SECTION 15557 - SCOTCH MARINE PACKAGED BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Specifications, apply to this section.
B. Basic Mechanical Materials and Methods sections apply to this section when so designed in the applicable contract documents.

1.2 SUMMARY:

A. This specification applies to packaged, factory-assembled and tested, firetube steam boilers, trim, and accessories.
B. Related Sections:
   1) Section 15030: Electrical Provisions for Mechanical Work.
   2) Section 15570: Boiler Accessories.
   3) Section 15575: Breechings, Chimneys, and Stacks.
   4) Section 15580: Feedwater Equipment.
   5) Section 15586: Boiler Water Treatment System.
   6) Section 15642: Deaerators.

1.3 SUBMITTALS:

A. Product Data - Manufacturer's technical data shall be presented prior to start of fabrication in an organized and bound submittal and shall include the following:
   1) Boiler:
      a. Product General Arrangement Drawing.
      b. Rated capacities of selected models.
      c. Product dimensions including required clearances.
      d. Unit weights (shipping and operating).
      e. Customer Order Data Sheet confirming job site conditions and requirements.
   2) Boiler Controls, Trim, & Instrumentation:
      b. Instrument & Electrical symbols legends.
      c. Drawing Index.
      d. Bills of Materials listing manufacturer, models, and quantity of supplied components.
      e. Control Panel Layout Drawings.
      f. Panel Controls and Indicators Layout Drawing.
      g. Ladder Diagram type wiring schematics.
      h. Wiring schematic drawing index and symbols legend.
   3) Accessories and Custom Components:
      a. General arrangement or component drawing.
      b. Component Data Sheet.
      c. Panel layout drawing (when applicable).
      d. Wiring Diagram (when applicable).

B. Operating & Maintenance Instructions - O & M manuals shall be compiled in an organized and bound volume and submitted prior to commissioning of the equipment. The manuals shall include the following:
   1) Pre-commissioning installation, checks, and adjustment instructions.
   2) Step by step commissioning instructions.
   3) Step by step unit normal start-up instructions.
4) Step by step normal operating instructions.
5) Step by step normal shutdown instructions.
6) Step by step emergency shutdown instructions.
7) Trouble shooting guide and instructions.
8) Maintenance data for components and system.
9) Preventative maintenance schedules or recommendations.
10) Lubrication schedules and specifications for applicable components.
11) Vendor data or “cut sheets” on major components.
12) Boiler General Arrangement Drawing.
14) Piping and Instrument symbols legend.
15) Control panel layout drawing.
16) Instrument & Electrical component bill of material.
17) Copy of ASME P-2, P-4, P-6, P-7, and U1A forms, where applicable.
18) Copy of CSD-1 data sheet, where applicable.
19) Recommended spare or replacement parts lists.

C. Factory Test Report: Submit a factory test fire report covering testing of the boiler on all fuels that will be used in the field. Test report is to include the following:
1) Data on each fuel fired at minimum, 50%, and 100% of rated capacity:
   a. Fuel input or flow rate in BTU/hr and volumetric measurement corrected to STP.
   b. Flue oxygen levels or percent excess air.
   c. Flue carbon monoxide content expressed in PPMVD.
   d. Flue Nox expressed in PPMVD corrected to 3% flue O2 content.
   e. Boiler steam pressure or water temperature.
   f. Flue outlet gas temperature (stack).
   g. Fuel supply pressure.
   h. Fuel regulated pressure.
   i. Fuel manifold or nozzle pressure.
   j. Atomizing media pressure (when applicable).
   k. Flame monitor signal strength on pilot.
   l. Flame monitor signal strength on primary fuel(s).
   m. Furnace pressure measured at the distal end of the furnace tube.
   n. Combustion air static pressure profile.
   o. Other data or information as applicable.
   p. Name, signature, and date of each tester certifying the accuracy of the results.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications:
1) Firms must be regularly engaged in the manufacture of scotch marine boilers of types and capacities required. The firms' products must have been in satisfactory use in similar service for not less than 10 years.
2) The firm must have a written Quality Control manual and program which is currently maintained and includes the following information:
   a. Authority and Responsibility for content and implementation of the QC program.
   b. Company organization and individual authority and responsibility for each phase of the QC program’s operation.
   c. Sales order entry requirements, documentation, and control.
   d. Design criterion requirements, documentation, and control.
   e. Drawing requirements, documentation, and control.
   f. Calculation requirements, documentation, and control.
   g. Fabrication specifications, requirements, documentation, and control.
   h. Material procurement requirements, documentation, and control.
   i. Material handling and storage requirements, documentation, and control.
   j. In-process inspection and examination program.
   k. Non-conformity identification and correction program.
   l. Welding process and qualification control.
m. Non-destructive examination program.

n. Heat treatment requirements, documentation, and control.

o. Calibration program for test, measurement, and production equipment.

p. Record requirements and retention.

q. Third party inspection program.

3) The firm must establish individual qualifications for each person engaged in welding and establish and maintain the following:

a. Weld standards and procedures for each identified manufacturing process.

b. Tests to qualify each individual for any weld process employed in his job responsibilities.

c. Accredited on-site welding instruction and testing facility to train and certify welding personnel.

B. Codes and Standards:

1) Boiler testing and rating will be in accordance with American Boiler Manufacturer's Association (ABMA) "Packaged Firetube Rating".

2) Minimum steady-state efficiency of boilers will not be less than prescribed by ASHRAE 90A "Energy Conservation In New Building Design".

3) High pressure boiler construction will be in accordance with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Pressure vessels shall bear the appropriate ASME stamp.


5) Gas Fired-boiler installations shall be in accordance with National Fire Protection Association (NFPA) Code 54 "National Fuel Gas Code".

6) Ancillary electrical components shall be Underwriters Laboratories (UL) listed and labeled.

7) The complete boiler package is to be designed and fabricated per UL guidelines.

8) Instrument and piping drawings and electrical drawings are to use symbology and protocol established and defined by the Instrument Society of America (ISA).

9) The installation shall be in accordance with ASME CSD-1.

10) The installation shall be in accordance with NFPA 8501 when so designated in the applicable contract documents.

11) The installation shall be in accordance with Factory Mutual (FM) requirements when so designated in the applicable contract documents.

12) The installation shall be in accordance with local codes and other guidelines and requirements when specifically delineated in applicable contract documents.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Packaged boiler critical envelope dimensions shall be provided to allow review for clearances prior to transport or insertion into restricted spaces.

B. Exposed electrical components that may be subject to transportation damage due to ambient exposure shall be wrapped and isolated with appropriate elastomeric or weatherproofing material at the factory.

C. Exposed physical utility connections (flanges, pipe ends, etc.) shall be isolated for transport from ambient influences with appropriate blinds, caps, or weatherproofing materials.

D. Manufacturer shall provide lifting lugs at points of crane or lift attachment. Lifting load (weight) shall be provided by the manufacturer.

E. Manufacturer shall make available, if specified in the contract documents, "push pads" or "jack pads" to facilitate installation or handling.

F. Water shall be drained from all water storage areas, piping systems, valves, and components prior to shipment.

PART 2 PRODUCTS

2.1 MANUFACTURERS :

A. Available Manufacturers: Approved packaged firetube boiler manufacturers must be subject to and in compliance with this specification and other applicable contract requirements. Approved manufacturers include the following:

Johnston Boiler Co. - Ferrysburg, Michigan
Other boiler manufacturers must be approved in writing prior to the bid due date.

2.2  PACKAGED FIRETUBE BOILER

A. Steam Boiler: The selected unit shall be a scotch marine packaged firetube steam boiler. The boiler (pressure vessel), burner, fuel and combustion air delivery systems, burner management systems, electrical control, feedwater, and conditioning systems (where applicable) shall be specifically engineered as a compatible packaged system. The system, boiler, and accessories shall be factory mounted on a heavy steel base frame. Solid supports or saddles should be used to attach and provide placement of the pressure vessel with the frame and package. The system (package) shall be factory assembled and tested. The packaged unit shall be designed to be transported and installed with a minimum of field assembly required.

B. General Boiler Specifications: The boiler shall be designed to provide reliable and consistent performance to the following operating parameters:

1) Boiler shall have a nominal rated capacity of _____ Boiler Horse Power.
2) Boiler shall have a maximum output of _____ lb/hr of steam at 212 degrees F.
3) Boiler shall have a design pressure of _____psig.
4) Boiler and controls shall be designed for a working pressure of _____ psig.
5) Steam shall be 99.5% dry and saturated.
6) Boiler shall provide a minimum fuel to steam efficiency of _____% at maximum output. (Efficiency shall be calculated as prescribed under “Heat Loss Efficiency” of the ASME Power Test Code PTC4.1).
7) Burner shall provide a minimum fuel combustion efficiency of 99.9%.

C. General Boiler Design: The packaged firetube boiler shall be designed with the following features to provide optimized efficiency and unit life:

1) “Four pass” heated gas contact configuration.
2) Horizontal firetube orientation.
3) The boiler shall be of the “water back” design.
4) The boiler shall have a minimum of five (5) square feet of heat transfer surface per rated boiler horsepower, measured on the fireside (ASME method calculation).
5) The boiler package shall be complete with integral forced draft burner manufactured for that boiler.
6) The boiler shall utilize the Prosser technique for mechanical tube to tubesheet connections.
7) The boiler shall be designed with front and rear observation ports.

2.3  BOILER SPECIFICATIONS

A. Boiler (pressure vessel): The boilers shall be a four-pass waterback Scotch Marine type listed and rated by the American Boiler Manufacturers Association, Firetube Section. The boiler will be designed and built to comply with the latest ASME Code Rules for _____ lbs per square inch working pressure and be inspected and stamped by an authorized boiler inspector. The boiler design shall include the following:

1) The combustion chamber shall be fully submerged within the boiler water.
2) The boilers shall have two separate rear tube sheets.
3) The boilers shall have tubes attached by prossering, roller expanding, and beading.
4) High pressure boilers (=300 psi) shall have welded tube connections.
5) Connections for bottom blowoffs shall be supplied on both ends of the boiler shell.
6) Openings for trimmings and external connections shall be flanged and/or threaded.
7) A minimum of six (6) hand holes and one manhole for thorough inspection and cleaning shall be provided.
8) The boiler shall be equipped with a steam baffle to ensure steam quality and prevent water carry over.
9) Gas tight inspection doors shall be provided.
10) Boilers must bear ASME Stamp and be inspected under National Board Rules.

B. Front and Rear Flue Doors:

1) The boiler’s front and rear flue doors shall be:
   a. Hinged or davited for easy access and interference clearance.
   b. Sealed with heat resistant gaskets.
   c. Fastened with lugs or threaded studs with nuts and washers.
   d. Designed so that front and rear tube sheets and all flues are accessible for inspection and
cleaning when doors are open.

e. The doors shall be thermally insulated with ceramic fiber blanket insulation.

2) Front and rear flue doors shall carry a full fifteen (15) year parts and labor warranty.

C. Exhaust Gas Vent: Boilers shall have a flanged flue exhaust vent at the top front of the boiler. The vent is to include a 5” diameter stack thermometer and will be designed for convenient connection to flue or stack exhaust equipment provided by others.

D. Insulation and Jacket: The boiler shall be factory insulated around its full circumference with 2” thick fibrous, no asbestos containing, insulation. The insulation shall be held in place by spacer pins welded to the shell and covered by a corrosion resistant galvannealed sheet metal jacket. The jacket will be assembled with lock seam joints. Insulation shall also be provided on the boiler rear head. The jacket shall be designed and arranged to provide adequate support for personnel along the top centerline of the boiler to facilitate installation and inspection work.

E. Boiler Trim: The boiler shall include the following control and accessory equipment (trim):

1) Water Column complete with try cocks, chain operated gauge glass set, red line gauge glass, and water column blowdown valve.

2) Feedwater Pump Control will be an integral part of the water column. The control will be selected to automatically actuate a motor driven feedwater pump to maintain boiler water level within normal limits.

3) Low Water Cutoff shall be an integral part of the water column. The LWCO shall be factory installed and wired into burner control circuits to prevent burner operation if water level falls below safe operating limits.

4) Auxiliary Low Water Cutoff, if specified in contract documents, will be supplied. The ALWCO will be a second float type or probe type low water cutoff, installed to activate below the primary low water cutoff. Control to be either manual reset type or wired into non-recycle limits of the flame safeguard control.

5) A continuous surface water blowoff connection shall be provided.

6) Bottom blow down valves are to be provided when specified in the applicable contract documents. The blowdown valves will include one/two quick opening and one/two slow opening valve(s) factory mounted and hydro tested on the boiler or as required by code.

7) Feedwater piping will be provided when specified in the contract documents and will include a stop valve and check valve mounted and hydrostatically tested on the boiler. The feedwater piping shall incorporate means for field connection of chemical feed line.

8) Steam Pressure Gauge: Steam pressure gauge shall be located on the front end of the boiler. The gauge installation shall include siphon, shut-off cock and test connection. Gauge range shall suit the specified design pressure.

9) Steam Safety Valves shall be provided in types, sizes and quantities to comply with ASME Code requirements.

10) Steam Pressure Controls will be provided to regulate the burner operation and boiler output and safety. The following controls will be mounted near the water column:

a. One pressure to electrical transducer to provide process control for modulation of burner firing rate.

b. One primary operating pressure switch to sense boiler high steam pressure. The switch will be wired into the burner management system to turn the boiler off in the event steam pressure reaches the set pressure. The switch will be part of the boiler auto recycling limit circuit.

c. One high limit pressure switch, with set point above the primary operating pressure set point and below the boiler design pressure, will be provided. Activation of the switch shall turn boiler off in the event pressure reaches the set pressure. The switch may be manual reset type or wired into the burner safeguard non-recycle circuit.

1) Data Reports: The Manufacturer shall supply two copies of data reports, ASME form P-2, P-4, P-6, and P-7 (when applicable).

F. Burner: The gas and/or light oil burner will be flame retention ring type complete with integrally mounted combustion air blower. The burner and blower will be specifically designed for the boiler and will be built and assembled by the boiler manufacturer. The burner, burner management and safety system, combustion control, and fuel delivery systems shall have the following certifications and features:
1) Standards and Certifications:
   a. The burner system (hereafter referred to as burner) shall be designed, built, and tested to
guidelines established by UL-296 (oil), UL-795 (gas), and/or UL-2096 (emissions reduction
equipment), as applicable.
   b. The burner shall be designed, manufactured, and assembled as an integral portion of the boiler
package by the boiler manufacturer.
   c. The burner shall meet the requirements of CSD-1.
   d. The burner shall meet the requirements of Factory Mutual (FM) if specified in applicable contract
documents.
   e. The burner shall meet the requirements of NFPA-8501 if specified in the applicable contract
documents.

2) Construction:
   a. The burner shall be supplied with an integral packaged combustion air blower.
   b. Burner housing will be rigid and robustly designed with wall thickness of not less than 1/4".
   c. Burner shall be self-supporting for transportation and operation.
   d. Fuel oil pump (when required) shall be integrally mounted on the burner assembly in near
proximity to the burner.
   e. Burner internals shall be readily accessible for adjustment or replacement by utilization of a
hinged assembly.
   f. A burner mounted observation port with optical lens shall be provided.
   g. Burner components shall include stainless steel alloy diffuser assemblies.
   h. External adjustment of burner primary and secondary air will be provided to optimize
performance.
   i. Air flow dampers shall be driven to a closed position with minimal leakage to ensure minimum
heat loss through the boiler during boiler shutdown periods.

3) Gas Operation: The burner shall have the following operating characteristics or capabilities when
firing natural gas:
   a. Full modulation of combustion air and fuel over the entire firing range.
   b. 8:1 fuel turndown on standard operation. 4:1 on Low NOx operation.
   c. Excess air limited to 15% (3% flue gas oxygen).
   d. Carbon monoxide emissions of less than 50 PPMVD over the entire operating range when
specified in contract documents.
   NOx emissions levels of less than 30 PPMVD can be obtained if specified in the applicable contract
documents utilizing recirculated flue gas.

4) Oil Operation (#2 or #4 oils): The burner shall have the following operating characteristics or
capabilities when firing light oils:
   a. Full modulation of combustion air and oil over the entire firing range.
   b. 6:1 fuel turndown.
   c. Excess air limited to 20% (4% flue gas oxygen).
   d. Carbon monoxide emissions of less than 50 PPMVD over the entire operating range when
specified in contract documents.
   e. Manufacturer to supply, on request, anticipated NOX levels based on specific fuel oil fuel bound
nitrogen content.
   f. Atomizing air compressor (when required) will be integrally mounted on the boiler base in near
proximity to the burner.

5) Oil Operation (#6 oil): The burner shall have the following operating characteristics or capabilities
when firing heavy oil:
   a. All items specified in Oil Operation, #2 or #4 oils, in Section 2.3.F.4 and .9.
   b. Heavy oil electric trim heater capable of 50 °F temperature rise to provide “fine tuning” of supplied
oil temperature.
   c. Oil recirculation loop to allow supply system “warm up” prior to operation.

6) Accessories and Components: The gas, light oil, or gas and light oil burner shall include the following
accessories or components:
   a. Differential air pressure switch for proof of air flow.
b. Gas Pilot of the fuel/air premix type with automatic electric ignition. The unit will be complete with an electronic detector to monitor pilot so that the primary fuel valve cannot open until the pilot flame has been established.

c. Pilot train is to include:
   1. Pilot electrically actuated solenoid valve.
   2. Pilot gas pressure regulator.
   4. Pilot gas pressure gauge.

7) Combustion Control: The burner shall include a combustion control system to maintain fuel and combustion air ratios at pre-determined rates for optimum efficiency. The Combustion control system shall be fully integrated into the flame safeguard or burner management system. Features shall include:

a. The combustion control system shall provide load control over the entire operating range of the boiler.

b. Boiler operation will be maintained to within 3% of set point when operating at or below stated operating output rates.

c. The system shall have the capability of custom characterizing or matching desired fuel and combustion air ratios throughout the operating range.

d. Each fuel will be independently characterizable.

e. The burner fuel characterization devices shall be provided with externally mounted position indicators.

f. Assured low fire position shutdown on standard (non-safety interlock) shutdowns will be provided.

g. Additional combustion system capabilities will be described in detail in item 10. below.

8) Burner Gas Piping: The gas delivery system supplied with and to the burner shall be delivered completely assembled and installed with the packaged boiler. The gas piping system shall be designed to deliver the required fuel flow rates and pressures to the burner with the supply gas composition and characteristics defined in the packaged boiler quotation or specifications. The gas pipe train shall include as a minimum the following:


b. Characterized gas flow control valve.

c. Main gas shut off valves, electrically actuated, with proof-of-closure switch.

d. Normally open electrically actuated gas vent valve.

e. Main gas shut off manual hand valve.

f. Main gas pressure regulator designed for _____ psig gas supply pressure when specified in contract documents.

g. High and low gas pressure switches.

9) Burner Light Oil Piping: The oil delivery system supplied with and to the burner shall be delivered completely assembled and installed with the packaged boiler. The oil piping system shall be designed to deliver the required fuel flow rates and pressures to the burner with the supply oil composition and characteristics defined in the packaged boiler quotation or specifications. Supply oil pressure to the burner supplied piping and fuel pump system shall be at the flow rates desired at pressures between -15 in wc to 25 psig. The oil pipe train shall include as a minimum the following:

a. Oil shut off manual hand valve.

b. Inlet fuel oil strainer.

c. Characterized fuel oil flow control valve.

d. Main oil safety shut off valves, electrically actuated, with proof-of-closure switch.

e. Main oil shut off manual hand valve.

f. Main oil recirculating piping connection.

g. Low oil pressure switch.

h. Oil pump.

10) Control Panel and Wiring: The control panel shall incorporate the following features and components:
A. Quality Assurance

1) Acceptable suppliers: The combustion system including: the fired equipment control and flame safeguard systems, transmitters, controls valves, and actuators shall be furnished by a single supplier who is regularly engaged in boiler room boiler installation and upgrade control projects. The same manufacturer shall design the system and provide start-up and training services. The combustion system supplier must accept sole source responsibility for system design, manufacture and start-up. The fired equipment control and flame safeguard systems shall be manufactured and supported in the United States.

2) Combustion system manufacturer qualifications: In order to assure a quality project, the combustion system manufacturer shall have the following qualifications:
   a. Manufacturer must be an established burner supplier with similar control projects and shall include a reference list with submittals.
   b. Manufacturer shall have a minimum of (10) combustion control engineers and (5) instrument technicians able to provide field service.
   c. Manufacturer shall have fully operational CAD capability, including the ability to create drawings in AutoCAD 2004 format, if required.

3) Control System Supplier Certification: The control cabinet(s), panel(s) and all the instrumentation shall be supplied by a single Original Equipment Manufacturer (OEM). The only control equipment that will be acceptable shall be provided by a controls OEM that has employees who manufacturer, design, start up and service control systems of this nature throughout the United States. Proof of manufacturing and starting up a system of this magnitude and nature within the last five years must be supplied. The boiler control and burner management systems shall be U.L. recognized for use in the U.S. and Canada. Simply supplying individual UL recognized components is not sufficient. The assembled control cabinet as a whole must be inspected for proper wiring methods, fusing, etc., and must be labeled as conforming to UL 508A. Inspection and labeling shall be supervised by a UL, FM, ETL or other OSHA approved Nationally Recognized Test Lab (NRTL). The system shall be designed to ensure the safe start-up, on-line operation and shutdown of fuel firing equipment. The system shall comply with NFPA 85. Per NFPA 85 “1.9.3.2.3 Requirement for Independence,” the flame safeguard system shall be provided with independent logic and power supplies and shall be physically separated from the combustion control logic.

4) Combustion System Supplier
   The complete combustion system shall be supplied by Preferred Utilities Manufacturing Corporation of Danbury, CT.

5) Submittals: The combustion system supplier shall provide the following submittals:
   a. Boiler Control Configuration Diagrams
   b. Flame Safeguard Functional Chart Diagrams
   c. Cabinet Outline Diagrams
   d. Bill of materials with cross-reference to cut sheets and drawings.
   e. Cabinet Internal Wiring Diagrams
   f. Catalog cuts and instructions of all instruments, controls and accessories.

2.5 BURNER/BOILER CONTROL SYSTEM REQUIREMENTS

1) General Requirements:
   A Parallel Positioning Combustion Control System with Oxygen Trim and (optional) VSD shall be provided. The system shall be designed to provide continuous operation within design limits with a high level of safety and the lowest cost of fuel. As required the system shall provide continuous process control of steam pressure and drum level. The system shall be fully integrated to the burner management system to provide fully automatic, safe and reliable startup and shutdown.

2) Equipment Requirements:
   To assure system integrity, a pre-wired and factory-tested, microprocessor-based, multiple control
loop combustion system shall be provided to implement boiler control functions. As packaged in an enclosure, the system shall be manufactured and tested according to UL 508 requirements. To meet NFPA 85 paragraph 1.9.3.2.3 “separation requirements”, flame safeguard functions shall be performed in a separate processor from that performing the combustion control and other boiler control functions.

3) Controller equipment requirements:

a. Controller shall be designed for sub-plate mounting inside a control enclosure. Wiring connections are to be made by plug-in terminal blocks for ease of wiring.

b. Optional Modbus/Ethernet/web-based remote monitoring shall be available.

c. Minimum required basic setup parameters: 33

d. Number of servo outputs: 6

e. Minimum number of F(x) curves to be provided per output: 6

f. Minimum number of points per F(x) curve to be provided: 15

g. Controller shall be commissioned by parameter set-up. No ladder logic, function block or block ware programming shall be required.

4) To regulate access to the system parameters, the controller shall maintain separate password levels for operators, technicians, and engineers. To prevent unsafe operation, system parameters that affect boiler operation shall only be permitted to be changed when the flame safeguard is in shutdown or lockout mode. In the event of AC power loss, the controller shall allow the user to select whether the boiler restarts or goes into lockout when power is restored.

5) Provide a Standard LCD Display: 4 Lines, 20 Characters per line, flush-mount.

6) Provide separate direct-acting digital servo actuators for the fuel gas and fuel oil flow control valve(s), combustion air damper(s), draft damper, FGR damper, and/or feedwater control valves. The actuators shall be totally enclosed in a dust-tight, splash-proof housing. Servo actuators shall include a direct shaft-connected, electrically isolated feedback potentiometer with 0.1 degree position resolution, integral brake, and 90° rotation in 25 seconds. The actuators shall be capable of being stopped, started, or instantly reversed without loss of power or overloading. For repeatable fuel air ratio control, servo actuator positioning accuracy shall be 0.1 degrees. To ensure all servos are functioning correctly, servo full stroke safe start check shall be provided. No servo feedback adjustments shall be required with pushbutton zero setup. Electrical connections to all actuators shall be with one single daisy chained conduit. Re-wiring the servo shall not be required to change direction of travel. Actuators shall be Preferred Instruments, Model BMU-SM series. Flame scanners shall be Preferred Instruments Model BMU-IR, BMU-UV, or BMU UVSC for infrared, ultraviolet, or self-checking ultraviolet, respectively.

7) Optional Touch Screen Operator Interface Terminal / Control

Touch screen requirements must conform to the following specification if provided:

a. Application

Provide a ten (10) inch Operator Interface Terminal (OIT) designed to provide local operation, graphic display of information, alarm message display, historical and real time trending, remote controller tuning, x/y plots of fuel-air curve data for intuitive commissioning, Ethernet connectivity, and standard internet browser remote communication. The OIT shall be networked to the fired equipment control and flame safeguard systems.

The system shall be an industrially hardened OIT. Development software shall be standard IBM PC compatible to simplify future expansion, replacement and service requirements. The terminal shall be web-enabled and allow remote monitoring via a standard internet browser and must support Modbus TCP/IP Master, TCP/IP Slave, RS-485 Modbus Master, Allen Bradley DF1 Master and OPC communications.

Hardware features shall include the following as a minimum: The OIT’s display shall measure 10.4-inch and utilize Thin Film Transistor (TFT) with 256 Colors
and 640 x 480 pixel LCD resolution.

The OIT shall be suitable for panel sub-plate mounting. The OIT operating front face plate shall be rated NEMA 4X/IP66, (for indoor use only) and shall have an aluminum construction. Plastic type cases shall not be acceptable.

Ethernet communication
10 BASE-T /100 BASE-TX, RJ45 jack connection with Protocols; web enabled, Modbus TCP/IP Master, TCP/IP Slave, Encapsulated Modbus Master, Allen Bradley DF1 Master, OPC RS422 / 485 communication (2) ports with up to 115,200 baud, RJ45 jack connection, Protocols; Modbus Universal Master, ASCII Slave, RTU Monitor, RTU Slave, Danfoss VLT 6000, Allen Bradley DF1 Master, DH485 Master, Siemens S7 via MPI Adapter, S7 via PPI, Simovert via USS, TI-500 Series

RS232 communication
(2) ports with up to up to 115,200 baud. RJ12 jack connection, Protocols; Modbus Universal Master, ASCII Slave, RTU Monitor, RTU Slave, Danfoss VLT 6000.

USB Port for Programming, Type B connection
Field replaceable backlight, real-time clock, battery-backed clock time stamps critical data, 8 MB on-board flash application memory, 512 MB memory card, application expanded memory card for historical, alarm & event storage, resistive analog touch screen with free formable to fit target shape

b. Software features shall include the following:
Operator interaction shall be touch screen-based to allow for easy selection of screens, manual / automatic status changes, start/stop functions, setpoint changes, output changes and PID tuning parameters without any special programming skills. Screen selection shall also be available through tactile feedback function keys.

The OIT shall provide facsimiles of the local controllers and clearly labeled English language and engineering unit display of the control parameters.

The OIT must have x/y plotting capability. When the OIT is used in conjunction with fired equipment fuel/air ratio control, provide automated fuel/air ratio curve and oxygen trim setpoint curve adjustment for rapid, error-free burner setup. Curve data shall be graphically displayed for easy review. Only a single operator action shall be required to store commissioning data into multiple characterizer curves for a particular load point.

Touch screen program must include a minimum of 75 total graphic pages. Information shall be displayed on the HMI as part of an easy to understand pictorial representation of the process. At a minimum, an individual boiler overview and individual control loop overview shall be provided. As an example, a typical steam generator would display (when available): steam drum pressure, steam flow for each boiler, steam temperature, drum water levels for each boiler, flame failure, combustion air temperature, flue gas temperature, flue gas recirculation damper position, outlet damper position, controller faceplate grouping for each boiler, trend screens for each group of controlled process variables as they pertain to each controller in the system. All values shall be displayed in engineering units adjacent to the pictorial point of measurement.

Each controller in the system shall be capable of remote tuning of gain, reset, rate and other important parameters via the OIT. When each controller is placed in the remote tuning mode, a real time trend chart of controller inputs shall be displayed on the OIT to aid the technician in setting the proper parameter values. This function shall be password protected for security.

Where applicable, alarm status shall be displayed on the OIT generated process pictorials. In addition, all alarms shall be logged in an alarm and event log. The alarm log shall indicate the time at which the alarm occurred, the time at which the alarm was acknowledged and the time at which the value returned to normal status. In addition to alarm conditions, this log shall also document status changes such as a transfer from automatic to manual, a setpoint change, etc. so
that the resultant collection of alarms and events is a true and complete log of plant operating conditions.

The OIT shall include historical and real-time trend displays. This display shall include up to four traces per chart. Arrow keys shall be provided to change the chart span from 30 seconds, 1 minute, 2 minutes, 3 minutes, 4 minutes, etc., on up to 1 hour. Provide a chart cursor to allow the user to display the value of each trace at a selected point on the trend. The OIT shall display the trace values at the point the cursor intersects the traces. The cursor shall be positioned backward or forward in time using arrow keys. Real time data shall be displayed when a trend is first displayed.

The OIT shall automatically create a historical data file each hour. Each file shall be accessible over an Ethernet connection using a standard internet browser. The files shall be Microsoft Excel® compatible. As an example, for a steam generator application a data file could include (when available); steam pressure, steam flow, and feedwater flow.

The OIT shall have dedicated communications between the OIT and the flame safeguard system so as to allow all alarms to be graphically represented and summarized. The OIT must be capable of displaying and recording the following statistics: burner limits, individual lockouts, burner operational hours, total burner cycles, burner status, last six lockouts, total lockouts, and flame signal strength.

The OIT shall provide graphic pages allowing step-by-step commissioning of the controller parameters using English language prompts and selections.

The OIT shall be manufactured in accordance with UL50, IEC 1010-1 and EN 61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1. The Operator Interface Terminal shall be a Preferred Instruments, Danbury, CT, Model OIT 10 with part number 90283 expanded memory card and 90284 additional communication card.

c. Controller Functions:

Flame Safeguard (FSG)
Integral with the combustion system controller shall be a Burner Management System (BMS)/Flame Safeguard System (FSG). The system shall be designed to ensure the safe start-up, on-line operation and shutdown of fuel firing equipment. Burner management system components shall be located in the combustion control cabinet and shall be fully integrated for automatic sequencing of light-off and shutdown.

An industrial duty microprocessor-based FSG shall monitor safety interlocks, servo position, and flame status. The controller shall sequence the burner through purge, light-off, run, shutdown, and post-purge. The FSG shall be capable of firing up to three fuels. Fuel selection to be determined by hard-wired contact or Modbus link according to user configuration. Additional FSG functions shall include as a minimum:

- All recycle and shutdown interlocks will be wired to separate, parallel 120 VAC inputs. Analog sensors for gas or oil pressure shall not be required.
- The controller shall supply both 120 VAC and 24 VDC power for flame scanner(s). To prevent nuisance trips, dual flame scanners shall be wired into separate digital inputs. Analog (flame signal quality) inputs shall be used for flame strength indication only.
- To minimize thermal stress on the boiler “assured low fire cutout” shall be provided to drive the burner firing rate to low fire before shutting down the burner.
- Because dry boiler operation is a leading cause of boiler explosions and meltdown, flue gas temperature shall be input to the controller and monitored to alarm or trip the burner in the event the boiler is dry-fired and the low water cutouts malfunction.
- Adjustable time delays (up to four seconds) shall be provided for the low fuel pressure, low atomizing flow, and low draft cutout interlocks to reduce nuisance shutdowns due to transient conditions.
- The controller shall accommodate automatic gas valve leak detection when required by the user.
To prevent unsafe purging of oil guns, oil gun purge logic shall be provided to enable either the safe purging of any resident oil in the atomizer into the furnace (with pilot energized), or the activation of a scavenging pump to draw the unused oil out of the oil gun.

A minimum of five user-configurable auxiliary relays shall be provided for alarm, or to start auxiliary fans, oil pumps, oil heaters, gas booster pumps, etc.

When the optional in-situ oxygen analyzer is provided, the controller will alarm and/or shut down the burner when a user-configurable low stack oxygen set point is reached.

Individual annunciation shall be provided for up to six recycle limits and twenty non-recycle (shutdown) limits.

To allow easy controller trouble-shooting, individual annunciation shall be provided for up to nine recycle limits and thirty-three non-recycle (shutdown) limits.

The controller shall provide time/date stamp of individual servo positions, status of each digital input, and the status of all controlled functions for up to the last ten boiler shutdowns.

Flame safeguard system shall include Modbus RS-485 communications. A common dry alarm contact output shall be supplied for the Building Management System for any fault or alarm condition related to the Flame Safeguard System.

d. To ensure a safe and reliable system, flame safeguard logic and associated software shall be recognized by Underwriters Laboratories.

8) Combustion Control

a. The combustion control system shall position up to eight independent servo actuators for fuel or feedwater valves, and combustion air, FGR, or draft damper control, as required. In addition up to five separate 4-20 mA analog outputs shall be provided for stack damper, feedwater valve, or VSD operation (FD fan, ID fan, or FGR blower). PID combustion controls shall be designed to safely maintain the desired process variable (steam header pressure or water or thermal fluid exit temperature) at the operator-selected value. A parallel positioning control logic scheme with oxygen trim and optional VFD control shall be used. Demand from the boiler master shall serve as a demand for both fuel and air control devices with “position cross-limiting” features being implemented to insure that a safe fuel-air ratio is maintained.

b. One servo actuator shall be applied to each fuel flow control valve(s) while a separate actuator(s) shall position the air control damper(s). Each actuator shall be equipped with an integral position retransmitter. Fuel-air ratio shall be established and adjusted by use of a “soft” function curve of fuel valve position vs. air damper position.

c. The fuel flow controller shall be “position cross-limited” with the air flow controller so that fuel demand cannot be increased until an air damper position increase is proven by the air damper position feedback signal. Additionally, air demand cannot be decreased until a fuel flow valve position decrease is proven by the fuel valve position feedback signal. To ensure a safe and reliable system, software regulating fuel-air ratio shall be recognized by Underwriters Laboratories.

d. The boiler master shall utilize a steam flow feed-forward index to the drum pressure feedback for improved response. Fuel valve and air damper shall be modulated in response to an external plant master demand signal or the boiler master output signal. A minimum of 15 points must be entered for each “setup” curve. The controller shall interpolate between curve points to ensure smooth operation during load changes.

e. The controller shall automatically detect a failed or malfunctioning servo actuator. During purge, all of the servo actuators shall be driven to their minimum and maximum positions. If the feedback signal from any positioner is out of range, the burner will go into lockout to prevent firing under dangerous conditions.

f. An in-situ oxygen analyzer shall measure the oxygen concentration in the flue gas and trim the air/fuel ratio to follow the oxygen vs. load curve input during unit commissioning. Oxygen trim can be turned off when the firing rate drops below a user-defined firing rate. In addition, the controller shall provide a user-defined lag time during which the oxygen trim function is nullified for a set amount of time after light-off to allow the burner to warm-up and stabilize.

g. Provide microprocessor-based flue gas recirculation (FGR) control for each burner. FGR flow rate shall be controlled in response to boiler load for both forced and induced type FGR systems. The
controller shall have a characterizable setpoint curve for damper or variable speed fan output signal.

h. Because many low Nox burners can be unstable until the flue gas recirculation heats up to steady state temperature, cold FGR low fire cutback shall be provided when FGR control is required. This ensures that the FGR is heated to steady-state temperature before the burner is released for automatic operation.

i. To ensure burner operation is witnessed to be safe and within manufacturer's limits at all firing rates, the controller shall require the burner to be run at each load point to verify and confirm combustion at that point is stable before the controller can be put in the automatic mode. This requirement shall apply whenever the adjustments are made to a curve point as well. The controller shall include software-enabled high and low firing rate limits in the event the technician needs to limit the upper or lower end of the firing rate in automatic operation. The fuel controller shall be configured to provide for control of the gas and/or oil control valve, depending on the fuel selected.

j. The control system shall allow changeover from gas to oil and from oil to gas when initiated by hard-wired input or Modbus connection. When a fuel changeover is initiated, the burner will be directed to shut down and re-light on the newly selected fuel.

k. To ensure the burner can continue to be run safely even with a failed FD fan VSD, the combustion controller shall contain independent variable and full speed fan setup curves for each fuel. In the event of a Variable Speed Drive (VSD) failure, the burner shall trip, the operator shall be able to transfer the VSD bypass transfer switch and restart the equipment.

l. “Off-curve” points shall be provided to allow the technician to determine the servo positions during standby, ignition, and purge modes.

m. Alternately, the controller shall be selectable by parameter configuration to control a jackshaft system in which fuel and air are mechanically linked.

n. All external or auxiliary power supplies necessary for electronic transmitters (or final control element) shall be included.

9) Enhanced (Auxiliary) Boiler Control Functions

a. Feedwater Control. The controller shall include user-selectable single-, two-, or three-element PID drum level control. Drum level shall be controlled by modulating the feedwater control valve in response to boiler water level in single element mode, a combination of water level and steam flow in two-element mode and the combination of water level, steam flow and feedwater flow in the three-element mode. The transfer between single-, two- or three-element control shall be automatic as operating conditions warrant. The controller shall position a feedwater control valve or VSD feedwater pump, as required. Adjustable time-delay alarms shall be provided for high and low water level.

b. Draft Control. Using an analog input from a Preferred Instruments JC-22XMTR draft transmitter, the PID draft control loop shall position the boiler outlet damper (or ID fan VSD) to maintain consistent draft pressure at all boiler loads. An internal firing rate signal from the combustion control loop shall be used as a feed-forward to the draft control loop to better control draft during boiler load swings. In the event a VSD drive is used on the ID fan in lieu of a boiler outlet damper, the controller shall provide a 4-20 mA output to control the ID fan VSD drive. A low draft (high stack pressure) alarm with adjustable time delay shall be provided to alert the operator of unexpected draft conditions. Abnormal burner shutdown (safety lock-out of flame safeguard control) shall cause the outlet damper to drive open where it shall remain until the flame safeguard system is reset.

c. Remote Boiler Operation. Call for heat (burner on signal) may be generated locally by an operating limit switch, or remotely by digital input or Modbus/Ethernet communication. In addition, the controller shall allow either the boiler firing rate or steam pressure set point to be determined remotely by either hard-wired inputs or Modbus/Ethernet communication.

d. Outdoor reset (Hot water boilers only). To save fuel on warm days, the controller shall provide dual outdoor air temperature set-point curves (normal and setback) to lower the boiler exit temperature set-point when the outside air temperature increases.
e. Domestic Hot Water Override. When a heating boiler provides domestic hot water as well, the exit water temperature can be configured to override the outdoor reset curve and set a user-defined minimum water temperature. Controller shall include a warm standby start/stop cycle.

f. Warm Standby. To respond rapidly to a call for heat, the controller shall cycle the burner in response to an external shell temperature, boiler water temperature, or steam pressure signal. Start and stop set points shall be user-defined. Controller shall include low fire hold, and cold start warm up ramping.

g. Low Fire Hold. To prevent thermal shock to the boiler, the controller shall be capable of holding the burner at low fire after a cold boiler start. The boiler shall be released to modulate after a user-defined time delay, or when the boiler warm-up signal (shell temperature, water temperature, or steam pressure) set point is reached.

h. Cold Start Set-point Ramp. When enabled, the boiler will be warmed up using a user-defined set point ramp. Step increments and duration shall be selectable by the boiler operator.

i. Automated Boiler Water Column Blow-down. To ensure the low water cutouts on a boiler are working correctly, the controller shall sequence an automated water column blow-down test. The operator shall be able to select the time of day and duration of the blow-down test. The controller shall monitor the low water cutouts and alarm or lockout the burner in response to a failed low water cutout test.

j. The above controls, flame safeguard system, and other electrical devices and services that are not boiler, burner, or skid mounted shall be housed in an enclosed control panel.

The control panel will additionally provide:

- Low Water light.
- Demand On light.
- Ignition light.
- Valve Open light.
- Lockout Alarm light.
- Burner On switch.
- Burner Off switch.
- Fuel Select switch (if applicable)
- Manual/Automatic selector.

k. All wiring in the panel and on the boiler shall be identified and marked on each end.

l. Wiring from the water level and pressure controls shall be rated for high temperature service from the components to the first termination or junction.

m. I.E.C. motor starter with overload protection shall be provided.

10) Control voltage for the control panel shall be 120 VAC, one phase, 60 Hertz and shall be provided from a 460/3/60 primary voltage step-down transformer.

11) The control circuit shall be provided with fused over-current protection.

2.6 Field Devices To Be Provided

A. Provide field devices according to the specific job and design parameters chosen in the control system called for above. Such items as draft range transmitter and low draft switch, flue gas Oxygen Analyzer, FD Fan Variable Speed Drive, Pressure transmitters (steam), temperature transmitters, fuel or steam flow meters, Digital Servo Actuators, etc. as required will be called for here.
2.7 Warranty

A. Complete burner - boiler package to have a limited warranty on all materials and components supplied for 12 months from date of initial commissioning or 18 months from ship date, whichever occurs first. Manufacturer will submit detailed provisions of warranties as part of submittal packages.

1) Boiler firetube, all tube sheets, and rear submerged combustion chamber to carry a fifteen (15) year parts and labor warranty.
2) Front and rear flue doors to carry a fifteen (15) year parts and labor warranty.

2.8 Packaged Boiler Commissioning:
A. The owner, operator, or contractor will ensure that all utilities, connections, piping, electrical, and other associated equipment and tie-ins are completed, serviceable, and ready for boiler operation.
B. The boiler manufacturer will make available the services of a factory authorized service engineer for the boiler start-up if requested by the responsible entity. Factory authorized service will be charged at the rates and conditions offered in the manufacturer’s quotation or applicable terms and conditions.
C. Manufacturer will ensure that start-up time frame will be a minimum one day per fuel fired. This will be exclusive of chemical boil-out or delays caused by services, equipment, or utilities not supplied by the manufacturer. Instrument and controls start-up shall be separately quoted based on the system components and parameters elected and shall be required for boiler commissioning.
D. A comprehensive start-up report shall be completed and provided to the job site and other parties.
E. Factory authorized training for operators, maintenance, and others shall be performed at the time of commissioning.

2.9 Boiler Efficiency Performance Guarantee:
A. The unit shall operate at the following fuel to steam efficiencies firing the specified fuels at boiler maximum capacity:
   1) Natural Gas - ______%
   2) Fuel Oil - ______%

B. Efficiency shall be calculated as prescribed under "Efficiency By Input-Output Method" of the ASME Power Test Codes PTC4.1. Details of the ASME test procedure are to be supplied by manufacturer upon request.
C. In the event the test does not yield results per Certified Minimum Efficiency stated above, boiler manufacturer to provide a purchaser’s rebate of $7,500.00 for each full 3/4 of 1% certified efficiency not achieved. This guarantee is valid during the first year of boiler operation. Condition and requirements for the efficiency guarantee are available from the boiler manufacturer upon request.

2.10 Additional Field Service and start-up Commissioning:
A. Acceptable Field Personnel: Approved manufacturers authorized to work on the equipment specified must be used in compliance with this specification and other applicable contract requirements. Approved manufacturer’s field service personnel are as follows:

B. Field Personnel Responsibilities: The following field labor shall be provided with the contract:
   1) Boiler controls Job survey to access installation requirements( if needed) - (x) days
   2) Perform start-up for oil and/or gas, program controller(s)- (x) days
   3) Provide controls training and warrante service- (x) days

2.11 SOURCE QUALITY CONTROL:
A. Boiler pressure vessel shall be designed, constructed, and hydrostatically tested in accordance with ASME Boiler and Pressure Vessel Code and will bear the appropriates ASME label. Quality control shall be executed, inspected and documented per the manufacturers approved ASME Quality Control program and manual.

PART 3 - EXECUTION
3.1 EXAMINATION:

A. The buyer or assigned designee may inspect the order execution and job progress at the manufacturer’s facility during normal business hours at any point during the design, procurement, and fabrication processes. A minimum forty-eight hour notification is required prior to the inspection. All aspects of the job execution may be inspected except those data, information, or processes considered by the manufacturers to be proprietary.

3.2 INSTALLATION:

A. Critical boiler installation dimensions and considerations shall be incorporated into and supplied by the manufacturer on equipment general arrangement drawings. Manufacturer, upon notification of discrepancies or errors by the job site or others, will correct such drawings, dimensions, and considerations in a timely fashion and re-submit to all concerned.

B. The Scotch Marine Packaged Firetube Boiler shall be designed to be installed on a 4” high concrete pad, 4” larger on each side than base of unit.

C. Boiler trim or other items “shipped loose” for field assembly shall be designated as “ship loose” on equipment bills of material and shippers packing documents.

D. Steam, fuel, and other connections: The location, size, and specifications for each applicable connection will be provided by the manufacturer’s supplied boiler Piping & Instrument Diagram, boiler general arrangement drawing, and bills of material.

E. Breeching: Manufacturer shall provide a fully flanged outlet connection for interface with the site supplied flue duct or stack equipment. Dimensions for the connection shall be provided in the boiler general arrangement drawing. The manufacturer will provide pertinent information delineating concerns, restrictions, or cautions associated with mating firetube boiler flue outlets with flue and stack systems not supplied by the boiler manufacturer.

F. Electrical: Electrical connection and service requirements shall be provided and clearly designated in the manufacturer’s electrical wiring diagrams.

FIELD QUALITY CONTROL:

A. The manufacturer will provide completed ASME P-2 forms to assist in completion by others of any required on-site hydrostatic testing or other testing in accordance with applicable sections of ASME Boiler and Pressure Vessel Code or other local codes.

B. Manufacturer will provide a written procedure by which any field defects or deficiencies will be brought to the manufacturer’s attention and by which the manufacturer will address such defects and deficiencies.