

SECTION 23 52 39

FIRE-TUBE BOILERS

PART 1 -GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Specifications, apply to this section.

1.02 SUMMARY:

- A. This specification applies to packaged, factory-assembled and tested, firetube steam boilers, including their applicable trim, and accessories.
- B. Related Sections:
 - 1. Section 23 09 13: Instrumentation and Control for HVAC
 - 2. Section 23 51 16: Fabricated Breechings and Accessories
 - 3. Section 23 53 13: Boiler Feedwater Pumps
 - 4. Section 23 25 19: Water Treatment for Steam System Feed-water
 - 5. Section 28 31 49: Carbon-Monoxide detection sensors

1.03 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.
 - f. Drawings showing the locations of all controls (LWCO, gauge glass etc.) and normal water line.
 - g. Detail calculation of steam space and disengaging area.
 - h. Boilers rigging plan
 - 2. Boiler Controls, Trim, & Instrumentation:
 - a. Piping & Instrument Diagrams.
 - b. Instrument & Electrical symbols legends.
 - c. Drawing Index.
 - d. Bills of Materials listing manufacturer, models, and quantity of supplied components.
 - e. Panel Controls and Indicators Layout Drawing.
 - f. Ladder Diagram type wiring schematics.
 - g. 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.
 - d. Wiring Diagram.
4. Others
- a. Shop drawings of Boiler Room layout with all equipment drawn in AutoCAD program provided on CD, as well as one set of mylars and two sets of prints. Layout drawings shall be provided for each trade. Layout shall include the actual boiler supplied with tube pull spaces and other equipment supplied in the vicinity, such as the condensate receiver with feed water pumps and control panels, steam separator, header, breeching, chemical feed units, etc. The drawing shall also show all piping layout, concrete pads, wall openings, electrical and power runs, plumbing, etc.
 - b. Upon completion of the contract work, Contractor shall provide As-built layout drawing in AutoCAD program on CD, one set of mylars and two sets of prints. As-built drawings shall show the actual installation with all the details including Mechanical, Electrical, Plumbing, Structural, etc.
- 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 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 applicable system.
 - 9. Preventative maintenance schedules or recommendations.
 - 10. Vendor data or "cut sheets" on major components.
 - 11. Boiler General Arrangement Drawing.
 - 12. Piping & Instrument Diagrams.
 - 13. Piping and Instrument symbols legend.
 - 14. Sequence of Operation and Logic Diagram.
 - 15. Instrument & Electrical component bills of materials.
 - 16. Copy of ASME H-2.
 - 17. Copy of CSD-1 data sheet.
 - 18. Recommended spare or replacement parts lists.
- C. Factory Test: Any boiler submitted for approval must go through a factory test for steam quality and boiler efficiency as specified elsewhere in this specification. Manufacturers previously approved shall include a statement in their submittal indicating prior acceptance and provide proof of same upon request. Boilers of any size or any manufacturer that have not previously passed a NYCHA factory acceptance test will require testing at the manufacturer's expense, including travel and living arrangements for two (2) NYCHA representatives.

1.04 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 firm's 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 their 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 as prescribed by ASHRAE 90A "Energy Conservation In New Building Design".
3. Low 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.
4. Electrical installations shall comply with National Fire Prevention Association (NFPA) Code- 70 "The National Electrical Code".
5. Gas Fired-boiler installations shall be in accordance with National Fire Protection Association (NFPA) Code 54 "National Fuel Gas Code".
6. Oil-fired boilers shall be in accordance with National Fire Protection Association (NFPA) Standard 31 "Standard for the Installation of Oil Burning Equipment".

7. Ancillary electrical components shall be Underwriters Laboratories (UL) listed and labeled.
8. The complete boiler package is to be designed and fabricated per UL guidelines. Compliance is to be proven prior to equipment acceptance.
9. Instrument and piping drawings and electrical drawings are to use symbology and protocol established and defined by the Instrument Society of America (ISA).
10. The installation shall be in accordance with ASME CSD-1.
10. The installation shall be in accordance with NFPA 85.
11. The installation shall be in accordance with Factory Mutual (FM) requirements.
12. The installation shall be in accordance with NYC Department of Environmental Protection and NYC Building Department. Compliance is to be proven prior to equipment acceptance.

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

PART 2 -PRODUCTS

2.01 MANUFACTURERS:

- A. Boiler Manufacturers: Approved packaged firetube boiler manufacturers must be subject to and in compliance with this specification and other applicable contract requirements. Approved manufacturers are or equal:
 1. Johnston Boiler Co.
 2. Cleaver Brooks.
 3. Burnham
 4. Hurst
 5. Easco

2.02 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, and feedwater systems shall be specifically engineered as a compatible packaged system. The boilers 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 boilers shall be factory assembled and tested. The packaged units 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. The boilers shall have a nominal rated capacity as per drawings.
2. The boilers shall have a maximum output as per drawings at 212 degrees F.
3. Boiler shall have a design pressure of 15 psig.
4. Boiler and controls shall be designed for a working pressure of 10 psig.
5. Steam shall be at least 98.0% dry and saturated.
6. Boilers shall provide a minimum fuel to steam efficiency of 80% when firing natural gas or #2 oil (Efficiency shall be calculated as prescribed under “Heat Loss Efficiency” of the ASME Power Test Code PTC4.1).
7. Boilers shall have an identified minimum steam space and disengaging surface area as represented by the following schedule:

Boiler Size (BHP)	Min. Steam Space (Cu. Ft.)	Min. Disengaging Area (Sq. Ft.)
100	22.5	35.3
125	28.9	39.9
150	33.8	44.9
200	44.3	50.8
250	56.3	57.0
300	53.4	71.3
350	59.4	75.0
400	74.8	82.2
500	95.4	103.2
600	100.1	107.8
750	148.8	125.1

8. The size of steam space and disengaging surface area shall be determined from the normal operating water level.

C. General Boiler Design: The packaged fire tube 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 tube sheet connections.
7. The boiler shall be designed with front and rear observation ports.

2.03 BOILER SPECIFICATIONS

- A. Boiler (pressure vessel): The boilers shall be a four pass water back Scotch Marine type listed and rated by the American Boiler Manufacturers Association, Fire tube Section. The boiler will be designed and built to comply with the latest ASME Code Rules for 15 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. Connections for bottom blow-offs shall be supplied on both ends of the boiler shell.
 5. Openings for trimmings and external connections shall be flanged and/or threaded.
 6. A minimum of six (6) hand holes and one manhole for thorough inspection and cleaning shall be provided.
 7. The boiler shall be equipped with a steam baffle to ensure steam quality and prevent water carry over.
 8. Gas tight inspection doors shall be provided.
 9. Boilers must bear ASME Stamp and be inspected under National Board Rules.
 10. Boiler shall have 2 ½" dia. Tubes and .105" tube thickness. In addition, boiler shall have ½" thick combustion chamber and shell plate, and 5/8" tube sheets, front and rear heads and wrapper.
 11. Boiler plate shall be made of carbon steel ASTM A-36 and have thickness of 5/8".
- 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.
- D. Insulation and Jacket: The boiler shall be factory insulated around its full circumference with 2" thick fibrous, non-asbestos containing insulation. The insulation shall be held in place by spacer pins welded to the shell and covered by a corrosion resistant galvanneal sheet metal jacket not less than 18 gauge thick. 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. Flue Gas Recirculation: Boilers shall have flue gas recirculation piping and a servo-controlled FGR damper to achieve <15PPMC NO_x when firing natural gas, and <90 PPMC NO_x when firing #2 Fuel Oil with maximum of 0.010% Fuel Bound Nitrogen content corrected to 3% "Dry" O₂.
- F. Boiler Trim: The boiler shall include the following control and accessory equipment (trim):

1. Water Column complete with chain operated gauge glass set, red line gauge glass, manual water column blowdown valve, and parallel slow opening motorized blowdown valve for burner controller daily low water float switch test.
2. Feedwater Pump or Valve 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, or modulate a motorized feedwater valve as shown on the contract drawings.
3. Low Water Cutoff (LWCO) 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 will be a second float type, installed to activate below the primary low water cut-off. Control has to be either a manual reset type or wired into non-recycle limits of the flame safeguard control.
5. A continuous surface water blow off connection and automatic surface blowdown control with solenoid valve, probe, and controller shall be provided.
6. 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.
7. Steam Safety Valves shall be provided in types, sizes and quantities to comply with ASME Code requirements, and as shown on contract drawings.
8. 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.
9. Data Reports: The Manufacturer shall supply two copies of data reports, ASME form H-2.

G. Boiler Breeching and Exhaust Ductwork Design

1. Pressure at the outlet of the boiler after the draft damper shall not exceed 0.5" W.C. at high fire. When multiple boilers are connected to the same stack, the pressure shall not exceed 0.5" at any boiler outlet when all boilers are operating at 100% capacity.
2. For installations having multiple boilers connected to a common stack, the breeching design shall be evaluated by the burner and boiler manufacturer for compliance with industry best practices.
3. For installations having multiple boilers attached to a common stack, exhaust from each individual boiler shall enter the main flue gas header at an angle no greater than 45 degrees.
4. Long radius elbows shall be used for changes in direction of the ductwork. Short radius elbows are not acceptable.

2.04 GAS/OIL BURNER

A. Manufacturers:

Preferred Utilities or approved equal.

B. Burner:

1. The burner shall be an industrial quality burner that includes Flue Gas Recirculation for achieving <15 ppm PPMC NO_x while firing natural gas and <90 PPMC NO_x when firing #2 Fuel Oil with maximum of 0.010% Fuel Bound Nitrogen content.
2. The gas/oil burner shall be mounted on front of the boiler and shall be of the flame retention ring type complete with integrally mounted combustion air blower, and designed for operation with natural gas and #2 Oil.
3. Standards and Certifications:
 - a. The burner system shall be designed, built, and tested to guidelines established by UL-795 (gas) UL-296 (oil).
 - b. The burner shall meet the requirements of IRI insurance codes.
 - c. The burner shall meet the requirements of NFPA-85.
 - d. The burner shall meet the requirements of ASME CSD-1

C. Burner Type: The burner shall be a Preferred API low NO_x burner or approved equal: low excess air combination natural gas and fuel oil, packaged, forced draft, modulating firing, with variable speed forced draft fan. Design for low NO_x emissions. Burner and controls system shall be manufactured by the same company for single source responsibility.

1. Gas Burner: Ring type with multiple ports or spuds.
2. Oil Burner: Gun type, Y-Jet type Inside Mix, low pressure air atomizing.
3. Igniter (Pilot): Interrupted, electrically ignited, natural gas or propane (quantit2).

D. Service:

1. Continuous operation at all firing rates on each fuel listed. Design the entire burner and fuel train system for application to the specific boiler furnished and for service at the available fuel pressures.
2. Igniter (Pilot) Fuels: Normal fuel will be natural gas. Propane will be used if there is an interruption in natural gas service.
3. Main Fuels: After boilers are accepted for operation, choice of fuels will be based on cost and availability.

E. Performance:

1. Igniter (pilot) flame on natural gas and propane shall form close to the point of ignition and shall be stable. Ignite both the gas and oil burner with dual igniters. In the event of gas curtailment, the igniters shall be capable of igniting the main fuel oil burner with the natural gas supply pressure.
2. Main flame on gas and oil fuels shall ignite at lowest firing rate.
3. Main flame characteristics at all firing rates:
 - a. Flame retained at the burner.
 - b. Flame stable with no blowoff from the burner or flashback into the burner. No pulsations.
 - c. No carryover of flame beyond the end of the first pass (furnace tube).
4. Operation:
 - a. Minimum turndown 10:1 firing natural gas, 8:1 firing fuel oil. There shall be five verifiable sites where this performance has been documented by a third party.

- b. Operate at all loads on any one fuel without any manual changes to burners, fuel trains or fuel pressures, atomizing media trains or pressures.
 - c. Excess Air in flue gases with oxygen trim at null position.
 - d. Performance at any load point shall be repeatable after increasing or decreasing the firing rate. Repeatability plus or minus five percent excess air, at 25 percent and higher boiler loading except excess air must remain within ranges specified above.
 - e. Oxygen trim control set at maximum position shall not blow out the fire at any load point. At minimum position, the combustion shall not go below stoichiometric.
 - f. Noise and Vibration: Burners shall operate without pulsation.
 - g. The burner must incorporate a VSD and operate at no greater than 20 Hz at low fire.
 - h. Excess air shall not exceed 10% from 50-100% firing rate.
5. Flue Gas Emissions Limits:
- a. Carbon Monoxide: Shall not exceed 100 PPM from 25-100% rate.
 - b. Smoke: On natural gas and No. 2 oil shall not be visible and shall not exceed No. 1 on the Bacharach smoke scale.
 - c. NOx: 15 ppm maximum, corrected to 3 percent oxygen, dry basis on natural gas; 90 ppm on No. 2 fuel oil with maximum of 0.010% Fuel Bound Nitrogen content. Maximum FGR flow shall not exceed 30% based on mass flow.

F. Construction:

- 1. Burner Access (Main Burner and Igniter): Arrange fuel valve and piping trains, controls and other devices so that they do not interfere with the removal and replacement of burner parts.
- 2. Arrangement of Fuel Valve and Piping Trains: All devices shall be accessible for maintenance or replacement without removal of other devices. Do not attach any piping or devices to boiler casings.
- 3. Coatings: Provide surface preparation, heat resistant prime and finish coats using standard color of Boiler and Burner manufacturer.
- 4. Combustion Air System
 - a. Air flow rates controlled by forced draft fan inlet or outlet dampers and variable speed drive.
 - b. Symmetrical, balanced distribution of combustion air into the burner proven with a CFD study.
 - c. Forced Draft Fan: Airfoil or backwardly inclined or curved wheel, electric motor driven. Design for required excess air and for static pressure that is based on losses from fan inlet to stack or chimney outlet, including economizer (if provided), at jobsite altitude. Fan shall have no resonant frequencies at all operating speeds. Fan shall be direct drive. Belt driven motors are not permissible.
 - d. Motor: TEFC, non-overloading under all fan operating conditions, design for 40 deg. ambient, premium efficiency type. Motors for variable speed service shall be rated inverter-ready. On 208 VAC applications, the fan motor shall have a 208 VAC, 3 phase, 60 Hz nameplate rating.
 - e. Damper: Design to provide accurate control of excess air with minimum hysteresis. On variable speed systems, the damper shall control only at lower firing rates. Damper shall be an opposed blade style.
 - f. Fan Housing must be removable and be capable of orientating the air inlet box.
 - g. Air Inlet Box with fresh air damper is required for noise reduction.
 - h. Minimum material thickness of the combustion air system shall be 0.179" in order to reduce noise levels below 90 dB and to increase product life. Manufacturers that use thinner metal construction shall not be accepted.

5. Provide flame viewport, with one clear and one tinted replaceable interchangeable glass. Locate to permit view of main and igniter flames.
6. Burner Throat: Refractory tile, shaped to promote proper combustion, arranged with provisions for expansion and contraction and rated by the refractory manufacturer for the maximum service conditions.
7. Service and Maintenance: Burner to have a swing open housing to facilitate service and maintenance of the burner. All removable burner components must be able to be removed without entering the boiler.
8. Flame scanner(s): The flame scanner is to be externally mounted for ease of access, and should not be located inside the burner. Two flame scanners shall be utilized for maximum reliability. Burner scanners shall have provision for scanner purging with air.
9. Oil Atomizer: The oil atomizer insertion shall be capable of being withdrawn during gas firing in order to extend the service life of the nozzle. The nozzle shall be of a steel or stainless steel construction. Brass oil nozzles are not acceptable. Limit switches tied into the burner management system shall prove the position of the atomizer for gas and oil firing.
10. Air Sleeve: The burner shall have an adjustable air sleeve capable of fine tuning flame geometry for furnace geometry and site specific conditions.
11. Gas Injectors: Gas injectors shall be of 316 SS construction.
12. Gas Manifold: Burner gas manifold shall be of stainless steel construction. Minimum metal thickness shall be 0.1196 in. Manufacturers that have gas manifolds with thinner metal shall not be accepted.
13. Flame Holder/Diffuser: The burner diffuser shall be of stainless steel construction.
14. Electrical Conduit: Provide liquid-tight flexible metal conduit with sealing fittings for all power and control services to fuel trains and burners.
15. Factory Testing: Mount burner and controls on boiler at factory and fire-test at all load points.
16. The burner shall be equipped with two gas-electric igniters for maximum reliability.
17. Changeover from gas to oil and vice-versa shall not require more than ten minutes. Interchanging of burner head components for oil firing is unacceptable.

G. Natural Gas Main Fuel Train:

1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, and shall include: shutoff valve, pressure gage, pressure regulator, valved connection to pilot burner fuel train, flow meter (if required), pressure gage, low pressure switch, two automatic safety shut off valves, valved leak test, high pressure switch, fuel flow control valve, manual shutoff valve, pressure gage, burner. High and low pressure switches shall be located to sense the constant pressure controlled by the burner pressure regulator and not the variable burner pressure.
2. Pressure Regulator:
 - a. Single seated, diaphragm-operated, designed for natural gas service. Controlled pressure shall be sensed downstream of main valve. Valve may be self-operated or pilot-operated as necessary to comply with performance requirements.
 - b. Service: Provide precisely controlled downstream pressure in fuel train, as required by burner and fuel trains furnished, with upstream pressure as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lock-up pressure of the nearest upstream pressure regulator.
 - c. Performance: Maximum outlet pressure drop of 5 percent or less of the set pressure over the burner firing range. Maximum lock-up pressure 1.5 times regulated pressure. Speed of response to opening of automatic safety shut off valves shall be sufficient to allow set pressure of low pressure switch to be within 20% of the normal operating

pressure with no nuisance burner trips. This characteristic shall be repeatable and essential for burner operation.

3. Automatic Safety Shut-Off Valves:
 - a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves are required.
 - b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble tight and be suitable for operation with upstream pressure of two times the highest pressure at entrance to boiler-mounted regulators.
 - c. Performance: Timed opening of 10 seconds or less to safely and smoothly ignite main flame, and close within one second.
 - d. Approval: UL listed for burner service.
4. Pressure Switches: Switch settings must be within 20% of the controlled pressure.
5. Fuel Flow Control Valve:
 - a. Type: Throttling, controlled by combustion control system. Driven by servomotor with 0.1 degree deadband for precise reliability
 - b. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.

H. Fuel Oil Train:

1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description: Starting at the entrance to the train, the devices are, in order: manual shut off valve, Y-strainer, pressure gage, pressure regulator (if required by burner furnished), low pressure switch, high pressure switch, flow meter (if specified), oil flow control valve, valved drain, automatic safety shut off valve, valved leak test, automatic safety shut off valve, valved leak test, manual shut off valve, pressure gage, burner. Burners below 12.5MMBTUH are to comply with CSD-1.
2. Y-strainer with 100 mesh screen. Provide plugged drain.
3. Pressure Regulator: Do not provide unless required by the burner furnished. Pressure control is provided by a back pressure control valve on the house fuel oil pump set.
4. Automatic Safety Shut-Off Valves:
 - a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves required.
 - b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble-tight and be suitable for operation with upstream pressure exceeding upstream safety relief valve set pressure plus accumulation.
 - c. Performance: Timed opening of six seconds or less to safely and smoothly ignite oil burner, one-second closure.
 - d. Construction: Threaded ends, valve position indicator visible from front or side of boiler. Closed position interlock switch on each valve.
 - e. Approval: UL listed for burner service.
 - f. Provide valved leak test connections between the two safety shut-off valves and after the second safety shut-off valve.
 - g. Proof of Closure Test: Provide non-latching push button controls in the proof of closure circuit to complete the circuit when the valves are open and interrupt the circuit when the valves are closed.
5. Pressure Switches: switch settings must be within 20% of the controlled pressure. High pressure switches shall have lockable service isolating valves and valved connections for pressurizing the switches and testing the set and trip points.
6. Fuel Flow Control Valve:
 - a. Type: Throttling, controlled by combustion control system. Driven by servomotor with 0.1 degree deadband for precise reliability

- b. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
7. Boiler/Burner-Mounted Oil Pump and Relief Valve:

I. Air Atomizing System:

1. Complete system for each burner, furnished by burner manufacturer, including compressor and drive, low pressure switch and all piping systems.
2. Atomizing air pressure to the burner shall be controlled by a servomotor driven air flow control valve according to an atomizing air pressure vs. firing set point curve.
3. Motor: Premium efficiency type
4. Motor Controls: Provide motor starter in NEMA 4 enclosure.
5. Shaft couplings: All metal and clamping type (not setscrew).
6. Screw type compressor shall be used. Piston compressors are not acceptable.

J. Igniter (Pilot) Fuel Train, Burner and Ignition System:

1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description: Connect to the main burner natural gas service downstream of the main burner pressure regulator. Join the natural gas and propane (or interruptible gas supply services by means of a three-way plug valve. Continue with one pipe line including a low pressure switch, pressure gage, automatic safety shut off valve, automatic vent, automatic safety shut off valve, igniter. Burners below 12.5MMBTUH are to comply with CSD-1.
2. Y-strainer with 100 mesh basket.
3. Pressure Regulators:
 - a. Type: Single-seated, diaphragm-operated.
 - b. Service: Provide controlled pressure in igniter train as required by igniter, with upstream pressures as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lockup pressure of the nearest upstream pressure regulator. As an alternate to the outlet emergency pressure rating, provide internal relief valve vented to outside set at pressure that will avoid overpressure on regulator outlet that could damage the regulator.
 - c. Performance: Lockup pressure shall not exceed 1.5 times the regulated pressure.
4. Automatic Safety Shut-Off and Vent Valves:
 - a. Type: Solenoid-type, two normally closed shut-off valves and one normally-open vent valve, arranged as shown, controlled by the burner control system. Provide threaded leak-test ports with threaded plugs on each shut-off valve body.
 - b. Service: Provide open-shut control of fuel flow to igniter and vent between shut-off valves. Design for 20 psi differential at shut-off.
 - c. Approval: Safety shut-off valves UL listed, FM approved for burner service. Vent valves UL listed for burner service.
5. Igniter and Ignition System: Provide removable igniter, ignition electrodes, ignition transformer, high voltage cable. Provide shield at ignition area so that spark is not visible to flame scanner from any position on its mounting.
6. Igniter fuel train pipe and fittings: ASME B31.1 requirements do not apply to low pressure natural gas.

2.05 BURNER CONTROLS

A. General Requirements

1. The burner controls shall include two functions, the Flame Safeguard System (FSG), and the Combustion Control System (CCS). The CCS shall be a linkageless parallel positioning combustion control system with oxygen trim and a variable speed drive (VSD) control. The system shall provide continuous process control of steam pressure, combustion air and fuel & flue gas flows. The system shall be fully integrated to the burner management system to provide fully automatic, safe and reliable startup and shutdown. 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. The control panels shall be manufactured and tested according to UL 508 requirements. The flame safeguard system (FSG) shall be performed in a separate processor from that performing the combustion control and other boiler control functions. The burner control chassis shall be UL listed and FM Approved.
2. 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. Modbus RS485 remote monitoring shall be available.
 - c. Minimum number of Servo Outputs: 8
 - d. Minimum number of F(x) Curves to be provided: 6
 - e. Minimum number of points per F(x) Curve to be provided: 11
 - f. Controller shall be commissioned by parameter set-up. No function block or block-ware programming shall be required.
 - g. No special or proprietary sensors shall be required
 - h. For additional nuisance trip protection, field adjustable time delays shall be provided for F.D. fan start, fresh air damper, minimum air flow, low draft cut out, and fuel pressure limits.
 - i. To protect against dry firing, an option shall be available for high flue gas temperature lockout.
 - j. A panel front-mounted English language, four line, twenty character LCD message display shall be provided to display flame signal strength, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and burner historical information. Historical information shall include the status of all limits and servos for the last ten lockouts.
 - k. To ensure air switches are functioning, minimum air flow pressure switch and purge air flow pressure switch safe start check shall be included.
3. Operator Interface Terminal (OIT): The optional OIT display shall measure 10" and utilize Thin Film Transistor (TFT) with 256 Colors and 640 x 480 pixel LCD resolution. The OIT shall provide Modbus Ethernet and BACnet Ethernet interfaces for remote FSG/CCS monitoring. The OIT shall be suitable for panel mounting. The OIT operating front face plate shall be rated NEMA 4X/IP66, and shall have an aluminum construction. Plastic type cases shall not be acceptable.
4. Manufacturer: Provide Model BMU-1ZNO-DGB1241 Burnermate Universal Controller as manufactured by Preferred Instruments.

B. Flame Safeguard System (FSG)

1. 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. Numbered terminal strips shall also be provided to permit termination of all field wiring.

2. 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, and shutdown, and post-purge. The FSG shall be capable of firing up to three fuels. Fuel selection is to be determined by hard-wired contact or Modbus link according to user configuration. Additional FSG functions shall include as a minimum:
 - a. Each recycle and shutdown interlock shall be wired to a separate, 120 VAC inputs. Pressure sensors for gas or oil pressure shall not be required.
 - b. The controller shall supply both 120 VAC power for flame scanner(s). Dual flame scanners shall be used, and they shall be wired into separate digital inputs for flame proving, and separate analog inputs for flame signal strength indication.
 - c. Assured low fire cutout shall be provided to drive the burner firing rate to low fire before shutting down the burner.
 - d. 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.
 - e. Adjustable time delays shall be provided for the low fuel pressure, low atomizing flow, and low draft cutout interlocks to reduce nuisance shutdowns due to transient conditions.
 - f. The controller shall accommodate automatic gas valve leak detection when required by the user.
 - g. Oil gun purge logic shall be provided to enable either the safe purging of any oil in the oil atomizer into the furnace (with pilot energized), or the activation of a scavenging pump to draw the unused oil out of the oil gun.
 - h. 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.
 - i. The controller will alarm and/or shut down the burner when a user-configurable low stack oxygen set-point is reached.
 - j. Individual annunciation shall be provided for up to six recycle limits and thirty-three non-recycle (lockout) limits.
 - k. The controller shall provide time/date stamp of individual servo positions, and the status of all controlled functions for up to the last eight boiler lockouts.
 - l. 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 lockout condition related to the flame safeguard system.
 - m. The control shall include the ability to do Automatic Change-over initiated by a dry contact from a temperature controller similar to the National Grid changeover controller.

C. Combustion Control System (CCS)

1. The combustion control system shall position up to eight independent servo actuators for fuel valves, and combustion air, or FGR control, as required. In addition up to two separate 4-20 mA analog outputs shall be provided for VSD operation.
 - a. PID combustion controls shall be designed to safely maintain the desired process variable (main steam header pressure, water or thermal fluid exit temperature) at the operator-selected value. A parallel positioning combustion control logic scheme with oxygen trim and 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 separate actuator(s) shall position the air control damper(s). Each actuator shall be equipped with an integral position transmitter. 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 flow position feedback signal.
- d. The controller shall automatically detect a failed or malfunctioning servo actuator. During purge, all servo actuators shall be driven to their minimum and maximum mechanical travel limit switch positions. If the feedback signal from any positioner does not match the original servo calibration data, the burner will go into lockout to prevent firing under dangerous conditions.
- e. The 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.
- f. 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 set-point curve for damper or variable speed fan output signal.
- g. Cold FGR low fire cutback shall be provided when FGR control is required. This ensures the FGR is heated to steady-state temperature before the burner is released for automatic operation.
- h. Whenever a curve point is changed by the technician, the controller shall require the burner to be run at that load to verify combustion at that point before the controller can be put in automatic mode.
- i. 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.
- j. The fuel controller shall be configured to provide for control of the gas and/or oil control valve, depending on the fuel selected.
- k. 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.
- l. The combustion controller shall contain independent variable speed and full speed bypass 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 (if provided) and restart the equipment. Separate servo actuator curves shall be supported for VSD bypass mode.
- m. “Off-curve” points shall be provided to allow the technician to determine the servo positions during standby, Ignition, and purge modes.
- n. All external or auxiliary power supplies necessary for electronic transmitters (or final control element) shall be included.
- o. The control shall include a field selectable draft control. The commissioning engineer shall be able to select proportional Floating Draft Control, or PID Draft Control with firing rate feedforward. The controller outputs shall be field selectable as Servo damper, 4-20 damper, VSD Draft Fan or combined damper and VSD Open Damper.

The draft damper starting position shall be full open or an Adjustable Starting position.

- p. Atomizing Media Pressure Control: The controller shall accept an input for atomizing air pressure. During commissioning, an atomizing air pressure curve shall be established. The controller will modulate an atomizing air flow control valve to keep the atomizing air pressure on curve at all firing rates despite fluctuations in atomizing air supply pressure.
- q. High Torque Servomotors. Integral with the boiler control system, the burner shall be supplied with high torque servomotors, 15-ft-lbs minimum, but up to 240 ft-lbs torque as required by the driven device. Servomotors shall include:
 - 1. Easy pushbutton set-up, not requiring the adjustment of internal or external potentiometers.
 - 2. Servo zero, span, and direction of travel shall be accomplished by push button configuration.
 - 3. Totally enclosed, dust tight, and splash-proof covers.
 - 4. Feedback potentiometer directly coupled to the output shaft without any gears, integral brake, 90° rotation in 25 seconds.
 - 5. The actuator shall be capable of being stopped, started, or instantly reversed without loss of power or overloading.
 - 6. Servo actuator positioning accuracy: 0.1 degrees. Servo full stroke safe start check shall be provided.
 - 7. For high torque applications such as water-tube boiler outlet dampers, servo torque shall be rated minimum 70 ft-lbs with 0.4 degree accuracy.
 - 8. No servo feedback adjustments shall be required with pushbutton zero setup. Adjustable travel limit switches shall be integral, with re-adjustment not requiring new fuel air ratio curve re-entry.
 - 9. Servos shall be cycled during each light-off cycle, and the feedback from each Servo monitored to ensure safe actuator operation.
 - 10. Servos shall be Preferred Instruments, model BMU-SM or BMU-UM (high torque).

D. Auxiliary Boiler Control Functions

- 1. Remote Boiler Operation. Call for heat (burner on signal) may be generated locally by an operating limit switch, or remotely by 120Vac input or Modbus communication. In addition, the controller shall allow either the boiler firing rate or steam pressure set-point to be determined remotely by either 4-20mA inputs or Modbus communication.
- 2. Warm Standby. To respond rapidly to a call for heat, the controller shall provide logic to cycle the burner in response to an external shell temperature, drum 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 adjustments.
- 3. 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, drum temperature, or steam pressure) set-point is reached.

4. 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.
5. Automated daily Low Water Cutout Test/Blowdown. When enabled, 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 cutout float switch and alarm or lockout the burner in response to a failed low water cutout test. Test result shall be time/date stamp logged in non-volatile memory.
6. Break glass Switches: Furnish and install two (2) break glass switches, one (1) at each boiler room exit. Cover and hammer shall be constructed of solid brass. A glass window in the cover shall maintain the switch in the closed position. The hammer shall be securely attached to the box with a chain. Switching mechanism shall be the single pole double throw type, connected so as to open when the glass is broken. Thermal cut-offs, break glass switches, and the spring loaded oil valve micro-switch shall be wired in series to shut down the boilers.
7. Thermal Cut-off: Furnish and install a Factory Mutual approved (hand wheel type) thermal cut-off set at 165° F on each boiler front, 24 inches above the burner. Mount another thermal cut-off 12 to 24 inches above the top-front edge of each boiler. Submit shop drawings for approval. All thermal cut-off switches shall be installed with the spindle in the horizontal position.
8. Feedwater Control (Steam Boilers): Provide a boiler water level controller capable of single-, two-, or three-element feedwater control. Single element logic utilizes only a drum level xmtr. Two element logic utilizes both a drum level and a steam flow xmtr. Three element logic utilizes a drum level, steam flow, and feedwater flow xmtr. Use the highest level control based on the xmtrs specified to be provided. Changing between feedwater control strategies shall be accomplished by parameter change.
 - a. Boiler drum level setpoint must be operator adjustable.
 - b. Provide a +/-0.2% accurate differential pressure 4-20 mA xmtr for drum level.
 - c. Feedwater flow control valve shall accept a 4-20 mA signal from the boiler controller, or be servo positioned.

E. Burner control panel

1. Factory mounted and wired control panels shall be provided (unless otherwise shown on plans). Wires shall be oil, heat and moisture resistant. Motor starter circuits shall be protected with thermal-magnetic circuit breakers. Electrical connectors to control panels shall be made to terminal blocks. Neutral connections to control devices shall be made to a common unbroken neutral conductor. Control panel enclosure shall be NEMA 12. Control voltage shall be 120 volts from an integral control circuit transformer. The control panel shall include the following devices.
 - a. Burner Management/Combustion Controller as detailed above with 10" color touch screen for Operation, Lockout reason display, Tuning, etc.
 - b. Switches: Burner On/Off, Gas/Off/Oil, Emergency Stop

- c. Pilot Lights: Low Water, Gas Valve energized, Oil Valve energized
- d. Motor Starters: Air Compressor, Oil Pump
- e. Branch circuit protection with circuit breakers
- f. Control Circuit Transformer
- g. Run Time Indicator: Non-resettable, non-volatile, meter to record the total number of hours of boiler operation. The meter shall have a six digit readout from 0 to 999,999 hours and shall be independent from the CCS, FSG, and OIT.

F. FD Fan Variable Speed Drive (VSD)

1. Provide a Pulse Width Modulation (PWM) type VSD suitable for microprocessor-based digital control.
 - a. The VSD shall be provided with a fused disconnect switch.
 - b. The VSD shall accomplish step-less speed control by adjusting both the output voltage and frequency to the motor.
 - c. The VSD shall utilize IGBT power semiconductor technology in the inverter section.
 - d. VSDs must be UL listed. Provide a NEMA 12 enclosure for the VSD to protect it from dust and splashed water. VSD shall be sized for 104° F continuous ambient air temperature conditions. The enclosure shall be completely self-ventilating with powered fans as required.
 - e. A NEMA type 1 rated enclosure will not be accepted.
 - f. The VSD shall automatically limit the rate of fan speed increase to that which will prevent an over-current or over-voltage trip in the event of a “STEP” speed increase of 0 to 100 %.
 - g. The VSD shall include a line reactor or DC Link Choke to reduce rectifier peak currents, and reduce total harmonic distortion (THD).
 - h. In order to extend motor insulation life, the VSD shall limit peak voltages. The “dv/dt” shall be limited to 900V/microseconds on a 500 foot cable length between the VSD and motor. VSD’s that do not include internal dv/dt limiting shall be provided with external filters.
 - i. The VSD shall control the speed of the forced draft fan. The VSD shall be Danfoss Model FC-102-DGB1241.

G. Boiler Instrumentation (as required)

1. Provide a draft range transmitter and high pressure (low draft) switch with time delay relay.
 - a. Both shall be supplied in dust-tight, splash-proof enclosures. Mount near and above the boiler outlet tapping with impulse tubing sloping continuously down to prevent improper operation due to trapped flue gas condensate.
 - b. A single draft connection shall be piped to -1"wc to +1"wc 4-20 mA dc transmitter and an independent UL Listed low draft switch.
 - c. The low draft switch set point shall be field adjustable from +0.05"wc to +1.0"wc.
 - d. The low draft switch shall include a pilot light that illuminates when the low draft switch activates. If the conditions persist for more than 5 second, the integral time delay relay “Low Draft Cut-Out” 10 ampere contacts shall cause a burner Lock-out. The time delay feature helps avoid nuisance burner shutdowns due to momentary draft fluctuations.
2. Provide manufacturer’s standard damper and a servo draft damper actuator for each boiler.

- a. The actuator shall be direct coupled to the damper shaft and have adequate power to position the damper and shall be suitable for control by the draft controller.
 - b. The actuator shall be totally enclosed in a dust-tight housing; be capable of being stopped, started, or instantly reversed without loss of power or overloading. Provide an open damper interlock switch, or via servo feedback if the servo is UL listed for combustion control.
3. Provide a stack temperature alarm and shutdown circuit for each boiler.
 - a. Stack temperature shall be digitally displayed and setpoints shall be provided for "inefficient" and "dangerous" alarm conditions.
 - b. Inefficient alarm setpoints will sound a local alarm requiring acknowledgement to silence.
 - c. Dangerous stack temperature conditions will shut the boiler down and require a manual reset.
4. Provide a boiler breeching mounted in-situ, zirconium oxide Oxygen analyzer for each boiler.
 - a. Extractive or "Wet Cell" type Oxygen analyzers are not acceptable.
 - b. The probe shall be of a suitable length for sensing the Oxygen level in the middle third of the breeching.
 - c. All wetted parts shall be stainless steel.
 - d. The Oxygen analyzer shall include a digital controller that performs continuous self-diagnostics with diagnostic codes for at least 10 common faults.
 - e. The system shall automatically force the oxygen trim control to the "null" position and trigger an alarm in the event of an Oxygen analyzer fault.
 - f. The detector shall be field replaceable without removing the probe from the stack and shall not require special tools.
 - g. The analyzer shall automatically perform periodic detector cell impedance tests to be used by the operator as an indication of calibration shift.
 - h. Analyzer calibration shall be pushbutton semi-automatic (no trim pots) with English language prompts and diagnostic messages.
 - i. Analyzer output shall be field selectable as 0-10% or 0-21% without field recalibration.
 - j. Analyzer shall be Preferred Instruments, Danbury, CT, Model ZP.
5. Smoke Opacity Monitors (One for Each Boiler): Provide a Smoke Opacity Monitor for each boiler.
 - a. The smoke monitor shall consist of a NYC BAR approved LED light source, solid-state optical detector, microprocessor-based alarm and indicating instrument, and remote smoke alarm.
 - b. The instrument shall provide a smoke opacity percent display in engineering units, warning indication, burner Safety Shutdown indication and relay contacts.
 - c. The instrument shall continuously indicate smoke density on a highly visible backlit LCD display.
 - d. Provide an integral or separate 4", 0.5% resolution (minimum) barograph display in engineering units with visual alarm setpoint indication.
 - e. Provide an "Alarm Silence" and "Manual Reset" pushbutton and two 10 ampere relays.
 - f. The housing shall be panel mountable, fully gasketed with NEMA 4 front face.
 - g. All adjustments shall be made from the front panel display in engineering units.
 - h. The "Standard" Operating Sequence shall be as follows:
 - 1) When smoke density exceeds setpoint, the barograph shall flash, and an "Alarm" message shall appear, and the Alarm relay contacts make.

- 3) Pressing the “Alarm Silence” pushbutton resets the alarm relay to silence the alarm device.
 - 4) If the smoke density reduces below the setpoint within 120 seconds (adjustable), the barograph stops flashing and the “Alarm” message disappears.
 - 5) If the smoke density exceeds the setpoint for 120 seconds or more, the “Shutdown” message shall appear, the “Alarm” relay re-closes and manual reset “Shutdown” relay contact open to shut down the violating burner.
 - 6) Pressing the “Alarm Silence” pushbutton resets the alarm relay to silence the alarm device.
 - 7) When the smoke density then falls to below the setpoint, the “Shutdown” message will remain on and the “Shutdown” relay will remain in the manual reset mode.
 - 8) With smoke opacity cleared, pressing the “Reset” pushbutton will reset the system, the “Shutdown” message will disappear, the “Shutdown” relay will reset to permit normal burner operation.
 - j. The optical sensing unit lenses shall be designed to accommodate regular cleaning without dismantling the installed assembly.
 - k. Light Source and Detector will sight 100% of the effluent path length.
 - l. Light Source will utilize a pre-focused long life LED lamp with a maximum 5 degree projection angle.
 - m. Photo Detector shall include a photopically filtered, solid state photo cell.
 - n. The Instrument shall include a RS485 Modbus network interface and a 4-20 mAdc retransmit output to communicate to a future Data Acquisition System (DAS) or Building Automation System (BAS).
 - o. The Instrument shall be manufactured and labeled in accordance with UL508 requirements (CSA C22.2 #14 for use in Canada). The opacity control system shall be a Preferred Instruments, Danbury, CT, Model JC-30D.
6. Digital gas meter: Provide a thermal dispersion Mass Flowmeter with an integral transmitter that will directly measure, indicate, totalize and transmit a linear 4-20 mA signal and a pulse output corresponding to the mass flow of the natural gas. The thermal mass flowmeter shall have the following features:
- a. Operating Principle: Constant temperature thermal anemometer circuit using two industrial grade Platinum.
 - b. 200 millisecond response time
 - c. Programmable pulse output for remote totalization
 - d. Optional Modbus Communications
 - e. Smart electronics to permit field adjustment of critical flow meter settings.
 - f. Field validation of flow meter calibration
 - g. NEMA 4X housing
 - h. Product and Manufacturer: The Insertion Mass Flow Transmitter shall be Model 620S BT as manufactured by Sierra Instruments.
7. Digital oil flowmeter: Provide a positive displacement gear type digital oil flowmeter with local indication to include flow and total. Flowmeter to have a pulse or 4-20mA signal compatible with the combustion control system. Flowmeter are to be manufactured by Great Plains or approved equal.

2.06 Warranty:

- A. Complete burner - boiler package to have a limited warranty on all materials and components supplied for 3 years from date of initial commissioning including material and labor. Manufacturer will submit detailed provisions of warranties as part of submittal packages.
- B. Boiler tube sheets and rear submerged combustion chamber to carry a fifteen (15) year parts and labor warranty.
- C. Front and rear flue doors to carry a fifteen (15) year parts and labor warranty.
- D. The burner shall carry a limited warranty of ten (10) years for parts only.

2.07 Packaged Boiler Commissioning:

- A. The 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.
- C. A comprehensive start-up report shall be completed and provided to the job site and other parties.
- D. Factory authorized training for operators, maintenance, and others shall be performed at the time of commissioning.
- E. UL Listing of the boiler-burner package shall be fulfilled prior to the final equipment acceptance after installation and commissioning.

2.08 BOILER MASTER CONTROL PANEL AND LEAD/LAG CONTROL

- A. Supply a fully integrated boiler control system to coordinate the operation of [up to 10] fully modulating steam boilers in order to maintain Steam Header Pressure at setpoint. The control system shall be microprocessor-based and suitable for wall mounting.
- B. The control system shall provide a PID based Boiler Modulation control scheme. Modulation shall be field selectable as either "Unison" (all at the same firing rate) or as "Series". Series modulation shall include "Base Load Auto-Shift" logic in order to minimize boiler on/off cycling. When the lead boiler's firing rate approaches high fire, the lag boiler(s) will automatically modulate up from the base load firing rate to "help" the lead boiler without starting another lag boiler. If the lead boiler approaches low fire, the lag boilers will modulate toward low fire to "help" the lead boiler and prevent a short cycle of a lag boiler. When the lead boiler leaves the high or low fire position the lag boiler(s) resume firing at the normal base load for peak efficiency. If the load increase or decrease is long term, a lag boiler shall be cycled on or off as required. Modulation signals shall be 4-20 mA_{dc} or 0-135 ohm (as required by the boiler) and shall be electrically isolated channel-channel and channel-ground.
- C. The operator may set the Steam Header Pressure Setpoint via a front panel display.
- D. The control system shall utilize both Steam Header Pressure and Boiler Firing Rate percent to start and stop the boilers and minimize the total number of boilers in operation. The controller shall start and stop boilers when the Steam Header Pressure is outside an adjustable pressure

limit band for longer than an adjustable short time delay. To anticipate and minimize header pressure deviations, the control system shall start or stop the next boiler if the “lead” boiler has been near high or low fire for longer than the adjustable time delay. The control system shall monitor each boiler’s lockout and limit circuits and shall rapidly and automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate every 1 to 168 hours or shall be manually selected by the operator. Provide a warm standby boiler shell aquastat input for each boiler. If recommended by the boiler manufacturer, the next off-line boiler in the sequence shall be periodically started and held at low fire until the warm standby temperature is reached, and then stopped. When called to run, the boiler shall hold at low fire until the temperature rises above the warm standby setting. Provide an aquastat release to modulate over-ride timer to prevent a protracted low fire hold. The Control System shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.

- E. The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tuning and troubleshooting. Alarms, events and operator actions shall be logged with Time/Date stamp and English language description. The Control System shall include a minimum of 200 point memory.
- F. Include hard wired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hard wired “Hand-Off-Auto” control switches must be wired directly into every boiler Start/Stop circuit. Each 4-20 mA_{dc} or 0-135 ohm modulating control output must include a hard wired manual backup station with Auto/Manual switch, output control knob and output level indicator (Bargraph, analog meter or digital display).
- G. The Control System shall communication to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be remotely readable and writable.
- H. The control system shall be manufactured and labeled in accordance with UL508 requirements. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). It shall be approved for use in NYC by Department of Building, Bureau of Electrical Control and Department of Air Resources. The control system shall be a Preferred Instruments, Danbury, CT, Model PWC-DGB-1241 or equal.

2.09 Boiler Room Alarms

Contractor shall provide a local boiler room alarm system and connect to NYCHA Intranet for the remote monitoring of flood alarm, power failure alarm and low steam pressure alarm. Contractor must engage a CHAS system specialist (Intech 21) for the installation of the alarm system.

A. Alarm’s Communication Panel

1. Provide, install and program a new RE2104/w new enclosure, by Intech21.
2. Provide a dedicated 110VAC/15A circuit for the RE2104 alarm panel.
3. provide testing and certification of communication wiring to ensure reliable communications to CHAS application.

4. Provide and connect CHAS alarm sensor pressure sensor (pressuretrol) or aquastat electrical supply monitoring sensor relay and flood sensor. Alarm sensor points must be wired to new communication panel for remote alarm point monitoring.
5. Remove all existing computer, RE2104 and wiring during removal of equipment. Reinstall and reconnect all existing wiring and cables as required to complete the CHAS system
6. Purchase/ install new server at 90 church street, by Intech21

B. Local Server Requirements for Hybrid Sites and Storm Damaged Sites

Processor: Quad-core Core Intel Xeon E3, 3.10 GHz, 8 MB Cache 1.33 GHz FSB.

Memory: 16 GB UDDR2 1333 MHz

Operation System: Windows Server 2008 SP2

Primary Hard Drive: 1TB 7.2K RPM SATA 3Gbps 3.5 Cable Hard Drive

Secondary hard Drive: 1TB 7.2K RPM SATA 3Gbps 3.5 Cable Hard Drive

Network adapter: Intel Pro 1GbE Dual Port NIC

HD Controller: Onboard SATA, 1-4 Hard Drives connected to onboard SATA Controller- No RAID

Database: SQL Server 2008 R2 SP1 Express Edition

ASP.NET: .NET Framework version 4.5

Additional Software: Intech BMS CHAS Local Server Edition

Network adapter: 1GbE 2 port NIC

Input / Output: keyboard and Optical Mouse

Optical Media: DVD- Rom

Monitor: Two 17" LCD Monitors

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Boiler and Burner Access Openings: Arrange all equipment and piping to allow access to openings without disassembly of equipment or piping. Provide space that permits full opening of all boiler and burner doors, panels and other access openings. Provide space for pulling full length of all boiler tubes directly from their installed location.
- B. Drainage Facilities for Boiler Water Column, Gage Glass, Low Water Cutoffs, Water Level Alarms:
 - 1. Refer to Detail, FIRETUBE BOILER.
 - 2. Locate and orient sight flow indicators so that one person can view the fluid flow while simultaneously operating drain valves and low water cutoff shunt switches.
- C. Boiler Flue Gas Outlet Location: Drawings show a location based on an assumption on the number of passes of the boilers. If the boilers submitted have a different flue gas outlet location, redesign and relocate the stack and breeching systems, at no additional cost to the Government.
- D. Boiler Casing Flashing: Flash or seal all openings in the casing at the top of the boiler at the piping and the flue penetrations to prevent leakage of water into the boiler insulation.

3.2 CLEANING AND PROTECTION FROM CORROSION:

- A. Boiler Cleaning:
 - 1. Upon completion of installation, the initial firing of the burner shall be performed to boil out, under supervision of boiler manufacturer, all internal surfaces with chemical solution recommended by boiler manufacturer, to remove all mill scale, corrosion products and other foreign material. Following boil out, boiler shall be washed and flushed until water leaving the boiler is clear. Drain boiler, inspect internal surfaces for cleanliness, then refill boiler with softened and treated water.
 - 2. Refer to the section INSPECTIONS AND TESTS for requirements for cleaning boiler after operational tests are completed.
- B. Protection from Corrosion:
 - 1. Protect the boilers from fire-side and water-side corrosion at all times.
 - 2. Dry Storage: When the boilers are not filled with water, protect the water-sides and fire-sides with a dry storage method recommended by either the boiler manufacturer or the ASME Code, Section VII.
 - 3. Wet Storage: If, after water is placed in the boilers, they are not fired for equipment adjustment or testing for more than two weeks, the boilers shall be protected with a wet storage method recommended either by the boiler manufacturer or the ASME Code, Section VII.
 - 4. Chemical Treatment: The quality of the water in the boilers shall be maintained by a professional water treatment organization furnished by the owner/end user.

3.3 INSPECTIONS AND TESTS:

- A. The following tests and demonstrations must be witnessed by the owner or his/her representative, and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements.
- B. Condition of Boiler and Economizer (if provided) After Delivery, Rigging, Placement: After setting boiler on foundation and placing economizer on supports, and prior to making any connections to boiler and economizer, the Contractor and owner's representative shall jointly inspect interior and exterior for damage. Correct all damage by repair or replacement to achieve a like new condition.
- C. Hydrostatic Tests:
1. Boiler, Economizer (if provided): Contractor shall hydrostatic test after equipment is installed and connected for operation and prior to initial firing. Test pressure shall be 1-1/2 times the design pressure of the boiler for a period required by the inspector. Provide written certification of the satisfactory test, signed by the owner's representative. Correct any deficiencies discovered during the testing, and re-test equipment until satisfactory results are achieved and are accepted by the owner.
 2. Boiler External Piping (as defined by ASME B31.1, Power Piping):
 - a. Test may be conducted concurrently with boiler and economizer testing.
 3. Identify and remove any connecting equipment which is not rated for the test pressure. Cap the openings left by the disconnected equipment. Reinstall the equipment after tests are completed.
- D. Boiler Steam Safety Valves:
1. Test each valve set pressure and blowdown pressure with boiler steam pressure. Perform accumulation test by operating burner at high fire to verify that safety valve flow capacity is sufficient to handle the maximum boiler steaming rate. Tests shall be performed with boiler isolated from the main steam header and all generated steam exhausting through the safety valves.
 2. Valve Popping Tolerance: Plus or minus three percent of set pressure for set pressures over 480 kPa (70 psi) gauge.
 3. Valve Blowdown Tolerance: Reset at not less than 6 percent below set pressure of valve with the lowest set pressure. Minimum blowdown two percent of the set pressure.
 4. Accumulation Test: With burner at high fire, the boiler pressure shall not rise more than six percent above the set pressure of the safety valve with highest pressure setting and shall remain below the maximum allowable working pressure of the boiler.
- E. Burner Control (Flame Safeguard-Burner Management) System:
1. Demonstrate operation of all control, interlock and indicating functions.
 2. Prior to scheduling final test submit certification that all control, indicating, and interlock functions have been pretested.
 3. Conduct final test immediately prior to boiler-burner tests.
 4. Experienced personnel representing the manufacturer of the system shall conduct the tests.

F. Performance Testing of Boiler, Burner, Economizer (if provided), Combustion Control, Boiler Plant Instrumentation:

1. Perform tests on each boiler on all main burner fuels.
2. If required by local emissions authorities, provide services of testing firm to determine NO_x and carbon monoxide. Test firm shall be acceptable to emissions authorities.
3. Boiler Performance Test
 - a. Operate boiler on each fuel, with economizer (if provided) in service and record data for at least six evenly spaced steam loads from low fire start to 100% of full steam output, and in the same sequence back to low fire. Demonstrate performance and efficiency required by paragraphs under Articles, BOILER, BURNER AND FUEL TRAINS, and ECONOMIZER and by boiler and economizer equipment lists on drawings.
 - b. Demonstrate proper operation of combustion controls, draft control (if provided), feedwater level controls, and instrumentation systems
 - c. When flue gas oxygen trim is provided, conduct tests with trim control on manual at the zero trim (null) position. After completion of tests with trim control on manual control, repeat the tests on one fuel with the trim control on automatic control.
4. Sound Level Test
 - a. Demonstrate sound level of fans and burner systems and atomizing air compressor.
 - b. Test point shall be at 100 percent of maximum boiler load.
5. Current Draw Text
 - a. Check current draw of forced draft fan motor at pre-purge and at 100 percent of maximum boiler load.
 - b. Current draw shall not exceed full load current stamped on motor nameplate.
 - c. This test may be combined with performance testing.
6. Test Methods:
 - a. Utilize permanent instrumentation systems for data. All systems shall be operable and in calibration.
 - b. Use portable electronic flue gas analyzer to determine constituents of flue gas. Analyzer shall be capable of measuring oxygen in per cent with accuracy of plus or minus 0.5 percent oxygen and carbon monoxide in parts per million (ppm) with accuracy of plus or minus 5 percent of reading (Range 0-1000 ppm). Obtain oxygen and carbon monoxide readings at each test point. Calibrate instrument with certified test gases within three months prior to use and immediately after analyzer cell replacement.
 - c. During performance test, retain boiler at each load point for a time period sufficient to permit stabilization of flue gas temperature and other parameters.
 - d. Steam loads for tests may be furnished by operation of the steam silencer vent system.
 - e. NO_x emissions shall be tested with electronic analyzer reading in parts per million. Analyzer shall be calibrated with certified test gas within three

months prior to use. Analyzer shall be accurate to plus or minus 5% of reading.

- f. An additional efficiency test will be required, conforming to ASME Performance Test Code PTC 4, if the boiler efficiency determined in the Test P-1 above, does not comply with requirements. Utilize ASME Test Forms PTC 4.1.a, 4.1.b, or the abbreviated input-output and heat balance methods.

3.4 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the owner's representative

3.5 COMMISSIONING

- A. Provide commissioning for all inspection, start up, and contractor testing required.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours per shift to instruct all personnel responsible in the operation and maintenance of units.
- B. The burner control system controller shall be able to be communicated via cable to computer loaded with control edit software program to set and adjust control parameters.

3.7 WARRANTY:

1. Complete burner - boiler package to have a limited warranty on all materials and components supplied for 3 years from date of initial commissioning including material and labor. Manufacturer will submit detailed provisions of warranties as part of submittal packages.
2. Boiler tube sheets, and rear submerged combustion chamber to carry a fifteen (15) year parts and labor warranty.
3. Front and rear flue doors to carry a fifteen (15) year parts and labor warranty.

3.08 PACKAGED BOILER COMMISSIONING:

1. The contractor will ensure that all utilities, connections, piping, electrical, and other associated equipment and tie-ins are completed, serviceable, and ready for boiler operation.
2. The boiler manufacturer will make available the services of a factory authorized service engineer for the boiler start-up.

3. A comprehensive start-up report shall be completed and provided to the job site and other parties.
4. Factory authorized training for operators, maintenance, and others shall be performed at the time of commissioning.

3.09 BOILER MASTER CONTROL AND INSTRUMENTATION PANEL

- A. Supply a fully integrated boiler control system to coordinate the operation of four fully modulating steam boilers in order to maintain Steam Header Pressure at setpoint. The control system shall be microprocessor-based and mounted and wired in the master control panel.
- B. The control system shall provide a PID based control scheme. Modulation shall be field selectable as either “Unison” (all at the same firing rate) or as “Series”. Series modulation shall include “Base Load Auto-Shift” logic in order to minimize boiler on/off cycling. Normally the lag boilers shall be base loaded at an operator adjustable firing rate for peak efficiency. When the lead boiler’s firing rate approaches high fire, the lag boiler(s) will automatically modulate up from the base load firing rate to “help” the lead boiler without starting another lag boiler. If the lead boiler approaches low fire, the lag boilers will modulate toward low fire to “help” the lead boiler and prevent a short cycle of a lag boiler. When the lead boiler leaves the high or low fire position the lag boiler(s) resume firing at the normal base load for peak efficiency. If the load increase or decrease is long term, a lag boiler shall be cycled on or off as required. Modulation signals shall be 0-135 ohm and shall be electrically isolated channel-channel and channel-ground.
 - i. The operator may set the Steam Header Pressure Setpoint via a front panel display.
 - ii. The control system shall utilize both Steam Header Pressure and Boiler Firing Rate percent to start and stop the boilers and minimize the total number of boilers in operation. The controller shall start and stop boilers when the Steam Header Pressure is outside an adjustable pressure limit band for longer than an adjustable short time delay. To anticipate and minimize header pressure deviations, the control system shall start or stop the next boiler if the “lead” boiler has been near high or low fire for longer than the adjustable time delay. The control system shall monitor each boiler’s lockout and limit circuits and shall rapidly and automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The lead boiler shall either automatically rotate every 1 to 168 hours or shall be manually selected by the operator. Provide a warm standby boiler shell aquastat input for each boiler. Each off-line boiler shall be started and held at low fire when the temperature drops. When called to run, the boiler shall hold at low fire until the temperature rises above the warm standby setting. Provide an aquastat release to modulate over-ride timer to prevent a protracted low fire hold. The Control System shall reduce the firing rate to a minimum before stopping a boiler to prevent accumulation of fuel in the furnace.
- C. The control system shall include a 16 line x 40 character (or greater) LCD display for boiler sequence control and status, alarm and event summaries, and setup menus for easy operation, tun-

ing and troubleshooting. Alarms, events and operator actions shall be logged with Time/Date stamp and English language description. The Control System shall include a minimum of 200 point memory. The Control System shall include a minimum 100x150 pixel historical trending display or a paperless chart recorder or other videographic hardware to permit logging of at least 32 data points for at least 45 days. Provide a minimum of 4 “pens” per chart with 8 minute thru 24 hour chart “width” selections available.

- D. Include hard wired backup stations to permit manual operation of the plant should the control system require service. Manual operation must be possible when the microprocessor is not functioning. Hard wired “Hand-Off-Auto” control switches must be wired directly into every boiler Start/Stop circuit. Each 0-135 ohm modulating control output must include a hard wired manual backup station with Auto/Manual switch, output control knob and output level indicator (Bargraph, analog meter or digital display).
- E. The Control System shall include simultaneous communication to a Data Acquisition System (DAS), Building Automation System (BAS) or Building Management System (BMS) via RS485 Modbus protocol and to a Personal Computer and an alphanumeric pager via standard telephone lines. The individual boiler limits, lockout, start/stop, warm standby, and firing rate status shall be readable. Header setpoint, plant firing rate, boiler quantity called to start, boiler selected as lead and all setup parameters shall be readable and writable.
- F. Provide a self-contained automatic sequence draft controller for each boiler. The controller shall be microprocessor-based and panel mounted. Provide a field mountable 4-20 mAdc pressure draft transmitter for measuring boiler outlet draft. Provide a high flue gas pressure (low draft) switch with 5 second delay for use in the Flame Safeguard Limit Circuit. The Controller shall continuously indicate boiler draft, draft setpoint and alarm setpoint on a highly visible backlit LCD display. The control shall provide both automatic and manual damper control. Provide an integral or separate 4", 0.5% resolution (minimum) bargraph display in engineering units with visual alarm indication. Provide a “High Boiler Pressure” alarm, “Alarm Silence” pushbutton and one 10 ampere alarm relay output. The housing shall be panel mountable, fully casketed with NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. The controller shall include setup menus for easy operation, tuning and troubleshooting from the Controller faceplate. No external configuration tools shall be required. The controller shall include an automatic draft sequence as follows: During burner “off” periods the draft control damper shall remain closed to hold residual heat within the boiler. On a call for burner operation the outlet damper shall be driven open for pre-purge. To prevent pressurizing the boiler, the burner fan shall start after a field adjustable time delay after starting to open the draft damper. The damper shall remain open for burner light-off. When the fuel valve opens, the draft control damper shall be released from the open position and modulate as required by the draft setpoint. During normal burner shut-down the damper shall be driven open during the post-purge period and then closed when the fan stops. Abnormal burner shut-down (safety lock-out of flame safeguard control) shall cause the damper to drive open where it shall remain until the flame safeguard system is reset. The controller shall interconnect with the flame safeguard system directly using 120Vac signals. The controller shall be capable of establishing an adjustable position for burner light-off. Each fuel shall have an independent light-off position. The controller shall not close the light-off contact output unless the damper is above the proper position and the pressure is below the starting draft setpoint.
- G. Provide a draft range transmitter and high pressure (low draft) switch with time delay relay. Both shall be supplied with field mountable, dust-tight, splash-proof enclosures. A single draft connection shall be piped to -1"wc to +1"wc 4-20 mAdc transmitter and an independent low draft switch. The low draft switch setpoint shall be field adjustable from +0.15"wc to +4.0"wc. The low draft switch shall be mounted and wired to a pilot light so as to illuminate when the

low draft switch activates and to a 5 second time delay relay so as to provide an isolated “Low Draft Cut-Out”, 10 ampere contact for use in the Flame Safeguard Limit Circuit. The time delay feature helps avoid nuisance burner shutdowns due to momentary draft fluctuations.

- H. Provide manufacturer’s standard Damper and an electric Draft Damper Actuator for each boiler. The actuator shall have adequate power to automatically position the damper and shall be suitable for control by the Draft Controller. The actuator shall be totally enclosed in a dust-tight housing; have integral, snap-action, travel limit and open proving switches, be capable of being stopped, started, or instantly reversed without loss of power or overloading. A double ended output shaft shall have an integral brake for precise positioning without backlash and rotate 90° in 30 seconds.
- I. Provide a stack temperature alarm and shutdown circuit for each boiler. Stack temperature shall be digitally displayed and setpoints shall be provided for "inefficient" and "dangerous" alarm conditions. Inefficient alarm setpoints will sound a local alarm requiring acknowledgement to silence. Dangerous stack temperature conditions will shut the boiler down and require a manual reset.
- J. Provide Smoke opacity monitors (one for each boiler)
Provide a Smoke Opacity Monitor for each boiler. The smoke monitor shall consist of a NYCBAR approved light source, solid-state optical detector, microprocessor-based alarm and indicating instrument, and remote smoke alarm. The instrument shall provide a smoke opacity percent display in engineering units, warning indication, burner Safety Shutdown indication and relay contacts. The instrument shall continuously indicate smoke density on a highly visible backlit LCD display. Provide an integral or separate 4", 0.5% resolution (minimum) bar graph display in engineering units with visual alarm setpoint indication. Provide an “Alarm Silence” and “Manual Reset” pushbutton and two 10 ampere relays. The housing shall be panel mountable, fully gasketed with NEMA 4 front face. All adjustments shall be made from the front panel display in engineering units. The “Standard” Operating Sequence shall be as follows: When smoke density exceeds set point, the bar graph shall flash, and an “Alarm” message shall appear. After a 20 second “smoke-puff” delay the “Alarm” relay contact closes the circuit for the remote alarm device. Pressing the “Alarm Silence” pushbutton resets the alarm relay to silence the alarm device. If the smoke density reduces below the set point within 120 seconds (adjustable), the bar graph stops flashing and the “Alarm” message disappears. If the smoke density exceeds the set point for 120 seconds or more, the “Shutdown” message shall appear, the “Alarm” relay re-closes and manually reset “Shutdown” relay contact open to shut down the violating burner. Pressing the “Alarm Silence” pushbutton resets the alarm relay to silence the alarm device. When the smoke density then falls to below the set point, the “Shutdown” message will remain on and the “Shutdown” relay will remain in the manual reset mode. With smoke opacity cleared, pressing the “Reset” pushbutton will reset the system, the “Shutdown” message will disappear, the “Shutdown” relay will reset to permit normal burner operation. In order to avoid nuisance burner trips due to dust build-up on the light source and sensor, the instrument must include an automatic, unattended re-calibration cycle whenever the burner fan stops running (ensuring a clear stack condition). The optical sensing unit lenses shall be designed to accommodate regular cleaning without dismantling the installed assembly. Light Source and Detector will sight 100% of the effluent path length. Light Source will utilize a pre-focused sealed beam lamp with a maximum 5 degree projection angle. Photo Detector shall include a photopically filtered, solid state photo cell and alignment verification bulls eye. The Instrument shall include a RS485 Modbus network interface and a 4-20 mAdc retransmit output to communicate to a future Data Acquisition System (DAS) or Building Automation System (BAS). The Instrument shall be manufactured and labeled in accordance with UL508A requirements (CSA C22.2 #14 for use in Canada). Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The draft control

system shall be a Preferred Instruments, Danbury, CT, Model JC-30D. Smoke opacity monitors shall be equipped and wired so as to actuate an audible and visual alarm in both the boiler room (central panel) and the engineers room (remote panel).

K. Microprocessor Lead-Lag Master Controller

1. The controller shall be pre-engineered and programmed exclusively for operation of multiple full modulating steam boilers.
2. The controller shall be UL Listed, tested per Standard 873 and CSA listed, tested per Standard C22.2 number 24-1987. It shall be approved for use in NYC by City of New York, Department of Buildings, Bureau of Electrical Control and Department of Air Resources.
3. The controller must be installed in accordance with the manufacturer's instructions and all applicable codes and regulations.
4. The controller shall be of modular construction to facilitate field modification, upgrading or repair.
5. The manufacturer shall set up installation supervision and full training program for building personnel.
6. The controller shall be compatible with the heating control system.
7. The contractor shall provide all required equipment, electrical and control wiring and conduits for the installation of the new Lead/Lag controller.
8. The control shall operate on 120 VAC, with a maximum power of 40 watts. The control shall operate between 20 and 130°F with an operating humidity of 20 to 80% RH (non condensing) with a storage temperature of no less than -4 and no more than 180°F.
9. The new microprocessor Lead/Lag controller shall be Multi-Mod by Heat Timer or Chief Dispatcher by Preferred Instruments and shall have the following features:

Display

The control shall have a four line by twenty character VFD display capable of displaying both numbers and characters. The display shall be visible with no ambient light. All control operation information shall be available for display.

During times of inactivity, or 15 minutes after last user entry, the display shall enter a lower power mode. In this mode, the display shall reduce visible light output. The control shall exit this mode whenever button or digital encoder activity is sensed.

User Information Entry

The control shall use five push buttons and one rotary digital encoder for user parameter entry. User parameter entry shall be accomplished using a menu system.

Network/Communications Capability

The controller shall be provided with remote communication capability and shall be capable of being field upgraded for use of future LON Works network.

The control shall be Johnson Metasys compatible. This communication shall be via RS485. The control shall have dual RS485 output capability to communicate with any two of the following: TGC, Notifact, or Metasys.

Sensors

The control shall have the capability of operating in a temperature or pressure mode. Temperature sensors shall be of the thermistor type. Standard operating range shall be -30 to 250°F. Pressure sensors shall be of the 4-20ma type. Standard operating range shall be selectable for 0-15, 0-30, 0-100, 0-200 and 0-300 PSIG.

External Shutdown

The control shall accept a dry contact input to shut all boiler stages down. The control shall keep any boilers being shut down in low fire for 45 seconds before opening the limit circuit relay.

Boiler Lockout Inputs

The control shall be capable of accepting four dry closure type boiler lockout inputs.

Outputs

The control shall have four normally open contacts that can be used to start/stop the burner. These outputs shall have a minimum current carrying capability of 5 amps. The relays controlling these outputs shall be field replaceable.

The control shall have four modulating outputs. These outputs shall be modules with two outputs per module. The control shall have the capability to operate modules having 0-5 volts, 1-5 volts, 0-10 volts, 2-10 volts, 135 ohm, and 4-20 ma outputs. The control shall be capable of operating two different output groups. The control shall be capable of identifying the output module types and adjusting control methods accordingly. Where practical, the output modules shall be protected from accidental incorrect connection. Should damage occur, where practical, damage shall be confined to the output module.

Additional Outputs

The control must be able to accept an extension module to increase the capacity by an additional 8 stages. All of the functions of the extension module will be displayed on the Multi Mod.

System Prove

The control shall be capable of accepting a dry closure type system prove input. This shall prevent any stages from activating until the contact is closed.

System Output

The control shall have a set of N.O. contacts that shall close when the Multi-MOD requires output. These contacts will remain closed for an adjustable period of time after the last stage is turned off.

User Parameters

The control shall have the following user adjustable parameters:

Sensor Set Point:

The control shall provide an integral sensor set point adjustment. The set point shall be adjustable in 1°F or 1 PSIG increments.

Ignition Start Point:

Adjustable from 1 to 50%. This setting shall determine the position of the firing rate (fully modulating) motor at the time the burner is energized or de-energized. There shall be an independent adjustment of this setting for each burner.

Modulation Start Point:

Adjustable from 0 to 100%. This setting shall determine the percent modulation a stage must achieve before the next stage is activated. There shall be an independent adjustment of this setting for each burner.

Purge Timer:

Adjustable from 0-10.0 minutes. This setting shall determine the delay time between a stage being energized and the beginning of modulation.

Lag Stage Delay:

Adjustable from 0 to 60 minutes. The next stage in the rotation shall not be fired until the previous stage has remained in high fire for the period of time set by the Lag Stage Delay.

Setback:

Setback shall be adjustable from 0 to 75°F, or 0 to 7.5 PSIG on 0-15 or 0-30 PSIG units, 0 to 75 PSIG on 0-100 PSIG units, 0 to 150 PSIG on 0-200 PSIG units, or 0 to 200 PSIG on 0-300 PSIG units. This setting shall determine the °F/PSIG drop from the primary set point whenever the setback mode is activated. The setback mode shall be activated by an external switch closure.

Standby Timer:

Adjustable from 1 to 60 minutes. This setting shall determine the delay period that must elapse before any designated standby stages are activated.

System Delay:

Adjustable from 0 to 60 minutes. This timer shall start after the last stage has turned off. The System contacts will remain energized until the time period has ended.

Rotation Mode:

The control shall be capable of the following rotations:

Manual rotation

Automatic rotation adjustable in one-hour increments from 1 hour to 7 days

First on/First off

Heat/Cool Mode

The control shall be capable of running either in a heating mode or a cooling mode.

Parallel Modulation Mode:

The control shall be capable of operating stages such that all active stages modulate at the same rate.

Process Mode:

The control shall be capable of accepting a throttling range around the set point.

Battery

A lithium “coin” type battery shall be included to maintain all system parameters in the event of a power failure. Storage capacity shall be 100 days.

- N. The control panel shall be manufactured and labeled in accordance with UL508. Inspection and labeling shall be supervised by UL or other OSHA approved Nationally Recognized Test Lab (NRTL). The control system shall be by Preferred Instruments, Danbury, CT, as represented by Analytical & Combustion Systems, Inc. or equal.

3.10 AUTOMATIC CHANGEOVER

- A. Changeover of fuels shall be accomplished automatically by means of an outdoor thermostat. Gas fuel shall be burned when outdoor temperature is above 22°F. On a fall in outdoor temperature to 20°F and below, oil shall be burned. On a rise in outdoor temperature back up to 22°F the changeover shall go to burning gas fuel. The changeover system controls and wiring to the burners circuitry shall be in accordance with the specific requirements of the Gas Utility Company. The Contractor shall obtain from the Gas Utility Company their requirements for the burner gas-train and their accessories together with the approved type of outdoor thermostat required and shall also obtain approval of the Gas Utility for this portion of the installation. The sensing element of the changeover control shall be mounted as directed, shall not touch the building surface and shall be provided with cover to protect the element but still allow free air passage. Changeover relay shall be mounted in the Master Control Panel.
- B. The location of the outdoor changeover control shall be approved by the Gas Utility.

- C. A pressure switch shall be installed at the inlet of the burner train and shall be wired in series with the outdoor changeover control. The wiring schematics, necessary for the installation of this switch, shall be provided by the burner manufacturer and coordinated and approved by the Gas Utility.
- D. While switching during firing from gas to oil or from oil to gas, there shall be a time delay interlock and the burners shall be so wired to go through a post purge and pre-purge period before firing with the new fuel.
- E. Vaporstat: Vaporstat shall be normally open type with a maximum operating pressure of 12 psig. Unit shall have a bellows operated SPST mercury switch which shall close on a rise of pressure. The unit shall have an adjustable differential of 2 to 16 oz. with the setting range calibrated in both English and Metric units. External adjusting screws shall permit adjusting the range without removing cover. Unit shall also have knockouts for 1/2 inch conduit and a 1/4 inch NPT male mounting thread.
- F. Provide emergency shutdown switch for each burner located adjacent to burner gas train.
- G. At fuel oil transfer station, an electrical interlock shall be installed so that when gas is the fuel used for combustion, the oil pumps are shut down. When fuel is changed from gas to oil, the transfer pump shall start automatically.

3.11 AUXILIARY CONTROLS

- A. Thermal Cut-off: Furnish and install a Factory Mutual approved (hand wheel type) thermal cut-off set at 165° F on each boiler front, 24 inches above the burner. Mount another thermal cut-off 12 to 24 inches above the top-front edge of each boiler. Contractor shall also install a thermal cut-off switch above two (2) main fuel oil pumps. Submit shop drawings for approval. All thermal cut-off switches shall be installed with the spindle in the horizontal position.
- B. Spring Loaded Oil Valve and Micro-switch: This oil valve shall be connected by a 1/8 inch stainless steel flexible wire rope run across the front of the boilers with an approved fusible link inserted at each boiler. Fusible links shall be designed to melt at 165°F and be mounted so as to be minimum of 10 inches and a maximum of 18 inches from the boiler front. Mounted adjacent to and interconnected with the spring loaded oil valve shall be a splash-proof micro-switch which shall open if the tension on the wire rope is released. New spring loaded oil valve shall be installed in upstream side of new duplex strainer.
- C. Breakglass Switches: Furnish and install two (2) breakglass switches, one (1) at each boiler room exit. Cover and hammer shall be constructed of solid brass. A glass window in the cover shall maintain the switch in the closed position. The hammer shall be securely attached to the box with a chain. Switching mechanism shall be the single pole double throw type, connected so as to open when the glass is broken. Thermal cut-offs, breakglass switches, and the spring loaded oil valve micro-switch shall be wired in series to shut down the boilers.

- D. Ultra-Violet Detector: Ultra-violet detectors shall be designed for sensing the ultra-violet radiation emitted by oil or combination gas-oil flames. Location of detectors shall be as recommended by the manufacturer.
- E. Aquastat: Provide aquastat to maintain minimum 180°F temperature in boilers. Aquastat shall be Honeywell Model No. L4006A or equal.

3.12 OTHER INSTRUMENTATION

A. Plant Steam Pressure Recorder

1. Furnish on control panel a 10-inch electronic type circular chart recorder for recording steam pressure in the boiler header. Gauge shall be mounted in an iron or cast aluminum case with enamel finish. It shall have a range from 0 to 30 pounds per square inch pressure. Clock shall be electronic type and shall be completely prewired in control panel. Supply with gauge 100 twenty-four (24) hour charts, bottle of recording ink, ink filler, and lock and key for recorder. Transmitter shall be connected to point in top of main header.
2. Plant steam pressure recorder shall be Honeywell Model DR-4200EVI-30 or equal.

- B. Run Time Indicator (One for each boiler): Provide in the control panel of each boiler a run time totalizing meter to record the total number of hours of boiler operation. The meter shall have a six digit readout from 0 to 999,999 hours.

C. Digital gas meter

DESCRIPTION: The Thermal Convection Mass Flowmeter will include a Single-Point Mass Flow Element with Integral/Remote Transmitter and shall directly measure, indicate, totalize and transmit linear 4-20 mA signals corresponding to the mass flow and temperature of the air (gas) in the pipeline.

1. Insertion Mass Flow Transmitter Required Features:

- a) **Operating Principle:** Constant temperature thermal anemometer circuit using two industrial grade Platinum RTD's, having two-wire, loop-powered sensor electronics, including automatic sensor lead wire resistance compensation, low-self-heat temperature sensor circuitry and five-wire RTD construction with surface mount electronics technology, and with CE Compliance for EMI, RFI and surges.
- b) **Velocity Range:** 0 - 18,000 SFPM (300 SFPS), air at standard conditions of 25°C and 760 mmHg, specific range digitally selected.
- c) **Velocity Measurement Accuracy/Interchangeability:** $\pm[(1\%+0.025\%/^{\circ}\text{C}) \text{ Reading}+(20 \text{ SFPM}+0.25 \text{ SFPM}/^{\circ}\text{C})]$ above or below 25°C.
- d) **Repeatability:** 0.25%.
- e) **Process Temperature Rating:** -40°C to +200°C.
- f) **Process Pressure Rating:** 300 PSIG.
- g) **Time Response (T/C):** Velocity changes: 1 second; Temperature changes: 1-3 seconds.
- h) **Sensitivity to Velocity Angle of Incidence:** Less than 2% for yaw or pitch angles of up to $\pm 20^{\circ}$.
- i) **Pressure Drop:** Less than 0.1" W.C.

- j) **Sensor Material:** Alloy C-276, all-welded construction.
- k) **Sensor Support:** 316L Stainless Steel, all-welded construction; 1/2", 3/4", or 1" diameter.
- l) **Insertion Length:** Per manufacturer's recommendations (See DCN 364002).
- m) **Process Line Sizes:** 2 1/2" pipe and larger.
- n) **Sensor Electronics Enclosure:** NEMA 4/7 painted aluminum dual chamber, Class 1, Div. 1, Groups B, C, D.
- o) **Sensor Enclosure Temperature Rating:** -40°C to +60°C.
- p) **Process Connection:** 1/2", 3/4", or 1" 316 Stainless Steel Compression fitting to fit FNPT fitting on pipe (by customer). Flange mounting optional.
- q) **Field Wiring:** Two pair of twisted and shielded 20-22 gauge wire for signal and one pair 14-18 gauge wire for power
- r) **Safety Approvals:** Options: Explosion-Proof (XP), Flame-Proof (FP), and Non-Incendive (NI).
- s) **EMI Approval:** CE compliance: light industrial: (EN 50081-2) for emissions, heavy industrial (EN 50082-2) for immunity and (EN 61000-4-5) for surges.

2. Electronics Specifications

- a) **Display :** Microprocessor Based with two-line sixteen character LCD display and 20 key user interface keypad mounted in the electronics enclosure for display of flow rate, temperature, flow area, time, date, flow totalization, alarms, and elapsed time. Easy read back-lit display with adjustable orientation.
- b) **Features:** User changeable STP reference conditions, multi-point calibration correction factors, with Help Screens. Digital input of all data including 12 character I.D., two access codes, built-in input/output calibration, two optically isolated 4-20 mA outputs, four sealed alarm relays, user entry of flow area, velocity or mass flow range, meter I.D., variable velocity flow correction factors, built-in RS-232C "Echo" terminal port for IBM laptop upload/download/recording. Velocity/Temperature/Mapping for wide ranging velocity and temperature processes. Remote Electronics enclosure optional, Flash EEPROM program memory. 12 bit analog outputs, 18 bit 18 bit input signal, resolution, auto-zero/span input calibration, Modbus network communications option available.
- c) **Field Service.** The vendor shall provide start-up assistance, check-out, training, perform the in-situ, flow calibration and input of flow calibration correction factors into the Mass Flow Computer. The flow calibration may be accomplished using an EPA type Pitot tube traverse for applications in which the upstream unobstructed L/D is greater than 8:1; or a Trace Gas Calibration for applications having less than an 8:1 L/D ratio. The Trace Gas Method is preferred for small pipes because of the difficulty of making accurate measurements.
- d) **Product and Manufacturer:** The Insertion Mass Flow Transmitter shall be Model 454-08, 454-12, or 454-16 as manufactured by Kurz Instruments, Inc., 2411 Garden Road, Monterey, CA

END OF SECTION 23 52 39