly?		
What was the safety valve relief pressure?		
Maximum allowable economizer pressure?		
What is the re-seat pressure?		
View port in place to view water flow thru relief valve?		

Comment:

Checklist for Propane Pilot Backup System

-
- Connect and/or align propane system to boiler.
 - Attempt to light boiler FIRING ON FUEL OIL.
-

Result	Y/N
Is system in place and operable?	

Comment:

Checklist for Outside Air Damper Interlock (OADI)

- If OADI exists, close outside air damper and prove that interlock shuts off boiler.
- If OADI does not exist measure fixed air intake area (fixed area required is 1.5 times the total combustion inlet air area for all boilers).

Result	Y/N	Manufacturer
Is there adequate FIXED opening to supply combustion air?		
If there is not adequate fixed opening, is there and OADI?		
If OADI exists, did it work?		

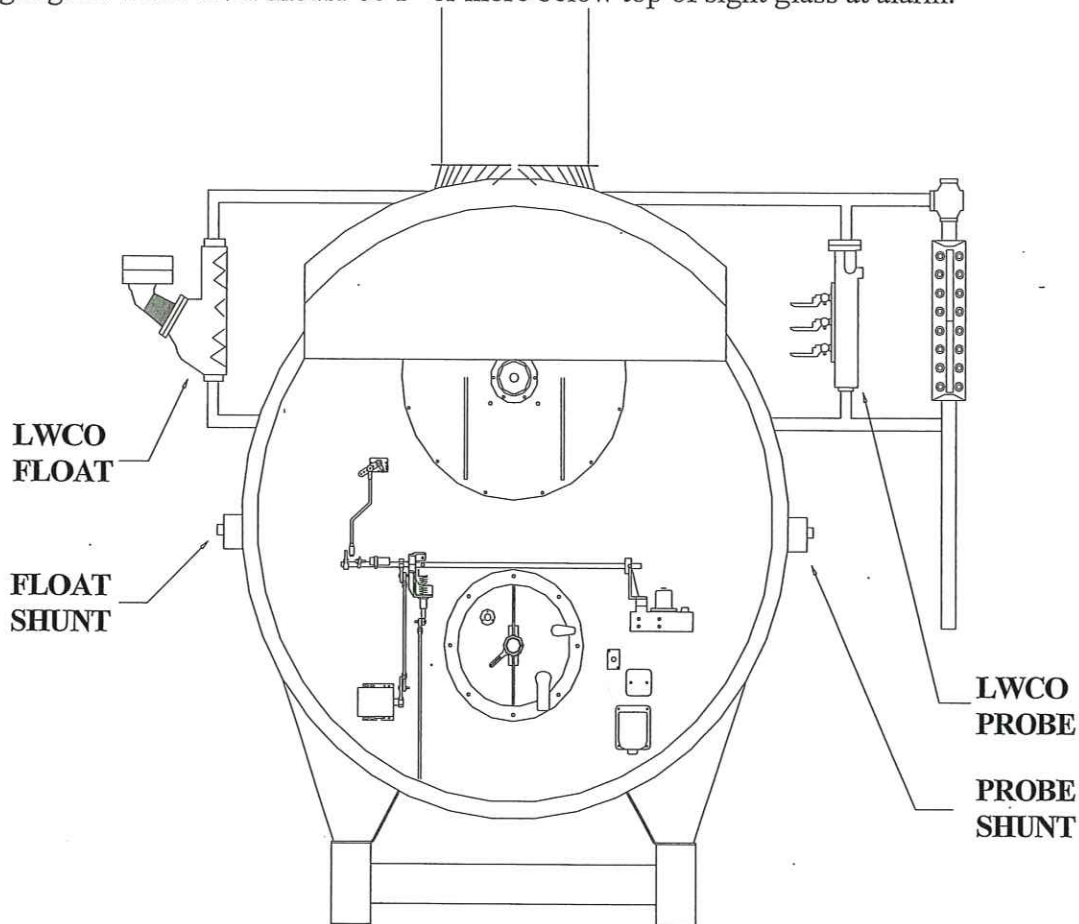
*Fixed intake area should be 1.5 times intake area for all boilers.

Comment:

Checklist for High Water Alarm on Boiler (HWAB)

Item	Make	Float / Probe	Correct Installation
HWA			

*Sight glass water level should be 1" or more below top of sight glass at alarm.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- With boiler off, open the bypass feedwater valve to fill the boiler. Use water level in sight glass to observe alarm point. The alarm should sound before water level leaves sight glass. **DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS**
- Close the bypass on feedwater line

Result	Y/N	Water Level
Did the alarm work correctly?		
What was the water level in sight glass at alarm point?		

Comment:

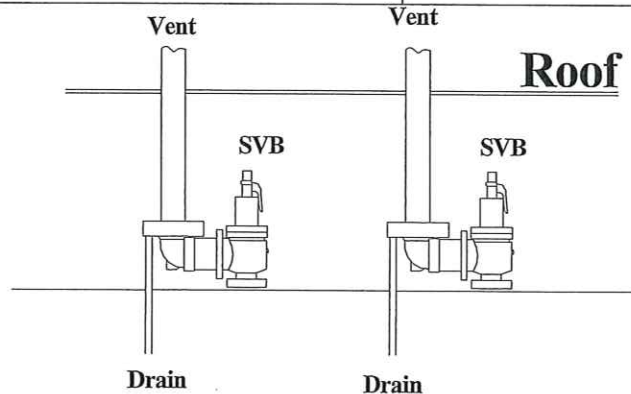
Checklist for Steam Safety Valves on Boiler (SVB)

Item	Make	Capacity (Lb/hr)	Range	SVB Setpoint	Normal Steam Pressure	Correct Installation / Capacity
SVB 1						
SVB 2						
SVB 3						
Pressure Gage						

*SVB1 should be set 5 psig higher than NRBSPLS & 10 psig below boiler MAWP.

*SVB2 should be set 5 psig or higher than SVB1 & 5 psig or more below boiler MAWP.

Item	MAWP (psig)	Capacity (lb/hr)
Boiler		



- NEVER ALLOW BOILER PRESSURE TO EXCEED MAWP
- With boiler off, jumper recycle and non-recycle steam pressure switches.
- Close the steam supply valves from the boiler and test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely. Unstop drains before proceeding.
- Raise the steam pressure slowly by firing the boiler at low fire.
- Note the pressure that the first & second safety valve opened. (may require increasing firing rate).
- Place boiler in high fire and determine if steam pressure rises with both SVB open.
- Shut boiler off and note the pressure that the safety valves close.

Result	Y/N	Lift (P)	Reseat (P)
Did the first SVB correctly? Record Pressure.			
Did the second SVB work correctly? Record Pressure.			
Did the third SVB work correctly? Record Pressure.			
Maximum pressure observed during accumulation test?			
Is SVB vent plumbing adequate?			

*Max lift pressure of 3% higher than rated lift pressure. Blowdown should be less than the greater of 2 psig or 2% of the set pressure, and shall not exceed 6% of set pressure.

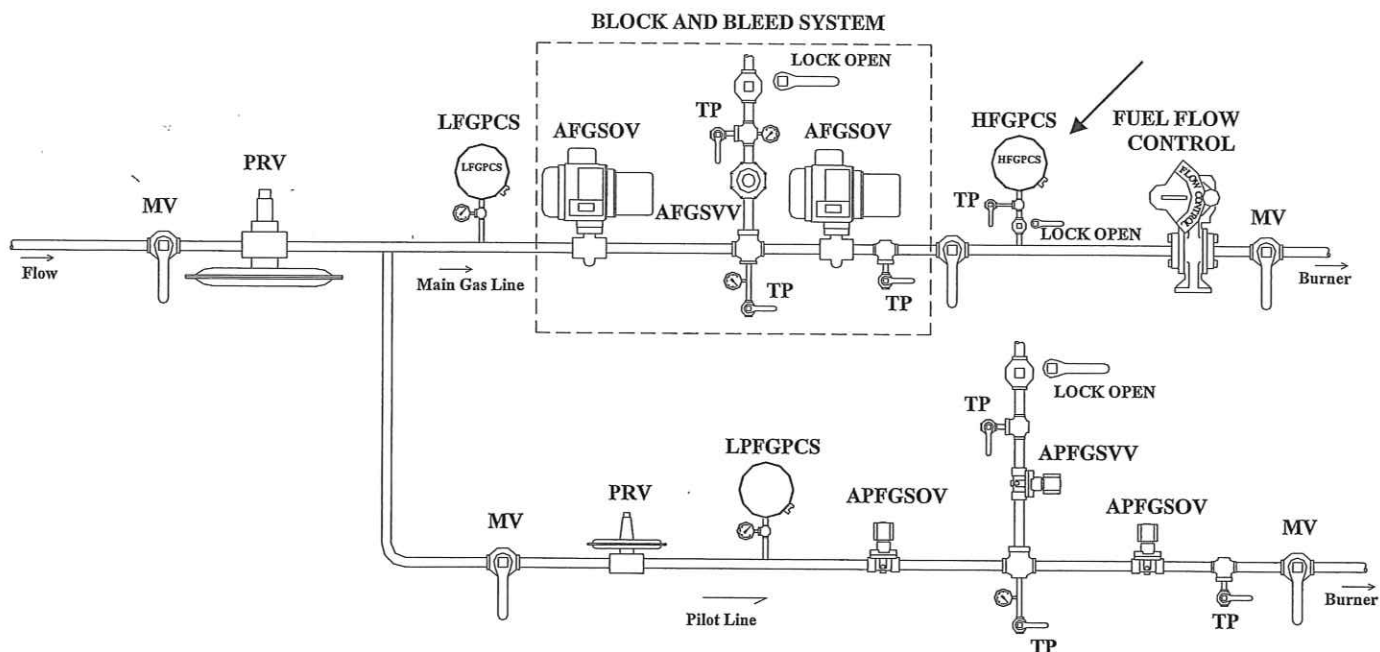
*Maximum accumulation pressure seen should not exceed 110% of highest SVB setpoint and never exceed boiler rated pressure.

Comment:

Checklist for High Fuel Gas Pressure Cutoff Switch (HFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint (inwc/ psig)	Regulated Pressure (inwc/psig)	Correct Location Y / N
HFGPCS					
Pressure Gage					

*HFGPCS must be downstream of PRV and upstream of flow control with a setpoint of less than 120% of regulated pressure.



- With boiler in low fire close lockable manual valve isolating the HFGPCS.
- Open test port between lockable manual valve and HFGPCS and pressurize with compressed air or nitrogen.
- Slowly raise pressure until switch trips boiler offline due to high test gas pressure, BUT NO HIGHER THAN 120% OF REGULATED PRESSURE.

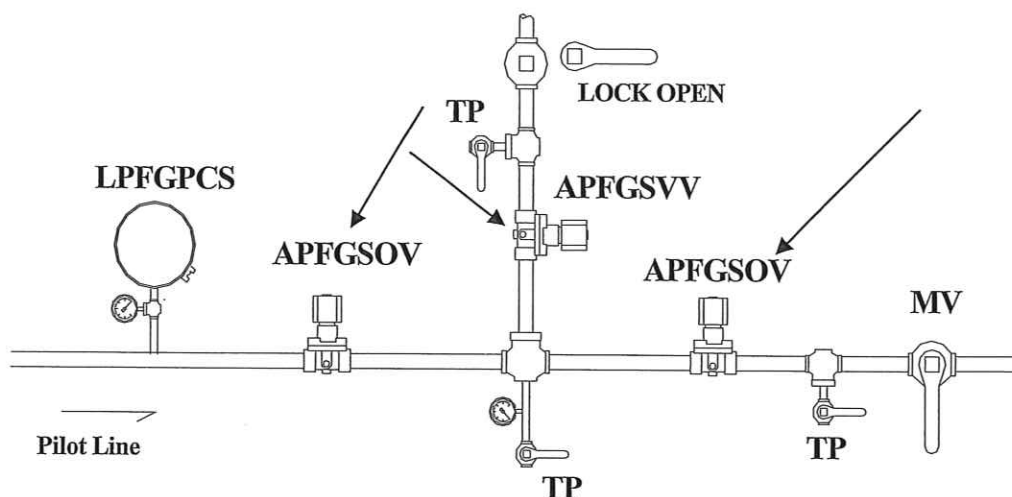
Result	Y/N	Switch Trip Point
Did the switch work correctly?		
Are manual test valves and test port valves in place as shown?		
What was the switch trip point?		
Is switch trip point 120% or less of regulated pressure?		

Comment:

Checklist for Automatic Pilot Fuel Gas Shutoff Valves and Automatic Pilot Fuel Gas Solenoid Vent Valve Seat Leakage (APFGSOV & APFGSVV) – Pilot Line

Item	Make	Range (inwc/PSIG)	Correct Installation Y/N
APFGSOV			
APFGSVV			
Pressure Gage			

*Maximum allowable leak rate is zero bubbles in 2 minutes.



- Verify all test port valves are closed and manual valve in vent line is open. Connect flexible tubing to the 3 test ports as shown.
- The test utilizes placing the flex line no more than ¼ inch in water. This test can be accelerated by pressurizing the flex line before submerging in water.
- With the boiler in low fire, close manual lockable valve in vent line and open test port valve in vent line. Verify that no bubbles appear.
- Provide regulated gas pressure (or more) before upstream APFGSOV and between APFGSOVs.
- Using the two test ports in the main gas line and the test port in the vent line, open the test port valves and observe water for sign of bubbles for 2 minutes.
- If no bubbles appear, the respective valve is not leaking.
- Open and lock manual vent valve and shut boiler off and verify that the pressure between APFGSOV is atmospheric.

Result	Y/N
Did upstream APFGSOV leak?	
Did downstream APFGSOV leak?	
Did APFGSVV leak?	
Did APFGSVV open with boiler off	

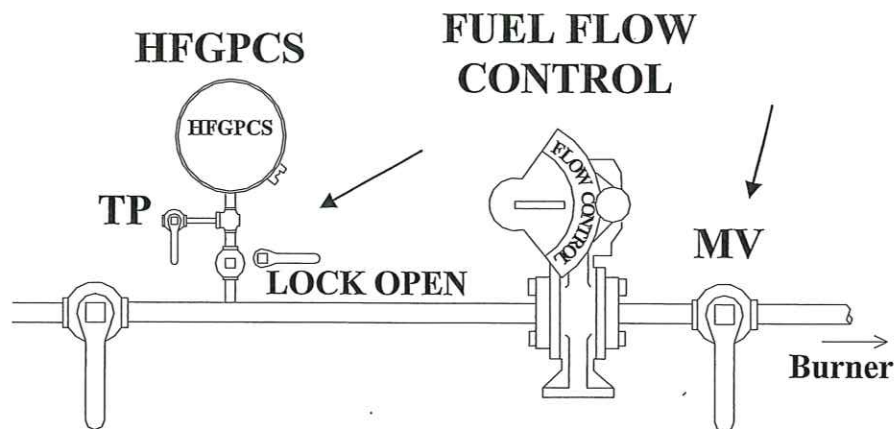
Comment:

Checklist for Flame Scanner-for main flame out (FSMFO)

Item	Make	Model	UV or IR	Self-Checking Y/N	Correct Scanner Y/N
Flame Scanner				-	

*Maximum allowable timing is 4 sec.

*Only a UV- Self checking scanner is allowed. If scanner is IR, system must be replaced.



- Close the lockable manual valve between the fuel line and the HFGPCS.
- Quickly close the manual valve in fuel line before burner.
- Observe the time required for the flame scanner to close the automatic fuel safety shutoff valves. (Valves should close within 3 to 4 seconds from the time the flame goes out in the firebox).

Result	Y/N	Time (seconds)
Did the scanner work correctly?		
Time to close fuel valves?		

Comment:

Checklist for Igniter Timing (IT)

Item	Make	Model
Programmer		

* Maximum allowable duration is 10 sec.

-
- Close manual valves in main fuel line and pilot gas line.
 - Start boiler.
 - View igniter by means of furnace front or back view port and time the ignition spark. (You can hear the igniter click on and off so that it may not be necessary to view the spark if not easily visible).
 - Observe the duration of the ignition spark with a stop watch.

Result	Y/N	Time (seconds)
Did the scanner work correctly?		
Igniter timing?		

Comment:

Checklist for Pre-Purge and Post-Purge Timing (PPT)

Item	Make	Model	Adjustable Timing Y/N
Purge Timer			

Boiler make	Fire Tube / Water tube	Boiler Fireside Volume (ft ³)

* Eight air changes are required for a water tube boiler and 4 air changes for a fire tube boiler.

-
- Begin firing boiler and record the pre-purge time in the table below.
 - Repeat this step for post purge cycle.
-

Result	Time (sec)	Y/N
Low fire to high fire?		
Time in high fire?		
High fire to low fire?		
Time in post purge?		
Equivalent High Purge Time?		
Is purge adequate?		

*Equivalent purge is all time spent at high fire plus half of the time spent in getting to high fire and returning to low fire.

Comment:

Checklist for Forced Draft Damper Wide-Open Pre-Purge Proving Switch (FDDWOPS)

Item	Make	Model
FDDWOPS		

* Must be open at positions lower than 90% of wide open (damper vanes).

-
- Measure the voltage across the switch during the purge cycle to determine if the switch is open or closed. Note load that switch closes.
 - Disconnect one electrical lead from switch. Let boiler go through purge cycle. (Boiler should stay at high purge).

Result	Y/N	Load that switch closes.
Did the switch work correctly?		

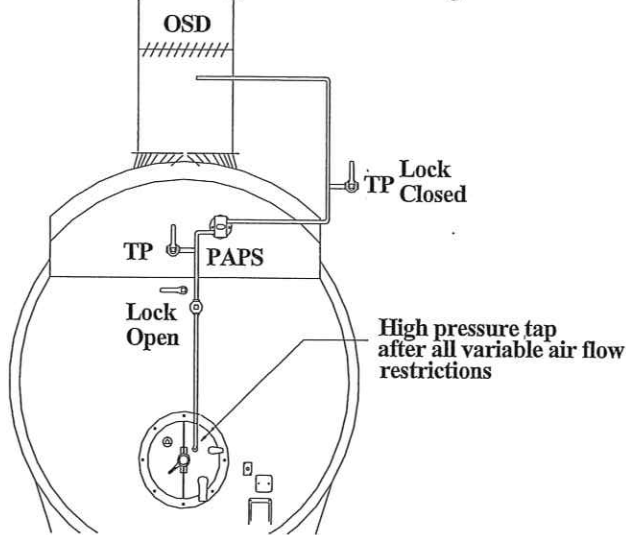
Comment:

Checklist for Purge Airflow Proving Switch (PAPS)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
PAPS					

*Should make at 80% maximum pressure signal.

* If the switch senses the correct pressure difference, the variation in pressure difference at low fire will be small and at high fire will be large.



- Connect a manometer to measure the pressure difference that the switch senses by opening the test ports across the switch and installing appropriate flex tubing to the manometer from the test ports.
- Start the boiler and record the pressure difference indicated by manometer from low fire to high fire positions.
- With boiler offline disconnect one lead from the PAPS.
- Close lock open valve and slowly pressurize the high pressure leg with air. Determine switch trip point using a manometer and measuring electrical resistance across the switch.
- With lock open valve open and high pressure leg test port open attempt to restart boiler. Boiler should hold in purge.
- Open lock open valve and close test port. Boiler should light.

Firing Rate	Pressure Difference	Maximum Pressure Difference (inwc)	Switch Trip (Make) Point (inwc)
Low			
Med			
High			

Result	Y/N	Switch Trip (Make) point (inwc)
Did the switch work correctly?		

Comment:

Checklist for Outlet Stack Damper Interlock Switch (OSDI)

Item	Make
OSDI	

*Must be open if dampers are not at least 80% open.

*Not required if damper is welded in the wide open position and there are no other potential obstructions.

-
- Connect a multimeter across the switch and measure voltage.
 - Start the boiler and monitor voltage across the switch. The switch should be open (no voltage) until the damper opens to wide open position.
 - Stop boiler and turn off power to controls.
 - Disconnect one lead from switch.
 - Start boiler. The boiler should not complete purge sequence.

Result	Y/N
Did the switch work correctly?	

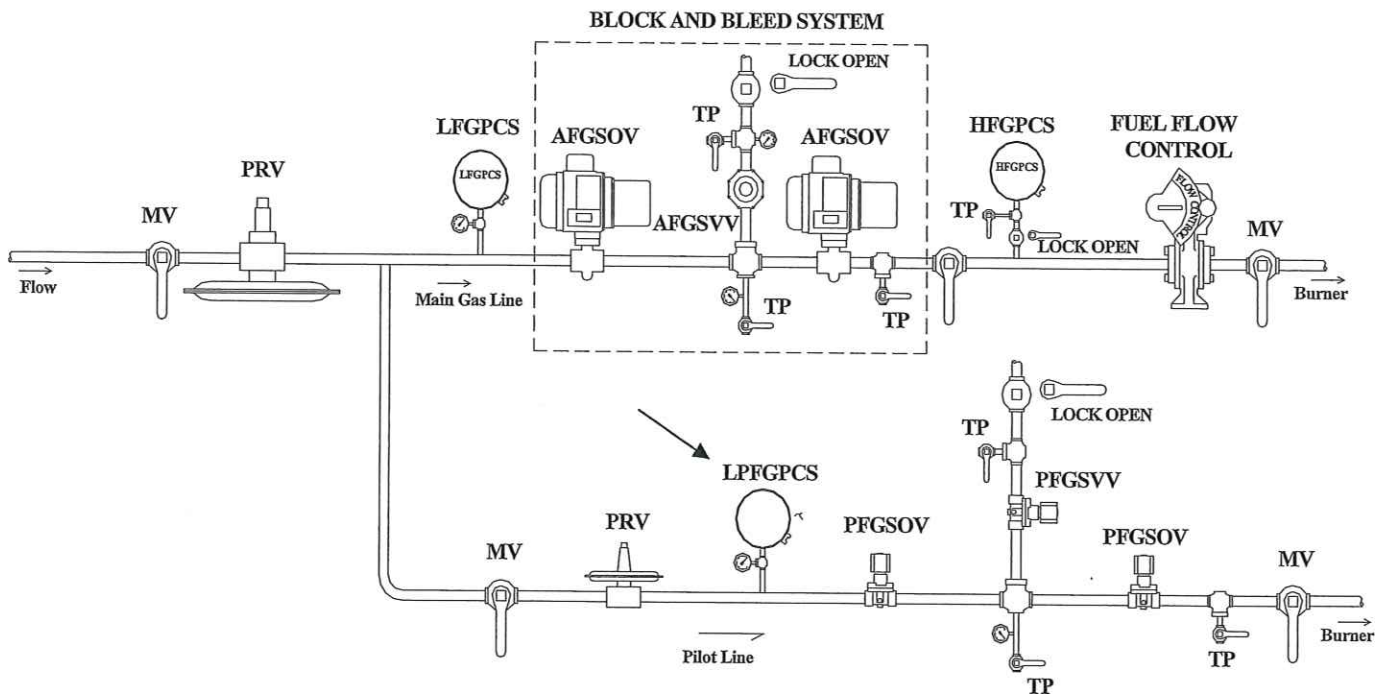
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Comment:

Checklist for Low Pilot Fuel Gas Pressure Cutoff Switch (LPFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
LPFGPCS					
Pressure Gage					

*Switch setpoint should be 80% of regulated pressure.



- Close the main fuel valve and allow the pilot burner to light and place programmer in check mode while holding in the pilot cycle.
- In low fire throttle manual valve upstream of the LPFGPCS slowly until switch trips the boiler offline due to low pilot fuel pressure.
- Open the pilot gas valve and again put boiler in check mode with pilot lit. Slowly close the pilot gas valve and regulate the pilot gas pressure to a value just above the trip point.
- Open the main gas valve, place the programmer in the "run" mode, and carefully observe that the main burner ignites immediately and smoothly.
- Be prepared to stop the burner immediately if this does not occur.

Result	Y/N	Switch Trip point
Did the boiler light smoothly with low pilot gas pressure?		

Comment:

Checklist for Low Flue Gas Oxygen Level Interlock (LFGOLI)

Item	Make	Alarm or Interlock
LFGOLI		

*Low oxygen alarm only is inadequate and should be replaced with interlock and alarm.

*Interlock should prevent boiler from operating with more than 200 ppm CO or combustibles in the flue gas.

- Measure the property values listed in the table below.

% Load	Steam P (psig)	O ₂ (%)	CO (ppm)	EFF (%)	T-Stack	NO _x	Economizer Temp IN OUT	
Low								
Med								
High								

- Use an flue gas analyzer to measure % O₂ and CO with the boiler at approximately 30% load.
- Slowly block the boiler air intake or increase fuel without increasing air. USE EXTREME CARE NOT TO CREATE A DANGEROUS CONDITION. NEVER ALLOW THE CO CONTENT OF FLUE GAS TO EXCEED 200 PPM!

Item	O ₂ % where interlock activated	CO (ppm) where interlock activates
LFGOLI		

Result	Y/N
Did the interlock work correctly?	
Did the LFGOLI activate with less than 200 ppm of CO?	

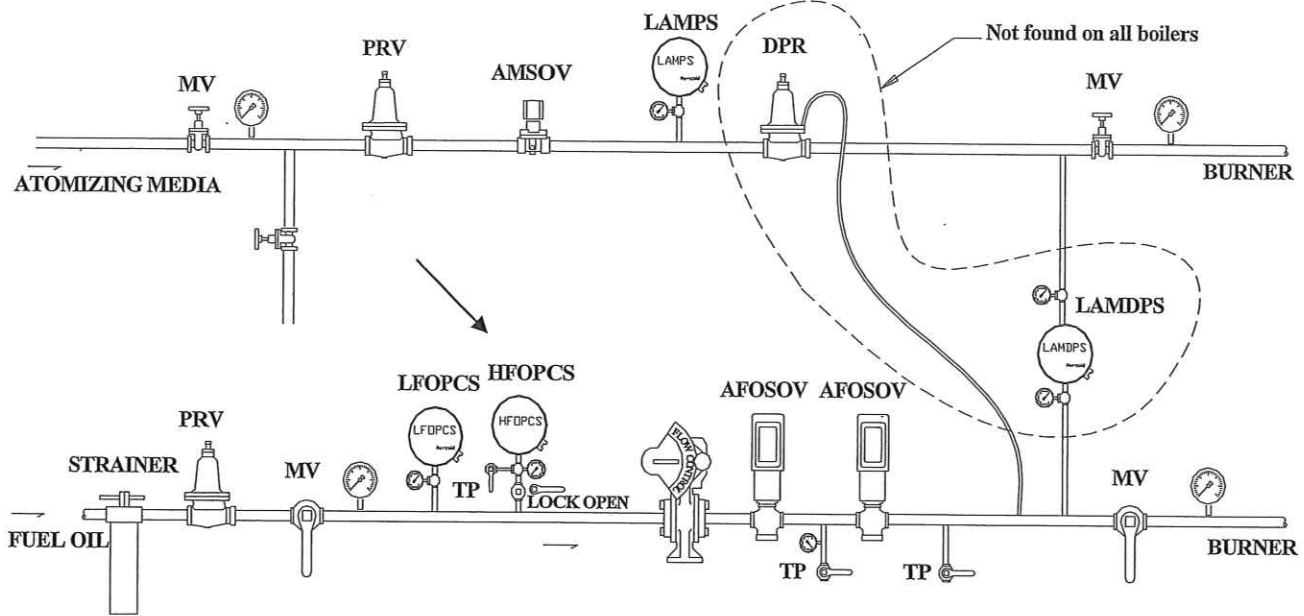
Comment:

Checklist for High Fuel Oil Pressure Cutoff Switch (HFOPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure	Correct Location Y/N
HFOPCS					
Pressure Gage					

*The HFOPCS location must be downstream of PRV and upstream of flow control valve.

*Trip point of HFOPCS should be equal to or less than 110% of regulated pressure.



- With boiler in low fire close lock open manual valve isolating the HFOPCS.
- Open test port between lockable manual valve and HFOPCS; pressurize switch with compressed air or nitrogen.
- Slowly raise pressure until switch trips boiler offline due to high fuel pressure.

Result	Y/N	Switch Trip Point
Did the switch work correctly?		
Is switch setpoint 110% or less of regulated pressure?		

Comment:

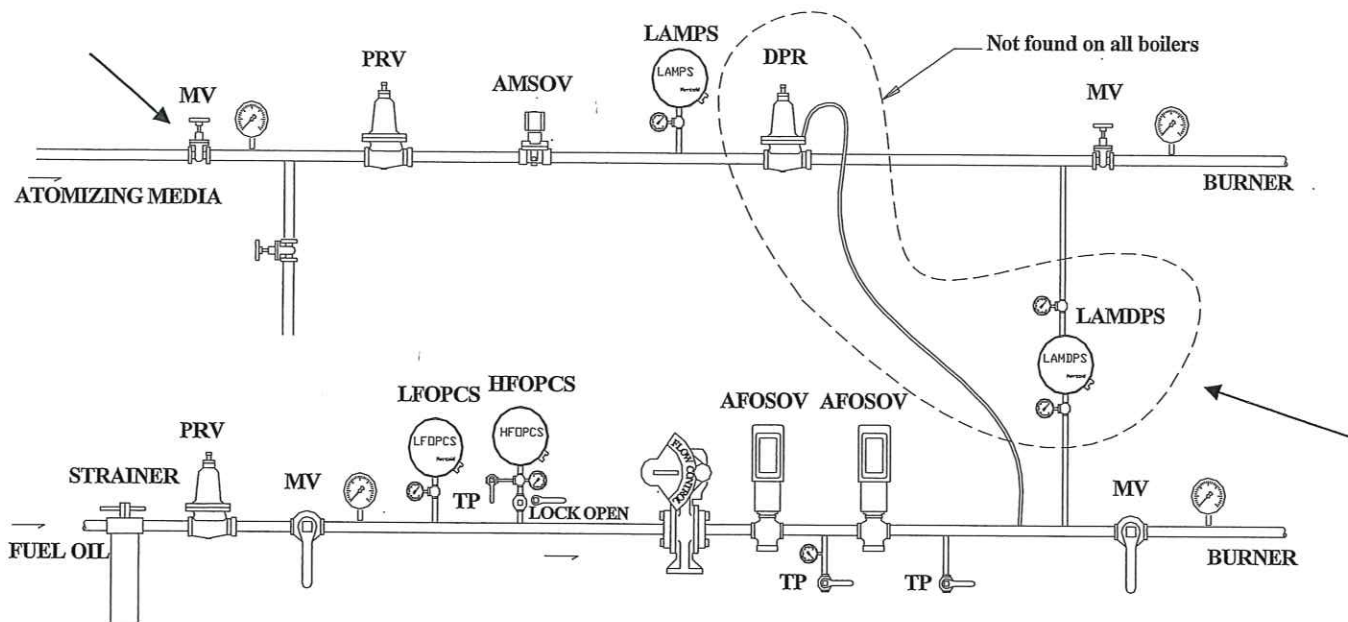
Checklist for Low Atomizing Media Differential Pressure Switch (LAMDPS)

Item	Make	Range (inwc/PSIG)	Switch Setpoint	Minimum Diff Pressure	Correct Location Y/N
LAMDPS					
Pressure Gage Fuel Oil Burner					
Pressure Gage Atomizing media					

*This switch is not required if oil pressure exceeds atomizing pressure at any firing rate.

*For this case the LOLI is the only protection against inadequate atomizing media.

*Setpoint should be 80% or more of minimum differential pressure between oil and atomizing media.



- Determine the minimum differential pressure from data table in LAMPS checklist and record in above table.
- In low fire throttle manual valve in atomizing media line before the LAMDPS slowly until switch trips the boiler offline due to low differential pressure but NO LOWER THAN 80% OF MINIMUM ATOMIZING MEDIA DIFFERENTIAL PRESSURE.

Result	Y/N	Switch Trip point
Did the switch work correctly?		

Comment:

Checklist for Proof of Closure on Automatic Fuel Oil Shutoff Valves (POC-AFOSV) – Oil

Item	Make
POC-AFOSV	

*Switch should open with a very slight opening of the valve.

*Switches on the two valves must be wired in series.

-
- Close manual fuel valve downstream of AFOSOV. Perform the following test on each AFOSOV separately.
 - Remove cover on both automatic shut off valves to provide access to two wires connected across proof of closure switch. Can also access wires in appropriate junction box. Disconnect both leads from switch going to control circuit.
 - Temporarily connect the wires disconnected from the POC switch in order to bypass the switch.
 - Start boiler and verify that switch opens with a very slight opening of the valve by measuring resistance across switch.
 - Shut boiler down and disconnect two wires going to control circuit. Try to start boiler and verify that the boiler does not allow ignition sequence to begin.
 - Repeat procedure for switch on 2nd valve.

Result	Y/N
Is proof of closure present in both valves?	
Did either valve being open allow the boiler to fire?	
Did both switches open with very slight opening of valve?	

Comment:

Checklist for Water Treatment

Sample	TDS ()	Sulfite (ppm)	Phosphate (ppm)	()-Alk (ppm)	Hardness (ppm)	pH
Boiler						
Feedwater						
Condensate						
Makeup						

$$\% \text{Makeup} = \frac{\text{Conductivity of Feedwater} - \text{Conductivity of Condensate}}{\text{Conductivity of MU} - \text{Conductivity of Condensate}} * 100$$

$$\% \text{Blowdown} = \frac{\text{Conductivity of Feedwater}}{\text{Conductivity of Boiler} - \text{Conductivity of Feedwater}} * 100$$

Not applicable. No changes to this portion of the system not in the project scope of work.

Sign In Sheet

<u>PRINT</u> Name	VA Location