

SECTION 23 09 11
INSTRUMENTATION AND CONTROL FOR BOILER PLANT

PART 1 - GENERAL:

1.1 DESCRIPTION:

Automatic controls, instruments, monitoring and data management systems and accessories for the boilers, burners and other boiler plant mechanical equipment. The specification classifies the systems into automatic boiler and burner control systems, burner management systems (flame safeguard), and data management and instrumentation systems.

1.2 RELATED WORK:

- A. Section 01 33 23, SHOPDRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS for NON-STRUCTURAL COMPONENTS.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION
- D. Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- F. Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.
- G. Section 23 10 00, FACILITY FUEL SYSTEMS.
- H. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- I. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
- J. Section 23 51 00, REECHINGS, CHIMNEYS, and STACKS.
- K. Section 23 52 33, WATER-TUBE BOILERS.
- L. Section 23 52 39, FIRE-TUBE BOILERS.
- M. Section 26 05 11, REQUIREMENTS for ELECTRICAL INSTALLATIONS.
- N. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS and CABLES.
- O. Section 26 05 33, RACEWAY and BOXES for ELECTRICAL SYSTEMS.
- P. Section 26 27 26, WIRING DEVICES.
- Q. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

1.3 QUALITY ASSURANCE:

- A. The boiler and burner control, monitoring, data gathering, instrumentation and associated systems specified in this section shall be provided by one company that has been in business at least three years engineering, designing and servicing industrial and institutional boiler control and instrumentation systems similar to those specified herein, as a primary business. That company shall furnish all components and provide complete calibration, programming, start-up, testing, demonstrations, instructions and training services.

- B. Submit documented evidence, including start-up and acceptance test data, and references, that the company has performed satisfactory work on at least six systems similar to those specified, list any VA boiler plant projects completed in the past. For instance, submit experience information on systems involving parallel positioning combustion control and on variable speed forced draft fan drives, if these systems are specified. Submit in writing that all specs were read and fully understood.
- C. If new burners are part of the contract, the burner manufacturer shall be responsible for the burner management system (flame safeguard), including interlocks, all accessories and for coordination with other control and monitoring systems.
- D. Equipment Experience Requirements: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- E. Code Approval:
 - 1. All burner management and combustion control systems and devices shall comply with NFPA 85, regardless of boiler type or size. Locations and arrangements of safety devices on fuel trains shall comply with diagrams included in "Annex A" in the code, as modified by the VA standard details and safety device testing requirements.
 - 2. All burner management controls and interlock devices shall be UL listed and FM approved. All controllers that include burner management functions shall be UL listed and FM approved.
 - 3. Parallel positioning combustion control systems shall comply with UL 1998, or current.
 - 4. Computer-based electronic equipment shall conform to the requirements of FCC Part 15, Subpart J, for Class A computing devices governing radio frequency electromagnetic interference (EMI) while continuing to operate normally.
 - 5. All electrical wiring shall be in accordance with NFPA 70.
- F. Personnel: All work shall be done by properly trained, skilled technicians who are regularly employed and qualified in the installation, programming, start-up, calibration, and testing of the systems provided, and who will be directed by experienced engineers employed by the equipment supplier. Personnel must have three years minimum experience with industrial and institutional boiler plant controls and instruments similar to those being furnished for this project.

1.4 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Certificates of compliance with Article, QUALITY ASSURANCE (Articles 1.3.A, B, D & F). In addition, submit past performance questionnaire (Form VA-NEBC) for five (5) past projects of the same class (scope & complexity) as this project.
- C. Submit information sufficient to verify compliance with all contract requirements as specified and shown on project drawings.
- D. Automatic Boiler Control and Burner Management and Safety Interlock Systems:
 - 1. Catalog cuts and specification sheets providing description and performance data on: Controllers, control and indicating stations, sensors and transmitters, signal conditioners, electric switches and relays, indicators and annunciators, safety interlock devices, drive units and actuators, control valves, mechanical linkage systems, compressed air filters and regulators.
 - 2. Statement from controller manufacturer that the type and model submitted is the current generation and that the manufacturer will support the units with parts and service for at least ten years, and that the equipment submitted meets all VA specs.
 - 3. Information on all the specific systems that is sufficient to allow complete troubleshooting. As a minimum this should include explanation of the control logic, and wiring diagrams of equipment and systems to include locations and wire numbers of any safety device test points that will be required to complete safety device testing in accordance with VA requirements, and sequence of operation of all components of the system.
 - 4. Hardware systems schematics showing field and panel equipment interface block diagram.
 - 5. Location of interlock devices on the burners, boilers, fuel trains and accessory equipment, all safety devices shall be easily accessible for testing...
- E. Boiler Plant Instrumentation:
 - 1. Catalog cuts and specification sheets providing description and performance data on instruments and accessories.
 - 2. Installation and troubleshooting instructions for all equipment in bound sets shipped with equipment.

3. List of ranges of recorder displays (remove all paper charts from the specs.
 4. Flow meter primary element design, size, performance, and sizing calculation. Steam flow performance data for flow meters verifying project performance requirements.
 5. Complete wiring and piping diagrams for all equipment and systems.
 6. Wiring and piping materials.
- F. Instrumentation and Control Panels:
1. Drawing showing arrangement of instruments and controls on panels.
 2. Drawing showing panel arrangements, construction, door swing clearance allowance, dimensions, finishes.
 3. Description of panel construction.
- G. Computer Workstation and Programming:
1. Catalog data with pictures, description, and performance data on all hardware.
 2. Hardware specifications.
 3. Software model number and supplier. Include complete documentation on all software with shipment.
 4. Confirmation that graphics to be provided complies with the specification.
 5. Description of computer furniture.
- H. As-built Logic and Wiring Diagrams: One set of reproducible prints and CAD disks delivered to Resident Engineer (RE) prior to turning systems over to VA for operation. Supply revised drawings if changes are made during the startup and commissioning process.
- I. Fluid Flow Meters:
1. Catalog cuts and drawings with description, specifications and dimensions of meters and accessories.
 2. Design and construction of meters and accessories.
 3. Performance data including flow, pressure drop, accuracy over the metering range of the actual fluids to be metered.
 4. Pressure and temperature limitations.
 5. Manufacturer's installation instructions.
 6. Arrangement of register face and remote indicator (if provided).
- J. Pressure Gages and Thermometers:
1. Catalog cuts showing design, construction, dimensions of gages and accessories.
 2. Accuracy.

3. Pressure and temperature limitations of gages and accessories.

4. List of scale ranges to be provided.

- K. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute (ANSI):
INCITS 154-1988(R1999)..Office Machines and Supplies - Alphanumeric
Machines - Keyboard Arrangements
- C. American Society of Mechanical Engineers (ASME):
B16.36-2009.....Orifice Flanges
B31.1-2007.....Power Piping
B40.100-2005.....Pressure Gauges and Gauge Attachments
PTC 4-2008.....Fired Steam Generators
- D. National Fire Protection Association (NFPA):
70-2011.....National Electrical Code
85-2007.....Boiler and Combustion Systems Hazards Code
- E. National Electrical Manufacturers Association (NEMA):
ICS 6-93(R2001, R2006)..Industrial Control and Systems Enclosures
WC 63.2-1996(R2003).....Performance Standard for Coaxial Premise Data
Communications Cables
- F. Underwriters Laboratories Inc. (UL):
508-06.....Industrial Control Equipment
1449-09.....Transient Voltage Surge Suppressors, Second
Edition
1998-09.....Software in Programmable Components

PART 2 - PRODUCTS:

2.1 AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD):

- A. Basic Description of Controllers and Control Functions:
1. Controllers shall be industrial-process-grade multi-loop programmable microprocessor or PLC.

2. Controllers shall be manufactured separate from and shall be separate assemblies from the Burner Management (Flame Safeguard System)
 3. Control functions:
 - a. Control of burner firing rates to maintain steam header pressure.
 - b. Parallel-positioning combustion control (air/fuel ratio, excess air) with flue gas oxygen trim.
 - c. Jack-shaft type combustion control (fuel/air ratio).
 - d. Flue gas recirculation (FGR).
 - e. Boiler outlet draft.
 - f. Boiler water level, 123 element system.
 4. Control features:
 - a. Operator interface on controller faceplates and touch screens and computer workstation. Operator interface shall include manual/automatic selection, manual loading, and displays that show set point, process variable, signal to actuator, process status and controller status. Touch screens have additional display requirements; refer to paragraph below.
 - b. Provide separate dedicated controllers/panels for each boiler and for the master steam pressure control. Fuel/air control loops, including flue gas recirculation (FGR) and oxygen trim may be incorporated into one station for each boiler. Boiler/economizer outlet draft and boiler water level control shall have separate stations for each item on each boiler. All control items for one boiler may be shown on one touchscreen.
 - c. VA Boiler Plants DO NOT ALLOW for any boiler to be automatically or remotely started or lead lag control systems are not allowed within the VA boiler plants, regardless of the size or type of boiler. The boiler shall be started by an operator standing at the boiler.
 - d. Variable frequency drives on forced draft fan motors.
 5. Refer to the paragraphs which follow for complete detailed requirements.
 6. Refer to Par. 2.2 for burner management controls.
- B. Controllers: Multiple-loop programmable microprocessor or programmable logic (PLC) proportional-integral-differential (PID) solid state

electronic controllers shall control all functions except burner management.

1. Accuracy: 0.1% analog inputs and outputs.
2. Resolution: 16 bit input and output.
3. Environment: 0 to 50 degrees C, 15% to 95% RH, non-condensing.
4. As a minimum, each controller shall have capability for four analog and four digital inputs, two analog and four digital outputs, and two PID loops.
5. Memory retention for twelve months minimum for power failure or for storage as spare parts.
6. Membrane push buttons with tactile feedback.
7. Displays shall be a combination of English language, color graphics, and digital with 0.5 percent resolution, visible from wide angle.
8. Bumbles manual/automatic transfer.
9. High and low alarms for all inputs.
10. Programming: Controllers shall have capability for quick (5 - 10 minutes) reloading of memory by operating personnel upon memory loss. Provide all software and hardware necessary to allow field downloading of configuration memory to the microprocessors.
11. Password Protection: Provide levels of password protection for all safety related options and parameters including all commissioning programming. Provide all passwords to Resident Engineer (RE).
12. In the event of a controller fault, the controller shall have a dedicated relay output that results in the shut down of the boiler and provides an alarm to a panel-mounted light and audible alarm. Failure of control system for one boiler shall not affect automatic and manual operation of other boilers.
13. Controllers and software that operate variable frequency drives shall be manufactured and tested in accordance with UL 508.
14. Controllers shall provide serial RS232/RS485 Modbus communication with computer workstation running latest Microsoft Windows based operating system. This includes data gathering and processing, report generation, monitoring, annunciation and control. Refer to Paragraph, COMPUTER WORK STATION AND PROGRAMMING. It shall be possible to defeat the remote control from the front panel of each individual controller, preventing any status changes from being initiated at the computer workstation.

15. All controllers, including those assigned to data processing, shall be same model and series.
 16. Controllers shall be the current generation product that will be supported by the manufacturer, with parts and service, for a minimum of ten years from time of installation.
 17. All controllers shall be mounted within specified control panels.
 18. Examples of acceptable controllers: Hays-Cleveland "AC Station", MicroMod "Mod 30 ML", Moore 323, Preferred "PCC III", Toshiba "LC500".
- C. Power Supplies: Provide separate uninterrupted power supply for each boiler controller. Any signal that is common to all boilers, such as plant master control signals, shall be isolated from all other boilers so that failure in one boiler circuit will not affect other boilers.
- D. Touch Screen Operator Terminals:
1. Provide one touch screen control station and display for each boiler mounted on the boiler control panel. Touch screen shall be in complete communication with all controllers associated with the boiler and with the burner management system. Provide alternate control station to replace touch screen control functions if touch screen fails.
 2. Control Station and Display Requirements:
 - a. Local operation and programming of controllers, graphic display of information, alarm message display, historical and real time trending, remote controller tuning, x/y plots of fuel air curve data for intuitive commissioning of controllers, Ethernet connectivity and standard Internet browser remote communication. Network to boiler control and burner management systems.
 - b. Selection of automatic or manual control of firing rate. Local manual control to increase and decrease the firing rate.
 - c. Indicate burner management control status and diagnostics in English messages: control on, pre-purge, trial for ignition, igniter flame signal, main flame signal, post purge, burner off, all diagnostic information available from burner management system, continuous indication of flame signal.
 - d. Real time display of all connected process parameters including control output, set point, process variable, all data gathering and processing from all controllers associated with the boiler.

- e. Display of all control system alarm messages and faults. History of alarms and faults and recommendations for troubleshooting.
 - f. Complete display and facilities to allow programming all controllers associated with the boiler or the master control. Burner management is excluded from this requirement.
 - g. Provide alternate means of automatic and manual operation of boiler firing rates and burner management status if touch-screen fails.
 - h. Provide continuous display of critical operating parameters, including but not limited to the following:
 - 1) Steam Pressure
 - 2) Water Level
 - 3) Draft Pressure
 - 4) Firing Rate
3. Touch Screen System Hardware and Software:
- a. 265 mm (10.4 inch) panel-mounted display, TFT with 256 colors, 640 x 480 pixel LCD resolution. Locate to allow easy viewing and access from operating floor.
 - b. Aluminum case allowing entire enclosure to be rated NEMA 4x.
 - c. Communication with SCADA program on computer work station.
 - d. Multiple RS-485 Modbus communication interfaces.
 - e. Field-replaceable backlight, real-time clock, battery-backed clock time stamps critical data, 8 MB on-board flash application memory, 512 MB memory card, application expanded memory card for historical, alarm and event storage, resistive analog touch screen with free formable to fit target shape.
 - f. Operation interaction shall be touch-based allowing easy selection of screens, manual/automatic status changes, start/stop functions, set point changes, output changes and PID tuning parameters without any special programming skills. Screen selection shall also be available through tactile feedback function keys.
 - g. Show facsimiles of each controller and clearly labeled English language and engineering unit display of the control parameters.
 - h. Graphic X/Y curve data plotting capability. When used in conjunction with fuel/air ratio control, provide automated fuel/air ratio curve and oxygen trim set point curve adjustment for rapid, error free burner tune-up. Only a single operator

action shall be required to store commissioning data into multiple characterizer curves for a particular load point.

- i. Configuration software Microsoft Windows based. Provide all necessary software to allow field modification or expansion of the system including graphics drawing programs and data base builders. Systems based on "run time only" programs are not acceptable.

E. Drive Units and Actuators for Dampers, Fuel Flow Control Valves, Feed Water Flow Control Valves:

1. Electric drive units are required.
2. Electric drive units shall have continuous modulating duty cycle without any duty cycle or thermal motor limitations. Shall start instantaneously at full rated torque, stop instantaneously without coast or overshoot. Shall smoothly operate all connected devices without overload. Provide 100 percent duty cycle maintenance free motors that never overheat or burnout under stalled conditions. Gearing shall eliminate backlash. Movement shall be constant speed and shall be coordinated with the controlled process so that performance parameters remain within specified limits.
3. Additional Requirements for Electric Drive Units on Parallel-Positioning Combustion Control Systems:
 - a. Drive units shall have precise positioning and repeatability to provide air-fuel positioning ratios with a maximum hysteresis of 2%.
 - b. Provide continuous precise feedback signals from drive units to controllers.
 - c. Provide auxiliary contacts to prove low and high fire positions, feedback signals are not permitted to perform this function within the VA. Belt-type drive units not permitted.
 - d. Drive unit shafts shall be keyed to fuel flow control valves and damper shafts to eliminate the possibility of slipping.
 - e. Drive units shall be industrial rated.
 - f. All gearing shall be brass or better, no plastic gears of any kind are permitted.
4. Boiler outlet damper drive units may be different model than drive units for fuel valves and forced draft damper. Drive units shall be capable of 136 Nm (100 ft-lb.) torque minimum. Less powerful drive

units may be utilized if certified as adequate by the burner manufacturer.

F. Variable Frequency Drives (VFD) for Forced Draft Fans:

1. Refer to Section 26 29 11 LOW-VOLTAGE MOTOR STARTERS, for electrical requirements. In addition, there shall be a VFD mounted operator interface unit that allows configuration of drive parameters and displays diagnostic information for troubleshooting.
2. Provide feedback system including motor speed and direction of rotation to combustion controller. Feedback transmitter must have no-drift guarantee. Feedback system shall not be affected by position of H-O-A switch on motor control system.
3. Provide noise filters.
4. The VFD shall automatically limit the rate of fan speed increase to that which will prevent an over-current trip in the event of a "step" speed increase of 0 - 100%.
5. Provide constant speed feature and operator-selectable air/fuel program in the controller for constant speed operation maintaining specified air/fuel ratios (excess air).
6. Forced draft fan damper operation is required in conjunction with operation of the VFD at the lower firing rates.
7. Provide a means of proving fan rpm to control set point at any firing rate. Deviation from set point rpm or greater than 10 percent will cause a safety shut down of the boiler.

G. Transmitters: See Paragraphs, PRESSURE SENSORS AND TRANSMITTERS, TEMPERATURE SENSORS AND TRANSMITTERS.

H. Final Control Elements:

1. Fuel flow control valves, forced draft fan dampers, flue gas recirculation (FGR) dampers (if provided), variable frequency forced draft fan drives (VFD)(if provided), feed water control valves: Refer to Section 23 52 39, FIRE-TUBE BOILERSSection 23 52 33, WATER-TUBE BOILERS.
2. Dampers in stacks and breechings: Refer to Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.

I. Uninterrupted Power Supplies:

1. Provide separate complete protected power conditioners for each boiler control and for master control. Power supply shall protect all computers, controls, instruments and accessories from damage due

to ground leakage, spikes, sags, surges, transients and overloads in the incoming power supply.

2. Line interactive, UL 1449-rated, interactive digital display. Automatic internal bypass. Smooth sine wave output.
3. Suitable for ambient temperature of 44 degrees C (110 degrees F) in boiler room panel.
4. Hot swappable batteries.
5. Audible and visual alarms to signal failure of power supply.
6. This UPS system can be deleted from the project if controls furnished have integral protection from power supply irregularities listed above, and if software can be immediately reloaded by plant personnel.

J. Spare Parts and Tools:

1. Master control steam pressure transmitter: One complete unit, calibrated for the service.
2. Hardware and software sufficient for downloading and uploading all programming configurations with all the controllers.
3. Electric power drive unit: One of each size and type used

K. Detailed Control Functions:

1. Control of Burner Firing Rates to Maintain Steam Header Pressure:
 - a. Automatic modulation of burner firing rates on all boilers to maintain set pressure of main steam header. Master controller receives signal from header pressure transmitter, processes and transmits signal to sub-master controller for each boiler/burner. Sub-master controls fuel flow and combustion air flow.
 - b. Set Points and Performance: Accuracy plus or minus two percent of the set pressure when steam load changes do not exceed 20 percent of the maximum continuous rating of the largest boiler in service in a sixty second period. System oscillations shall be minimal. Set point _____kPa/psi. Second set point _____kPa/psi.
Individual set point adjustment range: +/- 140 kPa (20 psi).
 - c. Control Stations: Individual control stations for master and sub-master controllers. Locate control stations on main instrumentation panel unless otherwise shown. Master controller shall have capability for two set points with easy selection.
 - d. Low fire hold capability and user definable optimum ignition position.

- e. Interface with burner management system for automatic positioning of forced draft fan damper ,forced draft fan speed and fuel flow control valves during pre-purge, ignition, shutdown and post-purge.
 - f. Interlocks to prove proper positions of forced draft fan damper ,forced draft fan speed, boiler/economizer outlet damper and fuel flow control valves for ignition and running cycles. Refer to paragraph, BURNER MANAGEMENT SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
 - g. The steam header pressure transmitter(s) shall be dedicated to header pressure control. Suppressed range transmitter(s), each with range +/- 20 percent of required set point. If two set points are required that are more than 138 kPa (20 psi) apart, provide two transmitters. Locate transmitters adjacent to main steam header. Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.
2. Parallel-Positioning Combustion Control (Air/Fuel Ratio, Excess Air):
- a. Boiler/burner sub-master controller provides firing rate signals to separate drive units (actuators) for forced draft fan dampers and for each of the fuel flow control valves and to the variable frequency drive (VFD) of the forced draft fan. Air/fuel ratio maintained by firmware and software programming of the sub-master controller. Software shall be factory-programmed for the specific application. Only tuning and scaling shall be performed in the field.
 - b. Hardware, firmware and software shall comply with UL 1998, or current revision of UL1998 Incorporate cross-limiting (air leading fuel on load increases, fuel leading air on load decreases) and deviation limiting (allowable tolerances on air/fuel ratio). Provide automatic burner shut down if deviation exceeds programmed limits or if there is a controller failure. Cross-limiting and deviation limiting shall be tested and proven. If at any time it is found this was not preprogrammed at the factory and UL tested and listed the controller shall be replaced at NO ADDITIONAL COST to the government.
 - c. Provide feedback signals from drives and actuators. Fuel flow shall not increase until appropriate combustion air flow increase

is proven. Combustion air flow shall not decrease until appropriate fuel flow decrease is proven. VFD feedback transmitters shall have "no-drift" guarantee.

- d. Accuracy of control of drive units shall result in fuel-air positioning ratios that are specified by the burner manufacturer for efficient and safe operation with a maximum hysteresis of 2 percent. Excess air in flue gas shall conform to limits given below.
 - e. Manual control function accessible to operating personnel shall be confined to base loading the firing rate of the burner and shall not permit separate control of fuel or combustion air. All other manual functions shall be password protected intended to be accessible only to qualified technicians. If system is improperly placed in a manual control mode, the system shall shut down the boiler or maintain safe excess air levels at all times, within parameters that limit the carbon monoxide emissions to specified limits.
 - f. From low fire to high fire the air/fuel ratio (excess air) shall be programmed over at least ten evenly spaced increments of fuel input.
 - g. Control positions and display indications shall be linear in relation to firing rate. For example, 20% control position shall be 20% firing rate (20% of full load).
 - h. Mechanical connections between drive units and dampers and valves shall not have hysteresis and shall be keyed to eliminate slippage. Use of linkage systems must be minimized and submitted for approval as a deviation to the contract.
 - i. Excess Air and Emissions Limits - New Burners: Refer to the boiler and burner specification.
 - j. Excess Air and Emissions Limits - Existing Burners:
 - Minimum excess air at all loads: 15%
 - Maximum excess air at 20 - 39% of maximum firing rate: 35%
 - Maximum excess air at 40 - 100% of maximum firing rate: 25%
 - Consult Resident Engineer if flue gas carbon monoxide exceeds 200 parts per million (ppm) within the excess air limits specified above.
3. Automatic Flue Gas Oxygen Trim System:

- a. Boiler/burner sub-master air/fuel controller shall utilize signal from flue gas oxygen analyzer and vary the combustion air flow to maintain the specified air/fuel ratio (excess air) at all firing rates 20 percent of maximum firing rate and greater.
 - b. Operation and Performance:
 - 1) Separate characterized set point curves for each fuel, minimum ten points per fuel. A single curve with biasing for the other fuel is not acceptable. Automatic changeover of set point curves when type of fuel being fired is changed.
 - 2) Maximum deviations from set points shall not exceed ten percent at any firing rate. Combustion shall not generate carbon monoxide (CO) in excess of 200 parts per million (ppm) at any time.
 - 3) At firing rates below 20 percent of maximum steam flow, trim shall automatically return to null position (no trim).
 - 4) Variable gain to decrease output sensitivity at low loads.
 - 5) Adjustable high and low trim limiting. Excessive high or low trim correction, low excess air, or oxygen analyzer failure shall actuate audible and visual alarm on the boiler sub-master air/fuel ratio controller. Analyzer failure shall cause system to go to null position.
 - 6) Manual trim output shall revert to null setting when system is placed in automatic control.
 - c. During burner start-up and adjustment of air/fuel ratios (excess air) by service technician, trim shall be on manual control at null position.
 - d. Refer to Paragraph, FLUE GAS OXYGEN ANALYZERS.
4. Flue Gas Recirculation (FGR) Control:
- a. Automatic operation of FGR damper to control NO_x emissions to required limits and to provide purging of combustibles from the FGR ducts during the pre-purge cycle.
 - b. Automatically disable FGR during burner start-up cycle due to potential for flame instability. Automatically enable the FGR after the boiler flue gas outlet temperature reaches a minimum of 150 degrees C (300 degrees F).
 - c. Interface with burner management system with interlocks to prove FGR dampers in proper position for pre-purge prior to ignition.

Refer to Paragraph, BURNER MANAGEMENT SYSTEMS WITH SAFETY INTERLOCKS AND ACCESSORIES.

5. Boiler Outlet Draft Control:

- a. Automatically modulate position of boiler or economizer outlet damper to maintain constant negative pressure (draft) at the flue gas outlet of the boiler. Utilize feed forward signal from the boiler/burner sub-master air/fuel controller to enhance control response. Position damper open and closed during boiler start-up and shut-down cycles.
- b. Maintain draft at negative 25 Pa (0.1 inches WC) plus or minus 10 Pa (0.05 inches WC). Provide local gauge with remote indication at operator interface.
- c. Panel-mounted automatic controller, with manual/automatic feature and set point adjustment, for each boiler. Locate on main instrumentation panel unless otherwise shown.
- d. Draft sensor, transmitter, and outlet damper actuator for each boiler. Refer to Article, PRESSURE SENSORS AND TRANSMITTERS.
- e. Automatically position damper as required for pre-purge, burner ignition and shut down. Provide damper position switch interlocked with burner management system. Refer to Paragraph, BURNER MANAGEMENT SYSTEMS WITH SAFETY INTERLOCKS AND ACCESSORIES.

6. Boiler Water Level Control:

- a. Automatically modulate the position of feed water control valve on each boiler to maintain the water level in the boiler within plus or minus 50 mm (2 inches) of set point with instantaneous load swings of 20 percent of boiler capacity. Adjustable set point.
- b. Type of System:
 - 1) Single Element System: Utilize signal from water level sensor on boiler.
 - 2) NOT APPLICABLE Two-Element System: Utilize boiler steam flow signal and boiler water level signal. Adjustable signal gain. Provide single-element (drum level) operation from low fire to 20% of maximum boiler load. Provide automatic switchover from single-element to two-element operation.
 - 3) NOT APPLICABLE Three-Element System: Utilize boiler steam flow signal, boiler water level signal and boiler feedwater header pressure signal. Adjustable signal gain. Provide single-

element (drum level) operation from low fire to 20 percent of maximum boiler load. Provide automatic switchover from single-element to three-element operation and vice-versa at 20 percent load.

c. Boiler Water Level Sensors:

- 1) Differential Pressure Transmitters: Provide on water tube boilers. Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.
- 2) Water Level Sensing and Safety Control Systems: Provide on fire tube boilers. Refer to Section 23 52 39, FIRE-TUBE BOILERS.
- 3) Probe-Type Capacitance Systems: Optional control for fire tube and water tube boilers. Dual probes mounted in water column controlled by microprocessor system. Provisions to compensate for shrink and swell of water level due to load changes. Self-checking function comparing the signals from each probe and causing burner shutdown if water level movement is not detected.

d. Steam Flow Sensors: Refer to Paragraph, FLOW METERS.

e. Feed water Pressure Sensors: Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.

f. Controller: Controllers for two and three element systems shall include: manual/auto control station and indicators showing signal level to actuator, set point and actual water level, steam flow rates and totals and boiler feed water flow rates and totals if flow meters are included. Locate on main instrumentation panel unless otherwise shown. For controller requirements for fire tube boilers, refer to Section 23 52 39, FIRE-TUBE BOILERS.

g. Set point position as recommended by boiler manufacturer.

7. Boiler and Economizer Efficiency Calculation and Display: If not provided on the computer work station, provide continuous automatic calculations and indication of heat-loss combustion efficiency based on flue gas outlet temperature of economizer (or boiler if economizer is not provided), flue gas oxygen, and type of fuel in use. Base calculation method on ASME Performance Test Code Form Number 4.1b, HEAT LOSS EFFICIENCY, with no consideration for boiler radiation and unaccounted losses.

2.2 BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES

- A. Complete automatic safety control and monitoring system for burner ignition sequencing, operating cycle, and shut-down sequencing. System shall include microprocessor programmer, self-checking ultraviolet (UV) flame scanner and amplifier, burner cycle display, first-out diagnostic annunciation display, burner safety shut down interlocks, communication with monitoring systems, and accessories. Mount controllers, control switches and displays in and on individual boiler control panels. Refer to Paragraph, BOILER/BURNER CONTROL PANELS. All interlock devices shall be designed to permit periodic operational testing, including set points and trip points, without changing set points or programming, and in accordance with the most recent edition of the VHA Boiler Plant Safety Device Testing Manual.
 - 1. Controller shall be manufactured separately from the Burner Control System controller.
 - 2. Controller shall be a separate and individual assembly from any other controller.
 - 3. Controller shall have its own mounting and wiring base to permit the controller to be replaced without disturbing any wiring or other components.
- B. Code Compliance: Conform to NFPA 85. All components UL listed, FM approved.
- C. Operate on 102 to 132 volts; 60 Hertz AC. Operating ambient temperature range 0 °C to 52 °C (32 °F to 125 °F).
- D. Flame Scanners: Provide self-checking ultraviolet (UV) scanners.
 - 1. Self-checking UV scanners shall have minimum checking frequency six times per minute. Position scanners so that they do not view the ignition spark. Scanner sight tubes must be non-reflective to avoid the scanner detecting the reflection of the ignition spark. UV non-self-checking scanners are not permitted because they can fail in an unsafe mode on continuously operated burners.
- E. Control Features:
 - 1. Automatic recycling on high steam pressure only.
 - 2. Interrupted ignition.

3. Electronically prevent UV scanner sensing ignition spark. Methods include early spark termination or by phasing the firing of the ignition spark off cycle from the scanner activation.
 4. Flame failure response time four seconds maximum.
 5. Ten seconds trial for ignition except 15 seconds permitted on heavy oil fuel.
 6. Pre-purge timing set for 4 air changes on fire tube boilers and 8 air changes on water tube boilers per NFPA 85. The exact timing must be determined by the boiler manufacturer. For example, typical pre-purge timing with wide open forced draft damper and forced draft fan at full speed has been 30 seconds for packaged fire tube boilers and 2 minutes for packaged water tube boilers.
- F. Provide components that can be easily removed from the panel without disturbing wiring.
- G. Memory storage and self-diagnostics of at least six most recent causes of burner shutdown, which can be accessed by operating and service personnel. Diagnostics shall include all individual interlocks.
- H. Provide Modbus RS232/RS485 and modem interface to allow remote access to detailed boiler plant operating data and memory. Provide interface with SCADA (Supervisory Control and Data Acquisition) software on computer workstation to allow access to burner management memory and to current operating information. In addition, provide a BACnet (read only) interface to the central medical center \DDC control system.
- I. Burner cycle indication on face of panel: Show instantaneous status of start up, run and shut down program. Provide indicator for control power on, ignition, main fuel valve open, and flame failure.
- J. Reset button on face of panel.
- K. Annunciator Display and Alarm:
1. Locate display on outside face of panel between 1200 mm and 1500 mm (4 feet and 5 feet) above the floor.
 2. English language read-out with individual identification of specific interlocks. Where two or more interlocks serve the same function, individual display of each interlock is not required.
 3. Indicate burner status in English messages: control on, pre-purge, trial for ignition, igniter flame signal, main flame signal, post purge, burner off.
 4. Continuously indicate flame signal strength.

5. Provide first-out annunciation, including English language message, and audible alarm (horn) for each of the following interlocks:
 - a. Flame failure.
 - b. Purge airflow low.
 - c. Combustion air low.
 - d. False combustion air (switch activated with combustion air flow).
 - e. High main gas fuel pressure.
 - f. Low main gas fuel pressure.
 - g. High oil pressure.
 - h. Low oil pressure.
 - i. Low igniter (pilot) gas pressure.
 - j. Low oil temperature (heated oil systems only).
 - k. Fuel safety shut-off valves not closed prior to ignition cycle.
 - l. Low fire position not attained prior to ignition cycle.
 - m. Low atomizing media (steam or air) static pressure at atomizing media service connection to burner piping.
 - n. Low atomizing steam/oil differential pressure. Where burner does not maintain differential pressure provide low atomizing media pressure at burner.
 - o. High steam pressure.
 - p. Low water cutoff.
 - q. Low control air pressure (if pneumatic feed water control valve drive units or other controls are furnished).
 - r. Flue gas recirculation (if provided) improper damper position.
 - s. Low flue gas oxygen.
 - t. High furnace pressure (if outlet draft control system furnished).
 - u. Building combustion air intake louver closed or make-up air ventilation system not operating.
6. Audible alarm (horn): Sounds upon all burner shutdowns except automatic recycle shutdowns on steam pressure. Provide silencing control, which automatically resets when burner control is reset.
- L. Pre-Purge Timing: Integral with the programmer. Non-adjustable after initially set to suit boiler pre-purge requirements.
- M. Auxiliary relays: Industrial type rated for the service, enclosed contacts.
- N. Selector switches, push buttons and control switches: Heavy duty, industrial type.
- O. Safety shut down and manual reset required for, but not limited to:

1. Flame signal detected prior to ignition cycle.
 2. Pre-ignition interlock open during pre-purge.
 3. High fire purge interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to high fire.
 4. Low fire interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to low fire.
 5. Igniter (pilot) or main burner fails to ignite.
 6. Malfunction of flame detector.
 7. Malfunction of programmer.
 8. Malfunction of flame signal amplifier.
 9. Combustion air proving switch actuated prior to start-up of forced draft fan.
 10. Lock-out interlock open during pre-purge (after 15 seconds), ignition or run period.
 11. Interlock open.
 12. Flame failure.
 13. Building combustion air intake louvers closed or make up air ventilation system not operating.
- P. Burner Safety Shut Down Interlock Devices:
1. Basic Requirements:
 - a. Adjustable Set Points.
 - b. Maximum Set Point Deviation: 5% of full scale.
 - c. Minimum Repeatability: 2% of full scale.
 - d. Minimum Set Point Accuracy: 10% of full scale or 20% of set point.
 - e. Scale range shall allow set points to be within 30 to 70% of full scale.
 - f. Safety interlock devices shall be separate from operating control elements, such as feedback devices. This is to avoid having the failure of an operating control device preventing the operation of the safety device. All safety devices shall be hardwired directly to the flame safe guard controller without passing thru any other device or control system.
 2. Provisions for Testing of Interlocks:
 - a. Installation of all interlock devices shall permit testing of set points and control operation without removing or disconnecting the devices and without adjusting set points of devices. Provide permanent connection points for test instruments, such as

manometers and pressure gages, on sensing piping and tubing. Where necessary, provide lockable valves to allow temporary isolation of device from the service to allow testing of the device.

- b. All interlock device wiring shall start out at and end at a terminal strip in the main cabinet. No device shall be wire directly to another device in series without returning to the main cabinet's terminal strip first. All series wiring will take place at the terminal strip.
 - c. No safety device is allowed to be PLC dependent or be included in any program where the input or output can be forced, or if the program is changed updated etc could have any effect on the safety device setting or function. All safety devices shall be hard wired from the device or sensor to the flame safe guard controller directly.
 - d. Provide all necessary control system passwords, wiring diagrams, and step-by-step written instructions specific to that facility to Resident Engineer to facilitate all interlock testing required by the latest edition of the VHA Boiler Plant Safety Device Testing Manual.
 - e. Provide written step by step safety device test procedures that follow the most recent edition of the VHA Boiler Plant Safety Device Testing Manual, and any test procedure that varies from this manual must be submitted to VACO CFM Consulting Support Services and VHA OCAMS for review and approvals.
3. Forced Draft Fan Motor Operation Interlock: Provide current relays on each phase of power circuits to fan motor. For variable speed drives, provide signals to control system from VFD fault and run contacts and signals from VFD shaft speed feedback to prove proper fan speed for purging, low fire ignition, and for each burner load point. Any disconnects or other power shut-off devices between the location of the interlock devices and the motor shall also shut down the power supply to the burner management control system.
4. Atomizing Air Compressor (when provided) Motor Energized Interlock: Provide current relays on each phase of power circuits to the motor. In the power supply to the motor there shall be no disconnects or other power shut-off devices between the location of the interlock devices and the motor.

5. Forced Draft Fan Damper, Boiler Or Economizer Flue Gas Outlet Damper (if provided) Pre-Purge Position Interlock: Prove dampers wide open for pre-purge. Actuate sealed snap-action switches by levers attached directly to dampers or to damper linkages, which are pinned to prevent slippage. Parallel positioning systems may have the interlock switches in the drive units.
6. Flue Gas Recirculation (FGR) Dampers (if provided) Position Interlock: Prove dampers positioned as required by burner manufacturer for pre-purge and firing. Actuate sealed snap-action switches by levers attached directly to dampers or to damper linkages, which are pinned to prevent slippage.
7. Pre-Purge Airflow Interlock:
 - a. Sense differential pressure between two points in combustion air system where the differential pressure at high fire is significant, such as several inches water column. There must be no intervening dampers. This is typically between the windbox and boiler outlet.
 - b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.
 - c. UL listed, FM approved.
 - d. Provide air pressure sensing connections for test manometer so that air flow switch settings can be verified.
 - e. Trip point shall prove at least 70% of maximum airflow.
8. Combustion Air Proving Interlock:
 - a. Sense differential air pressure across the forced draft fan with no intervening dampers.
 - b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.
 - c. UL listed, FM approved. Provide switch designed for "false combustion air" feature on start-up interlock.
 - d. Provide air pressure sensing connections for test manometer so that switch settings can be verified. Demonstrate that trip point is within 10% of minimum differential pressure over the firing range of the burner.
9. High And Low Main Burner Fuel (Gas and Oil) And Low Igniter (Pilot) Gas Pressure Interlocks:

- a. Solid-state sensor, mercury switch, automatic reset. Provide graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements either on the switch or as a part of the controller. Switch movements shall have bushings to eliminate metal-to-metal wear.
 - b. Gas pressure switch ratings: Sustained pressure capability shall exceed two times lock-up of nearest upstream regulator.
 - c. Oil pressure switch ratings: Sustained pressure capability shall exceed set pressure, plus accumulation, of oil pump safety relief valve. On heated oil system, sustained temperature capability shall exceed maximum operating temperature.
 - d. Low gas pressure switches shall include impulse dampener to reduce the effects of pressure dips during start-up.
 - e. Mechanical movements shall have bushings to eliminate wear of metal parts.
 - f. Approvals: UL listed, FM approved.
 - g. Switch Locations: Must be located where pressure is constant, as controlled by pressure regulator (if provided) on fuel train. Must be upstream of modulating fuel flow control valves.
 - h. Set points shall be within 20% of the normal operating pressure.
 - i. High pressure switches shall be piped to the service with lockable isolation valve and valved test connection so that switch can be set and tested using compressed air.
10. Low Oil Temperature Interlock (Heated Oil Only):
- a. Type: Solid-state sensor or sealed snap-acting switch, automatic reset. Provide graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirement either on the switch or as part of the controller.
 - b. Ratings: Sustained temperature capability shall exceed maximum oil temperature requirement.
 - c. Approvals: UL listed.
 - d. Location: Ahead of safety shut off valves.
11. Low Atomizing Media Pressure, Differential Pressure And Flow Interlocks:
- a. Type: Mercury switches, graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements, automatic reset. Switch movements shall have bushings to eliminate metal-to-metal wear.

- b. Rating: Shall exceed pressure setting of nearest upstream relief valve.
 - c. Provide siphon on steam connection to protect sensing element from live steam.
 - d. Approvals: UL listed.
 - e. Locations and types of switches on atomizing media piping: Two switches required for each burner, a static pressure switch on atomizing media supply ahead of differential pressure control valve, and differential pressure flow switch with flow meter orifice on atomizing piping adjacent to burner. On burners that maintain an approximately constant differential pressure between the atomizing steam and oil, provide a steam/oil differential pressure switch instead of the flow switch at the oil burner. Burners with individual air compressors for air atomization shall be provided with one air pressure switch and compressor motor interlocks as specified above.
12. Main Fuel (Gas And Oil) Automatic Safety Shut-Off Valves Proof-Of-Closure (Over Travel) Interlocks. Provide on all automatic safety shut off valves to prove closure prior to igniter (pilot) ignition. Provide manually-actuated test circuits through the proof-of-closure switches that will demonstrate that the switches close and open properly and that the circuit is connected to the burner management system.
13. Low Fire Position of Fuel Flow Control Valves Interlocks: Sealed snap-acting switches. Actuate switches by levers attached directly to fuel valves. As an option, the switch lever may be pinned to the jackshaft to which the fuel valve proportioning cams are also pinned or provide UL listed and FM approved position sensor (internal snap acting switches within the actuator a pot may not act as this safety device.) on the motor which positions the jackshaft to which all the operating levers are pinned.
14. High Boiler Steam Pressure Limit and Interlock: Operating limit switch allowing burner recycling and safety shut down interlock switch. Refer to Paragraph, BOILER TRIM, in Section 23 52 39, FIRE-TUBE BOILERS.
15. Low Boiler Water Level Interlocks: Primary and auxiliary low water burner shut down interlocks. Refer to Paragraph, BOILER TRIM, in Section 23 52 39, FIRE-TUBE BOILERS. Operation of auxiliary low

- water cutoff shall interrupt the power supply to the burner management control system.
16. Boiler Control Compressed Air Pressure Interlock (Pneumatic Control Systems):
 - a. Type: Mercury switch, graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements, automatic reset.
 - b. Rating: Shall exceed maximum relief pressure of nearest upstream relief valve.
 - c. Approvals: UL listed.
 17. Low Flue Gas Oxygen Alarm and Interlock: Signals from flue gas oxygen analyzer providing low oxygen alarm and low oxygen burner shut down. Refer to Paragraph, BOILER FLUE GAS OXYGEN ANALYZER SYSTEMS.
 18. High Furnace Pressure Interlock:
 - a. Required only for boilers that have boiler outlet draft control system.
 - b. Sense static pressure in furnace.
 - c. Diaphragm-actuated snap-action switch, adjustable set point, set point indicating scale, designed for maximum system pressure.
 - d. UL listed, FM approved.
 - e. Connect to the service with a lockable isolation valve and valved test connection to allow the switch to be set and tested with pressurized air source.
 19. Building Combustion Air Intake Interlock: Provide devices to prove outside air building wall louvers are open or H&V unit is in operation.
- Q. Automatic Programming Sequence:
1. After personnel select the fuel to be burned and operate the burner start switch, the control system shall automatically perform the following operations:
 2. Prove proper operation of all interlocks except purging interlocks or prevent further progress.
 3. Open all air dampers fully. This includes all dampers (if provided) in the boiler outlet breeching and stack system.
 4. Position flue gas recirculation damper (if provided) as required by burner manufacturer to purge flue gas from recirculation duct.

5. Prove 70% of maximum air flow through the boiler and prove all air dampers open wide and flue gas recirculation damper (if provided) in proper position.
 6. Pre-purge eight air changes for water tube boilers and four air changes for fire tube boilers.
 7. Return forced draft fan dampers and fuel flow control valves to low fire position.
 8. If boiler outlet damper is provided, retain outlet damper wide open. If outlet draft damper modulating control system is provided and excessive draft due to wide-open damper is incompatible with the burner, automatically position the outlet damper to an acceptable position for burner ignition.
 9. Prove low fire start position.
 10. Sensing of flame prior to this shall cause shutdown.
 11. Energize igniter and open igniter fuel automatic safety shut-off valves. Prove igniter flame in ten seconds or provide shutdown.
 12. On systems with ultraviolet flame scanners, terminate ignition spark five seconds before main fuel valves open.
 13. Open main fuel safety shut-off valves for fuel selected. Close igniter fuel valves within ten seconds after main fuel valves open (15 seconds on heated oil).
 14. Prove main flame or provide shutdown.
 15. Place flue gas recirculation damper (if provided) in modulating or in fixed position as required by design of burner furnished.
 16. If provided, release boiler/economizer outlet draft control damper to modulation.
 17. Release burner from low fire position to automatic or manual firing rate control.
 18. Provide 15 second post purge at end of burner firing cycle.
 19. Close all dampers upon completion of post purge.
- R. Spare Parts:
1. One flame control programmer chassis complete.
 2. One flame control amplifier complete.
 3. One flame scanner complete with connecting leads.
 4. Twelve lamps for each type of replaceable lamp.
 5. Two of each type of relay and timer.

2.3 MAIN INSTRUMENTATION AND CONTROL PANEL:

- A. Type: One free-standing factory-assembled steel enclosure with control stations, control switches, instruments and indicators on panel front and controllers, relays and other components mounted on interior sub-bases. NEMA ICS-6, Type 12 rating. Refer to drawings for arrangement and overall dimensions.
- B. Panel Construction:
 - 1. Minimum 3.5 mm (0.134-inch) thick steel sheet with steel angle or bar reinforcement. Provide vertical reinforcement from top to bottom of panel between each large instrument opening. Provide horizontal reinforcement above and below each large instrument opening.
 - 2. Provide sufficient reinforcement to prevent any warping or displacement due to weight of equipment mounted on and within panel.
 - 3. All corners and edges shall be smooth.
 - 4. Rear Access Doors: Sufficient quantity to cover full height and width of panel, three-point latches with key-type locks, three hinges per door, or piano-type hinges.
 - 5. Finish:
 - a. Exterior: Undercoat of rust-resistant primer, finish coats of textured spatter paint, dark gray.
 - b. Interior: Undercoat of rust-resistant primer, finish coats of enamel, light gray or white.
 - 6. Provide duplex 120 v. GFI receptacle inside the panel.
 - 7. Provide fan-type ventilation if necessary to protect equipment from overheating. Assume boiler room temperature of 38 degrees C (100 degrees F).
- C. Master Steam Pressure Control Station: Refer to Paragraph, AUTOMATIC BOILER AND BURNER CONTROL SYSTEMS. Unit shall be flush mounted on panel front.
- D. Boiler/Burner Sub-master Control Stations: Refer to Paragraph, AUTOMATIC BOILER AND BURNER CONTROL SYSTEMS. Units shall be flush mounted on panel front.
- E. Recording Systems: Refer to Paragraph, RECORDERS.
- F. Touch Screens: Refer to Paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM.
- G. Pressure Gages: Flush mounted, ½ percent accuracy, 150 mm (6-inch) dial diameter, micrometer adjustable pointer, solid front, blow-out disk in rear, back connected, and of indicated range. Provide gage cock within

panel for each gage. Provide gages for steam header pressure, boiler feed header pressure for each boiler, fuel header pressures.

- H. Push Button Stations and Indication Lights for Pump Control: Refer to Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS. Lights shall be oil-tight, standard industrial construction, 120-volt, utilizing lamps which are readily available. Lenses shall be red and green colored, held in place by threaded ring. Push button stations shall be flush mounting, oil tight, momentary contact. Provide non-latching lamp test control on main panel.

I. Boiler Economizer Temperature Indicator Systems:

1. RTD system measuring temperature at four points: feed water in and out, flue gas in and out. Separate indicators, graduated 0 - 600 °F
2. Accuracy: Plus or minus 5 °F.
3. Mounting: Mount indicators on instrumentation panel.
4. Include Modbus communication with computer workstation (present or future).

J. Annunciator:

1. Provide system for monitoring alarm functions listed below.
Annunciator shall include alarm lights, alarm bell, integral test and acknowledge push buttons. Include Modbus communications for use with computer workstation.
2. Type: Multiple rectangular back-lighted windows on which alarm functions are engraved; separate window for each function. Provide test and acknowledge controls. All alarm lights shall operate independent of the PLC or if PLC fails all indicator lights will still function.
3. Construction:
 - a. Window Size: 44 x 75 mm (1.75 x 3 inches) minimum.
 - b. Lamps: Minimum of two per window.
 - c. Operating Mechanisms: Solid state electronic, accessible for repair without removing entire annunciator from panel. Provide all equipment for complete system.
 - d. Bell: 150 mm (6 inch) diameter, surface mounted.
4. Operating Sequence:
 - a. Condition Normal: Bell and light off.
 - b. Condition Abnormal: Bell on; light flashing.
 - c. Acknowledge: Bell off; light on steady.

- d. Condition Returns to Normal: Bell and light off.
- e. Test: Bell on; light flashing.
- 5. Alarm Sensing Systems: Provide complete wiring, controls, conduits, and accessories.
 - a. Condensate Storage Tank and Feedwater Deaerator Storage Tank High and Low Water Level Alarms (4 functions): Actuated by sensors mounted on storage tanks. Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
 - b. High and Low Steam Header Pressure (2 functions): Actuated by adjustable automatic reset UL listed pressure switches. Range of adjustable set point 40-180 psi, 5 psi maximum differential. Provide steam siphon loops, shut-off valves.
 - c. Emergency Gas Valve Closed: Actuated by switch provided with valve assembly.
 - d. Oil Tanks - High and Low Level (2 functions per tank): Separate high and low level indications for each tank. Actuated by oil tank level monitor system. Refer to Section 23 10 00, FACILITY FUEL SYSTEMS.
 - e. Low Excess Air - Boiler (1 function per boiler): Actuated by flue gas oxygen analyzers. Refer to Paragraph, AUTOMATIC BOILER AND BURNER CONTROL SYSTEMS.
 - f. High Natural Gas Header Pressure: Actuated by adjustable, automatic reset, pressure switch connected to gas header. Switch shall be UL listed for natural gas service. Provide shut-off cock between gas header and switch.
 - g. LP Igniter (Pilot) Gas in Use - For Emergency Only: Actuated by adjustable, automatic reset, UL listed, FM approved, high pressure switch mounted on LPG header. Range of set point 1-10 psi, emergency rating 30 psi.
 - h. Fuel Oil Temperature - High and Low (Heated Oil Only): Actuated by temperature switches located on the fuel oil header. Automatic reset, adjustable set point and dead band, UL listed, set point range 50 - 150 °F. UL listed, removable without draining system, set point indicator.
 - i. Low feedwater pressure (1 function per header): Actuated by pressure switches on feedwater headers.
 - j. Input/Output (I/O) Modules: Provide 20% (2 minimum) installed spare I/O of each type for computer data acquisition system.

- K. Emergency Fuel Safety Shut-Off Valve Control: Provide maintained contact, emergency safety shut-off push-pull control switches with mushroom heads on outside face of panel and at outside personnel doorways. The shut-off shall shut down main and igniter emergency safety shut-off valves from power source shown and shut down all other fuel sources. Valves shall close when switch is pulled out.
- L. Remote Registers for Fuel Meters: Refer to Paragraph, FLOW METERS.
- M. Clock: Microprocessor-driven digital, 60 mm (2.5 inch) high wide angle LED display, selectable 12/24 hours, enable/disable automatic daylight savings time changeover, enable/disable alternating time and date, seven year battery-back-up memory, time base accurate to plus or minus two minutes per year.
- N. Nameplates: Provide engraved plastic laminated nameplates for all devices on front of panel. Nameplates shall have white letters on black background. Mount with screws or rivets. List equipment title and identification number, such as "BOILER FEED PUMP P-1." Do not use abbreviations.
- O. Auxiliary relays: Industrial type rated for the service, enclosed contacts.
- P. Selector switches, push buttons and control switches: Heavy duty, industrial type.
- Q. Wiring and Piping Methods:
 - 1. All devices mounted in and on panel shall be factory-wired and piped.
 - 2. All electrical contacts shall switch the phase conductor.
 - 3. Electric wiring: Conform to NFPA-70, all wiring in troughs, terminations in industrial class terminal blocks, terminals numbered for identification, 20 percent extra terminals. All wiring color coded and numbered using numbering system that identifies the destination. There shall be no exposed wiring connections exceeding 120 volts inside the panels. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS, and Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS and CABLES (600 VOLTS AND BELOW).
 - 4. Piping: Stainless steel tubing, securely mounted, terminate in fittings at top of the cabinets.
- R. Spare Parts Required:
 - Lamps: Six of each type in panel and instruments.
 - Touch-up paint for panel: One pint.

2.4 BOILER/BURNER CONTROL PANELS:

- A. Type: Individual boiler/burner control panels with control stations, control switches, instruments and indicators on panel fronts and controllers, relays and other components mounted on interior sub-bases. Panels shall be boiler-mounted.
- B. Panel Construction:
 - 1. NEMA ICS-6, Type 4. Freestanding panels shall be minimum 3.5 mm (0.134 inch) thick steel sheet with steel angle or other reinforcement. Boiler-mounted panels shall be minimum 1.9 mm (0.075 inch) thick steel sheet. Provide sufficient reinforcement to prevent any warping or displacement due to weight of equipment mounted within panel. All corners and edges shall be smooth. Mount all equipment on sub-bases. Mount switches, reset buttons, indicators and instruments on outside face of panel.
 - 2. Access doors shall be full height and width of panel, dust tight gaskets, key-type locks. On freestanding panels, doors shall have three-point latches and three hinges or piano hinges.
 - 3. Exterior finish: Undercoat of rust-resistant primer, finish coats of enamel. Color same as instrumentation panel or boiler manufacturer's standard color if panel is boiler-mounted.
 - 4. Interior finish: Undercoat of rust-resistant primer, finish coats of enamel, white.
 - 5. Identification: All elements on face of and on interior of panels shall be labeled. Nomenclature shall be keyed to wiring diagrams.
 - 6. Provide fan-type ventilation if necessary to protect equipment from overheating. Assume environment at 43 degrees C (110 degrees F).
- C. Burner Management System with Annunciator: See Paragraph, BURNER MANAGEMENT SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
- D. Boiler Control Stations or Touch Screens, burner management displays and resets: See Paragraphs, AUTOMATIC BOILER CONTROL SYSTEMS, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEMS WITH SAFETY INTERLOCKS AND ACCESSORIES.
- E. Draft Gages: See Paragraph, DRAFT GAGES.
- F. Control switches on face of panel:
 - 1. Fuel selector.
 - 2. Burner start and stop selector (off-automatic-on).
 - 3. Circuit breaker for power to burner control system.
 - 4. Alarm silence.

5. Forced draft fan start-stop for D-type water tube boilers.
 6. Burner stop switch with mushroom head.
 7. Reset for burner management system.
- G. Boiler water level alarm on face of panel (non lock-out):
1. Provide separate visual indications and audible alarm (bell) for high water and low water. Low water alarm is separate from low water cutouts and set at higher level than low water cutouts.
 2. Indicating lights: Industrial, transformer type, removable amber lenses. Burner status and shut down annunciator specified above may be used. Standard water level alarm display of water level control manufacturer may be used.
 3. Alarm bell: 150 mm (six inch) diameter. Provide silencing control, which is automatically deactivated when another alarm condition occurs.
- H. Horn and bell: Mounted high on exterior of panel, audible throughout the boiler plant. The horn is for burner management system alarms and the bell is for high and low water level alarms (not burner cutoff) (See Paragraph G).
- I. Wiring and Piping Methods:
1. All devices mounted in and on panel shall be factory-wired and piped.
 2. All electrical contacts shall switch the phase conductor.
 3. Electric wiring: Conform to NFPA-70, all wiring in troughs, terminations in industrial type terminal blocks, terminals numbered for identification, 20 percent extra terminals. Wiring shall be color-coded and numbered with numbering system that identifies the destination of each wire. There shall be no exposed wiring connections exceeding 120 volts inside the panels. All field wiring shall be brought to terminal strip in the panel. No wiring in series from one safety device to the next device is permitted.
 4. Piping: Stainless steel tubing, securely mounted, terminate in fittings at top of the cabinets.
- J. Panel Certification and Testing:
1. Manufacture and inspection of completed panels, including all wiring and components, shall comply with UL 508.
 2. Complete cabinets shall be factory tested and certified. The panel shall be labeled as complying with UL 508. A copy of the wiring diagram shall be placed in the cabinet prior to shipment.

2.5 COMPUTER WORK STATION AND PROGRAMMING:

- A. The individual boiler plant controllers and instrumentation system shall be networked with a central computer workstation to provide remote operation of the controllers, custom graphic display of information, alarm message display, report generation, historical trending and remote tuning of controllers. All control functions shall be accomplished within the individual controllers and shall be monitored by the central computer so that the integrity of the control system shall not be dependent on the status of the central computer or the interconnecting network. Burner management (flame safety control) systems shall not be controllable from the workstation but shall be monitored from the workstation for status and access to historical data. Modem and software shall provide remote communication with diagnostic and status indications.
- B. Hardware:
1. Microsoft Windows based desktop computer workstation with keyboard, mouse, two speakers, color graphic monitor, alarm printer, logging printer, uninterrupted power supply. Equip with latest version Microsoft Windows operating system compatible with SCADA software furnished. The system shall be designed so that additional workstations and peripheral equipment can be added in the future. Provide all devices necessary for complete access to all features of the programs applied.
 2. Desktop Computer: Comply with requirements published by SCADA software supplier for optimum performance of software furnished. System must include hardware as recommended by Microsoft for installation of Windows Business operating system. Minimum requirements are Intel Core 2 Duo processor, 4 MB L2 cache, 2.4 GHz, 1066 FSB; 4 GB 600 MHz DDR2 SDRAM memory ECC(2 DIMMS); dual hard drives each 400 GB SATA, nVIDIA QUADROFX4400 512 MB graphics, DVD+/-RW optical drive, integrated gigabit Ethernet, 250 MB Iomega Zip internal drive, sound card, high density 1.44 megabyte 88 mm (3.5 inch) drive floppy disk, audible alarm and a battery-backed clock which counts seconds, minutes, hours, days and years. Provide two parallel ports and two serial ports, minimum.
 3. Digital Flat Panel Color Monitor: TFT, 475 mm (19 inch) diagonal (nominal) screen with capability of 1600 by 1280 pixels resolution,

- non-interlaced, dot pitch 0.31 maximum. Minimum of True 16bit colors supported. Energy-Star compliant.
4. Keyboard: ASCII standard, QWERTY-style, enhanced 101-key consisting of at least 32 dedicated function keys and a 12-key numeric data entry section. Keys shall have tactile feedback and be permanently and clearly labeled. In addition, a set of arrow keys shall be provided for moving from the current screen of data to "next screen". Function keys shall have custom legends for each key to allow report generation, graphic display selection, alarm silencing, and data retrieval with single keystrokes. Provide removable continuous Mylar faceplate to exclude dust and spills.
 5. Mouse: The operator interface shall minimize the use of the typewriter style keyboard through the use of a mouse and "point and click" approach to menu selection. Users shall be able to access features of the program from graphical displays through the use of the mouse.
 6. Alarm Printer: Impact printer, 9-pin dot-matrix type. The printer shall have a minimum 96 character ASCII character set based on ANSI INCITS 154. The printer shall have tractor feed with adjustable sprockets for paper width up to 380 mm (15 inches), print at least 132 columns per line and have a draft quality speed of 680 characters per second. Character spacing shall be selectable at 10, 12 or 17 characters per 25 mm (one inch) at front panel. The printer shall utilize sprocket-fed fanfold paper. The printer shall have programmable control of top-of-form. The sound level of the unit shall not exceed 55 dBA at 1500 mm (5 feet). Provide one box of 2000 sheets of printer paper.
 7. Logging Printer: Black/color inkjet type, 20 ppm black and white - 15 ppm color - draft quality, minimum 8 scalable fonts, 4800 x 1210 dpi color, 16 mb RAM, capability of letter and legal paper size.
 8. Speakers: Provided by computer manufacturer.
 9. Uninterrupted Power Supply: Provide complete protected power conditioner. Line interactive, UL 1449 rated, interactive digital display. Power supply shall protect computers, controls, instruments and accessories from damage due to ground leakage, spikes, surges, sags, transients and overloads in the incoming power supply. Smooth sine wave output. Hot swappable batteries. Audible and visual alarm to signal failure of UPS.

10. Provide a desk unit for support of microcomputer, terminals and peripherals. The desk shall have a 600 x 760 mm (24 x 30 inch) workspace in addition to space for equipment. Desk shall have at least two drawers.

C. Supervisory Control and Data Acquisition (SCADA) Software:

1. Generally available non-custom system compliant with latest version of Microsoft Windows. Shall use Windows Open Systems Architecture (WOSA), such as in its use of dialog boxes and menus. Local system with capability for future networking. All features shall be supported on the in-plant hardware specified. The software shall be a complete package requiring no additional software to configure or run the features of the program. Program shall not require hardware "dongle" keys for licensing. The program shall be completely configured to perform all required functions at the required speed and with complete accuracy.
2. Configuration shall be accomplished from the keyboard or the mouse. All configuration changes shall be capable of being made while the system is on-line (operating) without interfering with the normal functions of the program. No programming, compiling or linking shall be required to configure the system.
3. Provide complete user documentation in electronic format, including examples of how to operate the various modules of the system. Provide keyword and specific text search features.
4. On-line "help" facility, based upon Windows standard Hypertext. This shall support full text word search, add custom comments, bookmark topics, copy and pasting into another application, printing, and use of system fonts and colors.
5. Provide pre-emptive multitasking to ensure that common Windows actions are permissible and do not interfere with I/O communications, processing of data, alarming, and the integrity of the real-time and historical data.
6. Functions shall be available to support the following:
 - a. Analog and Digital Input/Output.
 - b. Analog and Digital Alarm.
 - c. Analog and Digital Register.
 - d. Boolean Logic.

- e. Calculation: Includes add, subtract, multiply, divide, parentheses, absolute value, square root, exponentiation, logs, relational operations, change floating point values to integers.
 - f. Device Control.
 - g. Event Action.
 - h. Fanout.
 - i. Multi-state Digital Input.
 - j. Program: Sequencing, monitoring, process control.
 - k. Real-time Trend.
 - l. Text.
 - m. Timer.
 - n. Totalizer.
7. Wherever possible, the device communications program will perform error checking on messages. This will include lost response and data error. Should communications errors be detected, the software shall automatically indicate that the data is no longer valid and identify the invalid data. The system shall automatically attempt to re-establish communications, and, if successful, shall then replace the characters with valid data without any user programs or other actions to implement.
8. The system shall include a diagnostic program capable of running on-line or off-line that can monitor message rates from the communication program. The diagnostic will display the number of new messages, retries, time-outs, and any occurrences of error.
9. The system must support third-party objects and controls to be plugged in via OLE and Active X support.
10. Support of accessing data to and from the process database and historical archive to another (future) database using Structured Query Language (SQL) as a standard language.
11. Graphics Capabilities:
- a. Color object-oriented graphic displays for monitoring and controlling the process, which show the actual configuration of the process. Real-time values from various field devices shall be displayed in a variety of user-configurable formats. Displays shall be standard MS Windows files. Graphic screens shall be based on objects and not individual pixels.

- b. Interactive object-oriented editor or workspace that allows creation and editing of graphics using a mouse. Capability of making changes to the graphics without shutting down the system.
- c. Graphic screens that are opened in configuration mode must support tiling and cascading. Tiling must have horizontal and vertical support and no overlapping when the graphic screens are viewed.
- d. Size will be based on logical units; not pixels and any logical unit may be used. A design at one resolution must be able to run at a different resolution. Provide full screen option and the ability to add sizing borders to any graphic screen. Provide title bar enabled/disabled option.
- e. Support 256 colors. Color changes must be selectable from editing the individual foreground, background, or edge color property for each object.
- f. Provide configurable toolboxes that the user can customize as to what tools it contains and their position in the toolboxes. Provide a method to describe the function of each tool when the cursor is positioned on a particular tool.
- g. As a minimum, support the following object drawing tools: rectangle, square, rounded rectangle/square, oval/circle, straight line, polylines, polygons, arcs, chords, pie shapes, text.
- h. Operations that may be performed on objects or groups of objects must include: select/select all, deselect/deselect all, change color, move, nudge, cut, copy, paste, clear, duplicate, group/ungroup, align, space vertically/horizontally, grid, snap-to-grid, reshape, zoom in/out, send-to-back/bring-to-front, choice of line and fill styles, flip, search and replace tag names, undo, cursor position, rotation, space objects evenly, make objects same size, layers.
- i. Provide ability to dynamically update elements in the picture. Dynamic link elements shall include: data, time, date, system information, alarm summary, pushbutton, multi-pen chart, OLE objects.
- j. Multiple-pen chart link shall include: unlimited number of pens, display run time and historical data on same chart, configurable time span, configurable trend direction, configurable zoom,

scrolling grid, invert high and low limits, minimum of five line styles for pens, minimum of three prebuilt line makers and a customizable line marker.

- k. Dynamic properties for objects must include: color changes (foreground, edge, background), fill percentage (horizontal, vertical), position/animation (horizontal, vertical, rotate, scale), script language (commands on down, up, mouse click, mouse double click, mouse move, edit), fill style (solid, hollow, horizontal, vertical, diagonal, cross hatch), edge style (solid, hollow, dash, dot, dash-dot, dash-dot-dot, null, inside frame). Provide capability to assign more than one dynamic property to an object.
- l. For properties other than commands, configuration shall be by the mouse. Scripting or programming shall not be required. When building object dynamics, properties must support configuration from a dialog box, pop-up menu and user customizable dialog boxes or forms. Positioning property changes must support a method to get screen coordinates and automatically fill in the required coordinates for positioning. The user customizable dialog boxes or forms must be customizable through VBA. The system must supply the following pre-built forms: fill, rotate, position, scale, visibility, edge color, foreground color, background color, data entry, open/close picture, replace picture, open/close digital tag, toggle digital tag, acknowledge alarm.
- m. The refresh rate shall be user-definable on a per object basis with the fastest being fifty milliseconds.
- n. The animation of the graphics and objects shall be able to be linked to: Data acquired and stored by the system, data acquired and stored by a networked system, variables declared in the command language scripts, local and networked relational databases using SQL/ODBC.
- o. Provide a wild card supported filter for assigning a data source. Provide a mathematical expression builder that is accessible from the graphic workspace.
- p. Provide for easy reuse of graphic objects or groups of objects. The objects shall be intelligent Windows wizard-like objects. A library of objects shall be included: pipes, valves (manual and automatic types), pumps, motors, tanks.

- q. The system must allow for bitmaps created by other systems to be imported into the graphics. Bitmaps must support a transparent mode and Metafiles must import as objects, not just bitmaps. As a minimum, the system must import .bmp, .msp, .jpg, wmf, pcx, ico, cur, psd, epr, and wpg.
- r. MS Word and Excel documents must be able to live within a graphic screen, running with the graphic, not as an external call. Word and Excel toolbars must be inserted as part of the graphic toolbars.
- s. Printing of graphic displays in color and black and white shall be supported via the standard MS Windows print manager in both the graphics development and runtime environments.
- t. Operator entry methods shall be a flexible MS Windows NT method. Item selection and data entry shall be done with mouse or keyboard and the selected item shall be highlighted. The following data entry methods shall be supported: numeric, slider, pushbutton, ramp value, alphanumeric.
- u. The system shall print a descriptive message with time stamp and user ID on the alarm printer or to an alarm file (as selected by user) whenever any of the following events occur: alarm, alarm acknowledgement, data entry into tag, reloading database file, saving database file, restarting the system.
- v. The scripting language used by the system must be MS Visual Basic for Applications (VBA) or equivalent with one of the software packages specified. Scripts shall allow users to automate operator tasks, and create automations solutions. The scripting language must use MS IntelliSense feature, exposing all methods and properties of graphic objects. Editing will be with the Visual Basic Editor (VBE), which is part of VBA. Scripting language requirements include: animation of objects, automatic generation of objects, read write and create database blocks, automatically run other applications, incorporate custom security features, create custom prompts and messages, incorporate and communicate with third party and custom Active X controls, trap bad Active X controls, write custom wizards, scripts become part of the graphic screen, the VBE must allow import and export capability, there must be a link from the graphic editor to the VBE, VBA or VBE is launched from within the system without any

commands, all properties method and event of Graphic object created within the graphic editor of third party Active X controls used in the graphic screen must be exposed to VBA.

12. Alarms and Message Handling:

- a. The system shall be capable of detecting alarm conditions based on the states and values of the various sensed variables whether or not the variables causing the alarms are on display. Alarm set points shall be enterable by the user upon configuration and during run time. Alarm types shall include: high high, high, low, low low, bad input from I/O, alarm disable, off scan, deadband, change of state, open, close. Support at least three priorities for each alarm type: high, medium, low.
- b. Message enabling and disabling must be controlled at the block level. The system must be capable of sending messages based on the following events: an operator event occurs, process database event occurs. In addition to alarms, the following types of blocks must be able to generate messages that report to any transactions to and from the hardware: digital input, digital output, digital register, analog output, analog register, text.
- c. The system must generate applications messages that describe database-related activity or operator entry. These messages shall be logged to alarm areas. Types of messages include: operator changes a process value, loads process database, logs into the system; any recipe upload, download or save condition; send information from a VBA script to all enabled alarm destinations; send a message from the database to all alarm destinations.
- d. The system shall provide a means for placing an alarm message in one or more of the following locations: alarm summary display, alarm printer, alarm message file on disk, alarm history window.
- e. Alarm messages shall be independently user-configurable as to what information is provided and its sequence within the message. The following shall be available choices: time of the alarm occurrence, name of tag causing the alarm, engineering units value, descriptor text assigned to the tag, engineering units of the tag.
- f. When a new alarm condition is detected, an alarm message will be generated. If the alarm condition code text for the block is on the current display, then the text will flash until the alarm is

acknowledged. Alarm acknowledgement will be performed from the keyboard or with the mouse and shall require no more than one keystroke or mouse click. The software shall include the following capabilities: alarm suspension which allows the user to specify digital tags that, when closed, cause alarms not to be generated for alarm conditions; re-alarm time which allows the system to re-generate an alarm after a user-configurable amount of time; alarm delay time which allows the user to specify a period of time for which an alarm condition must remain before an alarm is generated; close contact on alarm which allows user to specify digital tags that become closed when certain alarm conditions occur or reopened under certain conditions to allow operation of audible and visual alarms in the plant.

- g. Provide an alarm summary display as a dynamic link within the graphics package. This must show a list of the pending alarms in the system. As new alarms are detected, entries are made to the display list. Placement of alarm information and color codes shall be configurable. Alarms can be acknowledged from the summary display either individually or for all alarms in the queue.
13. Archiving and Reporting:
- a. Provide facility for automatically collecting, storing and recalling data. Recalled data shall be made available to a trend display program, a report generation program and to user-written programs.
 - b. Store data in Windows-compatible files in compressed format. Entries containing time, name, value and status will be made in the file whenever the real-time value exceeds the previously stored value by a user-supplied deadband limit. A deadband value of zero will cause an entry in the file each time the real-time value is examined. Files shall be organized according to time and will contain values for multiple, named variables. The files can be placed on the hard disk or floppy disk. Provide a mechanism for on-line maintenance and automatic purging of files.
 - c. The data to be collected by the archiving program will be identified through an interactive, menu-based configuration. The user will enter the tag name, collection rate, and data compression deadband value. Collection rates shall be selectable:

1 second, 2 seconds, 10 seconds, 20 seconds, 30 seconds, 1 minute, 2 minutes, 10 minutes.

- d. The operator shall be able to recall archived data from the disk to be displayed in graphic format along with real-time data. The display of archived data shall be user-configurable. It shall be possible to configure objects in graphic displays that, when selected, fetch pre-defined historical trend data from disk and display it to the operator. Attributes of pens shall be editable during run-time.
- e. The historical trend display shall be made up of the following components:
 - 1) Pen Group: Configuration shall be used to define the particular tag names to be displayed. Along with tag names, pen color, marker style and engineering units may be defined.
 - 2) Time Group: Configuration shall be used to define the time period over which the archived data is to be displayed.
 - 3) Legend Group: Configuration shall be used to define the legend parameters for a historical display. Both a primary and alternate legend may be displayed.
- f. The display shall support unlimited variables to be displayed on the same time/value axis simultaneously. For each entry in the display list, the operator will be able to assign a given tag name and marker to a particular line color selected from palettes of unlimited colors. The operator may also enter display engineering units ranges to cause scaling of the display. Support shall be provided for multiple, different y-axis engineering units to be displayed as appropriate.
- g. The display shall have two fields of view. The top portion of the screen shall be the graphic field and will display the values of the variables (y-axis) against time (x-axis). It will also contain labels for the axes and graphs. The bottom portion of the screen shall be user-configurable to display information, such as node-names, tag names, and descriptors, pertaining to the tags in the trend display.
- h. The trend object shall allow for bi-directional trending and scrolling. A movable, vertical line will act as a time cursor on the display. The date, time and values of the trends corresponding to that time will be displayed in the bottom

portion of the screen. The grid of the trend object shall be scrollable. The trend shall be shifted forward or backward in time by clicking on the right/left buttons. New data shall be fetched from the historical file as appropriate. The ability to display historical data with current data on the same chart must be supported. A transparent option for the trend must be selectable. The user shall be able to "zoom" on any section of the trend display by "cutting" that section with the mouse. The software will automatically re-scale both the y-axis and the time axis and will fetch the appropriate data for the time period selected. The trend object must have a refresh rate selectable in 0.1 second increments from a minimum of 0.10 seconds to a maximum of 1800 seconds.

- i. The trend display shall be printable to a black and white or color printer via the standard MS Windows NT print manager.

14. Event Scheduling:

- a. The system shall support a scheduler with time-based printing of reports.
- b. The system shall allow for scheduling of the following time-based printing of reports: Hourly, shift, daily, monthly, yearly.

15. Security Management:

- a. Provide a user-based security system which, when enabled, must allow for the creation of users with certain rights and/or privileges. These rights must include the ability to run any combination or all of the applications in the data acquisition system. The ability to allow or disallow users access to change values, such as set points and control setups, on an individual tag basis shall be supported.
- b. Groups of users, such as operators or supervisors, can be created and granted rights. All users assigned to a group obtain the rights of the group although they are tracked by the system by their individual ID. Individual members of a group may be also assigned additional rights.
- c. The system must support a tie to Windows NT security. When user-based security is enabled, an audit trail will be generated in the system, which will tag every operator action with a user ID.
- d. The system must support at least twenty separate security areas, assignable on a per-tag basis. Each tag can be assigned all of

the available security areas, none of the available security areas, or up to three individual security areas. Only users with clearance for those security areas shall have the ability to change parameters. Security area names may be up to twenty characters in length.

- e. The following functions must be supported: enable/disable user-based security; define users, passwords and login names; define groups to which users may belong; define security paths; define user and/or group rights/privileges; define security area names; define system auto-start user.
 - f. The ability to lock an operator or other user into the runtime graphics environment shall be provided. Disabling any combination of the following shall be supported, as configured by the user: starting other applications; switching to other applications that may be running; exiting from the system; restarting the computer using <Ctrl><Alt><Delete>; opening unauthorized screens; closing current screens; using the system menu; switching to the configuration environment; accessing the system tree.
 - g. The system shall allow for a login timeout setting for each user account. The system shall support manual login in and logout as well as automatic login. In addition, security information must be customizable through VBA scripting.
16. Services:

- a. Training: An interactive on-line tutorial shall be provided as part of the software to teach the basic operations of the system, including graphics and tag development. The tutorial shall demonstrate the configuration operations using interactive on-screen instructions. Standard classroom courses for operators of the system that cover the configuration and use of the system shall be available.
- b. Customer Support: Programming staff shall provide 24/7 support via telephone and email. Field service by programmer, or programmer-trained distributor, shall be available on two-day notice.
- c. Quality Assurance: The vendor must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the

software. The software shall have been in use by customers for at least three years.

17. Remote Operation of Controllers

- a. Provide capability to operate controllers locally at the control and indicating stations and, except for burner management (flame safety) controls, remotely at the computer workstation. For safety, it shall be possible to defeat the remote control from the front panel of each individual controller, preventing any status changes from being initiated at the computer workstation. The controllers include: master steam pressure, boiler/burner sub-master, burner fuel/combustion air, boiler draft, burner oxygen trim, boiler feedwater level, deaerator water level, condensate storage tank water level.
 - b. The operating personnel, when controllers are so enabled, shall have remote control of the following functions from the computer work station:
 - 1) Select manual/automatic mode.
 - 2) Set point (requiring use of high-level password).
 - 3) Controller output when in manual mode.
 - 4) Proportional/integral/derivative tuning parameters (requiring use of high-level password).
 - 5) Controller analog output values.
 - 6) Controller discrete output values.
 - c. The monitor display shall provide a facsimile of the controller front plates with clearly labeled English language and engineering unit display of the control parameters.
 - d. No special programming skills shall be required for any routine operating sequence.
18. Graphics: As a minimum, the following pictorial "screens" shall be available for observation:
- a. Individual boilers with economizers (if provided) showing:
 - 1) Main flame proven and approximate firing rate as shown by flame size depiction.
 - 2) Steam output instantaneous flow rate (pressure compensated), lb/hr .
 - 3) Steam output flow totalization (pressure compensated), lb . This is total production starting from time, day, month and year as set by operating personnel. Calculation shall be

accomplished in control or instrumentation system, not in the SCADA software.

- 4) Steam header pressure, psi .
 - 5) Boiler flue gas outlet temperature, °F .
 - 6) Boiler flue gas oxygen percent. Set point of oxygen trim system (if trim provided).
 - 7) Boiler stack opacity (if opacity monitors are provided).
 - 8) Boiler flue gas outlet draft (if outlet draft control system is provided), inches WC.
 - 9) Economizer flue gas outlet temperature, °F .
 - 10) Economizer feedwater inlet temperature, °F .
 - 11) Boiler feedwater inlet (economizer outlet) temperature, °F .
 - 12) Signal to feedwater control valve.
 - 13) Water level in boiler plus or minus inches from normal level.
 - 14) Boiler plus economizer "Heat Loss" combustion efficiency not including radiation and unaccounted losses.
 - 15) Fuel flow rate and totalization if individual boiler fuel meters are provided gpm ; gal. Totalization calculations shall be accomplished at the meters, not in the SCADA software.
 - 16) Feedwater flow rate and totalization if boiler feedwater flow meters are provided gpm; gallons. Totalization calculations shall be accomplished at the meters, not in the SCADA software.
 - 17) Trends of all flow, pressure and temperature data as listed above.
- a. Boiler Plant:
- 1) Feedwater deaerator storage tank water level, inches of water.
 - 2) Condensate storage tank water level, inches of water.
 - 3) Oil tanks oil level, gallons of oil .
 - 4) Pumps in operation.
 - 5) Chemical feeders in operation.
 - 6) Steam header pressure, psi .
 - 7) Feedwater deaerator steam pressure, psi .
 - 8) Emergency gas valve status (open or closed).
 - 9) Natural gas header pressure, psi.
 - 10) Fuel oil header pressure, psi.

- 11) Fuel oil header temperature (if heated oil), °F.
 - 12) Boiler feed header pressure - each header, psi.
 - 13) LP igniter gas header pressure psi.
 - 14) Instrument air pressure psi.
 - 15) Fuel oil tank and piping leak detection in operation.
19. Specific Requirements - Historical Trending:
- a. Display No. 1 (one display per boiler): Individual boiler pressure-compensated steam flow rate, lb/hr; flue gas oxygen, percent; boiler stack temperature, ° F; economizer flue gas outlet temperature, °F; percent opacity (if opacity monitor is provided); fuel flow rate (if fuel meters are provided on the boilers), scfh, gpm, feedwater flow rate (if feedwater meters are provided on the boilers)//gpm,.
 - b. Display No. 2: Pressure-compensated steam flow rate for: total of all boilers; in-plant steam line; and each distribution steam line, lb/hr; total plant fuel flow, scfh, gpm.
 - c. Display No. 3: Outside air temperature, °F; feedwater temperature, °F; steam header pressure, psi.
20. Specific Requirements - Alarm Monitoring and Operation Log:
- a. Alarm Monitoring Sequence:
 - 1) Alarm occurs:
 - a) Monitor flashes alarm on all displays where point is shown.
 - b) Display screen point or group flashes.
 - c) Audible alarm sounds.
 - d) Identification of alarm point is displayed at bottom of monitor screen.
 - e) Printer logs alarm.
 - 2) Operator acknowledges alarm:
 - a) Audible alarm is silenced.
 - b) Alarm display stops flashing but remains highlighted.
 - 3) Point in alarm returns to normal after acknowledgment:
 - a) Alarm display clears.
 - b) Printer logs return to normal.
 - b. Alarm Summary Display: The alarm sequence summary display shall alert the operator when points are in alarm. The time of occurrence, point identification, type of alarm, engineering value, and point description shall appear on the display. The

most recent alarm shall be shown at the top of the display, with time of occurrence displayed in hours, minutes, and seconds.

- c. Operation Log: In addition to alarm conditions, this log shall also print status of pumps and burners (in service or out of service), status changes such as a transfer from auto to manual, set point change, etc., so that the resultant printout is a true and complete log of plant operations.
- d. Alarm points shall include:
 - 1) Burner management safety control system alarms.
 - 2) Boilers high and low water level.
 - 3) Boilers low flue gas oxygen.
 - 4) Boilers high stack opacity (if opacity monitors are provided).
 - 5) Condensate storage tank high and low water level.
 - 6) Feedwater deaerator high and low water level.
 - 7) Feedwater deaerator high and low steam pressure.
 - 8) High and low steam header pressure.
 - 9) Low feedwater pressure to each boiler.
 - 10) Emergency gas valve closed.
 - 11) High and low natural gas header pressure.
 - 12) High and low fuel oil header pressure.
 - 13) High and low fuel oil temperature (if heated oil is provided).
 - 14) Propane igniter gas header pressurized (normal is zero pressure).
 - 15) High and low oil level in each oil tank.
 - 16) Oil tank and piping system leak detected.
 - 17) Carbon monoxide (CO) or combustible gas in building.
 - 18) Control system faults.
 - 19) Medical gases.
 - 20) Medical vacuum.
 - 21) Emergency generator status.
- 21. Report Generation - Specific Requirements: The monitor shall display and the log sheet printer shall print out: instant, hourly, shift, daily and monthly plant operating reports. As a minimum, each report shall list:
 - a. Maximum simultaneous instantaneous steam flow rate, combination of all boilers, lb/hr.
 - b. Minimum simultaneous instantaneous steam flow rate, combination of all boilers, lb/hr.

- c. Totalization of steam produced, each boiler and combination of all boilers, lb.
 - d. Totalization of steam used in boiler plant, lb.
 - e. Separate totalization of steam exported into each distribution system, lb.
 - f. Totalization of oil consumed, gallons.
 - g. Totalization of natural gas consumed, mscf.
 - h. Totalization of feedwater consumed, each boiler, gallons.
 - i. Overall boiler efficiency, fuel vs. steam (combination of all boilers).
 - j. Electricity used, kWh.
 - k. Make-up water used, gallons.
 - l. Make-up water as a percent of total steam production of all boilers combined.
 - m. Number of heating degree-days.
 - n. Hours of operation of each boiler.
22. Communication with Burner Management (Flame Safeguard) Control Systems: Provide means to communicate with each burner safety control system to determine status, operating hours, flame signal strength, history of lockouts, number of short circuit events, other data necessary for remote trouble-shooting.
23. Monitor Screen Printout: Any display on the screen shall be able to be printed as required to provide hard-copy record.
- D. Sensors and Transmitters: Provide as necessary to satisfy programming requirements. Refer to Articles, PRESSURE SENSORS AND TRANSMITTERS, and TEMPERATURE SENSORS AND TRANSMITTERS.

2.6 FLUE GAS OXYGEN ANALYZERS:

- A. Oxygen content of flue gases of each boiler measured by zirconium-oxide in-situ systems with probe mounted in stack or breeching. Output to boiler/burner submaster controller for oxygen trim. Single range, 0 to 10 percent oxygen.
- B. Performance:
 - 1. Minimum accuracy of plus or minus 2 percent of reading.
 - 2. Speed of response eight seconds or less to 90 percent accurate reading.
 - 3. Resolution 0.1 percent oxygen.

4. These performance requirements are minimums and must be increased if necessary to suit the requirements of the oxygen trim system (if provided).
- C. Field-replaceable cell, heater, and cell temperature sensor. Resident Engineer has the option of accepting long-term guarantee of unit exchange at favorable cost in lieu of capability of field-replacement of components.
- D. Reference and Calibration Air (if required by units furnished):
Provide refrigerated air dryer and instrument quality compressed air supply to each unit. Coalescing color-change filter and pressure regulator at each analyzer.
- E. Automatic Calibration System: In-stack using bottled calibration gas mixtures containing oxygen and nitrogen. Number of mixtures and composition as recommended by analyzer manufacturer. See Article, TOOLS.
 1. Selectable manual/automatic calibration, which will operate at preprogrammed intervals and upon power-up.
 2. Calibration gas piping system with permanently installed stop valves, pressure and flow regulators, pressure gages, and flow meters to permit connection of gas bottles to unit. Locate all gas bottle connections, regulators, gages and valves accessible from floor without use of ladders.
- F. Analyzer Displays: Operating parameters, process and diagnostic data, including percent oxygen, cell temperature, and set points of alarms and burner cutouts.
- G. Analyzer Outputs:
 1. Modbus communications and analog output compatible with boiler/burner submaster controller for flue gas oxygen trim.
 2. Low flue gas oxygen alarm on main panel annunciator. Set point adjustable 0.5 to 3.0 percent oxygen. Interface with burner management system to provide low oxygen shutdown of burner. Set point adjustable 0.5 to 3.0 percent oxygen. Set points shall not be adjustable from the front of the panel. Refer to Paragraph, BURNER MANAGEMENT SYSTEMS WITH SAFETY INTERLOCKS AND ACCESSORIES.

2.7 FLOW METERS:

- A. Vortex Flow Meters with Transmitters:
 1. Provide vortex-shedding flow meters designed for accurate measurement of flow rate ranges shown at required pressures. Minimum

turndown capability shall be as scheduled. Meters shall have digital readout of pressure-compensated flow rate and totalization located at transmitter and transmit flow rate and totalization digital signals to computer workstation and recorders. As an option, pressure compensation and the compensated flow rate may be performed and displayed by a boiler plant controller receiving signals from the flow meter and from a pressure transmitter. Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.

2. Programmable microprocessor electronics with on-board programming. Output signals immune to ambient temperature swings. Continuous self-diagnostic routines that identify electronics problems and provide a warning. Electronics replaceable in the field without affecting metering accuracy. Provide power supply as recommended by meter manufacturer. Mount electronics separate from meter body in position accessible from platform or floor without the use of a portable ladder.
3. All welded wafer-type or flanged stainless steel meter body with no seals. No sensor parts exposed to the flow stream. Provide alignment rings with wafer-type meters to assure proper centering in the pipeline. Trapezoidal shedder bar, sensing by detecting stresses in the shedder bar caused by vortices, dual piezoelectric crystals located outside the process flow sense the shed vortices, dual crystal alignment cancels effects of noise and vibration. Designed for Schedule 40 piping.
4. Transmitted signal accuracy plus or minus 1.5% of flow rate. Repeatability 0.2% of actual flow rate. Meter designed to minimize vibration effect and to provide elimination of this effect.

B. Water Flow Meters:

1. Type: Continuous duty positive displacement disk or turbine type with meter-mounted totalizing registers.
2. Service: Provide individual meters to measure volume of cold water, soft water as shown.
3. Performance: Conform to scheduled flow range, accuracy, maximum pressure drop, maximum static pressure and temperature for the liquid shown. Minimum accuracy plus or minus 0.5% of flowrate over 4/1 turndown.

4. Meter Construction:

- a. Bronze or iron cases, threaded pipe connections, designed for 1025 kPa (150 psi) maximum pressure.
- b. Registers: Hermetically sealed, magnetic coupling, digital flow rate readout or sweep hand registering one or ten gallons per revolution and digital register for totalizer with at least five digits. Provide horizontal register box with gasketed viewing glass and hinged cover. Register shall have capability of being positioned to any of the four cardinal points for readability. Provide remote flow indication on main instrument panel with flow rate and totalization. Transmit flow data to computer workstation.

C. Fuel Oil Meters:

1. Type: Positive displacement screw type, cast iron cases, nitrided steel spindles, seals, threaded pipe connections, designed for pressure exceeding set pressure, plus 25 percent, of nearest upstream relief valve. Rated for 120 degrees C (250 degrees F) if utilized for heated oil. Accuracy plus or minus 0.1% of flow rate over required flow range.
2. Meter Registers: Hermetically sealed flow computer with digital flow rate readout and digital register for totalizer with at least five digits located at meter, positioned for easy viewing. Provide remote flow rate and totalization readout device. Transmit flow data to computer workstation.

D. Turbine-Type Natural Gas Flow Meters:

1. Type: Turbine-type with volume totalizing digital readout that is continuously updated and corrected for the line pressure and temperature. Meter readouts shall be located on meter and in computer workstation and on main instrument panel. Meter shall be designed for natural gas at job site characteristics.
2. Performance: Maximum flow rate as scheduled. Pressure drop shall not exceed 1.25 kPa (5 inches WC). Accurate flow minimum turndown range shall be 10/1 with minimum accuracy one percent of flow rate over the entire range.
3. Construction:
 - a. Meter: Design for 850 kPa (125 psi). Pipe connections flanged 850 or 1025 kPa (125 or 150 psi) ANSI. All bearings and gearing shall be in areas sealed from contaminants. Metering transducers

operated through magnetic coupling. The measuring devices shall be contained within a module that can be removed from the meter body for service and calibration without breaking the main gas piping connections. Corrosion-resistant material of construction or coating.

- b. Indication Devices on Meter: Electronic type which provides a totalized continuous volume flow digital indication in cubic feet automatically continuously corrected to the local contract base temperature and pressure from actual varying line temperatures and pressures. Unit shall also display a totalized uncorrected volume flow indication. The display shall show actual line temperature and pressure at the meter and pressure-temperature correction factor. Smallest corrected flow indication shall be one thousand cubic feet , and indicator shall have at least six digits. Unit shall be watertight where drawings show an outdoor location.
- 4. Calibration: Factory calibrated. Furnish three-point curve spanning required flow range on actual meter furnished.
- 5. Accessories:
 - a. Remote Digital Register: Provide a remote digital register system including pulse generator and all wiring and accessories for proper functioning. Remote register shall have a digital cubic feet volume readout corrected to the local contract base temperature and pressure from actual varying line conditions. Smallest indication shall be one thousand cubic feet, and indicator shall have at least six digits. Provide 120-volt power supply from panel. Main plant register shall be located on main instrument panel; individual boiler registers shall be located on boiler control panels.
 - b. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.
 - c. Filter: Shall have replaceable glass-fiber or cellulose cartridge with ten micron or smaller particle retention. Filter enclosure shall be the pipe size of the meter or larger as required by pressure drop considerations. Static pressure capability shall be at least twice lockup pressure of service supply regulators. Maximum pressure loss 1.25 kPa (5 inches WC) at maximum design

flow rate of meter. Plug all drains or instrumentation outlets.
Provide vent with cock for relieving pressure in filter.

2.8 BOILER STACK OPACITY MONITORS:

- A. Provide complete microprocessor-controlled system for each boiler with sensor mounted on boiler stack or breeching, separate control unit mounted in accessible location, and panel-mounted display. Electronics shall have RS485 Modbus communications and an analog output for input to the combustion control panel and transmittal to the computer workstation. Electronics shall have automatic and manual calibration via the front panel of the opacity monitor.
- B. Light source shall have life expectancy greater than one year. System shall automatically compensate for lamp aging and voltage variations.
- C. Provide panel-mounted display which shows the opacity and alarm and maintenance functions. These alarms and functions shall include:
 - 1. Pre-emission.
 - 2. Over-emission.
 - 3. Lamp out.
 - 4. Purge blower failure.
- D. Provide alarm bell on front panel, with silencing control, to sound when over-emissions or other alarm condition occurs.
- E. Mount control panel on the panel that includes the combustion controllers.
- F. Purge air system with blower, provided by manufacturer of opacity monitor, to reduce build-up of dirt on lenses. System shall include disposable air filters.
- G. Printer: Provide strip chart opacity recorder with date and time stamp. Connect to opacity monitor output.
- H. Spare Parts Required:
 - 1. Lamp for opacity monitor.
 - 2. Six air filters for opacity monitor air purge unit.
 - 3. Three months supply of chart paper for strip chart opacity recorder.

2.9 PRESSURE SENSORS AND TRANSMITTERS:

- A. Transmitters for gage pressure, differential pressure, fluid level, and draft utilized for instrumentation, computer workstation, and controls.
- B. "Smart" programmable electronics, sealed diaphragms, direct-sensing electronics, no mechanical force or torque transfer devices, non-interactive external span and zero adjustment, solid-state plug-in circuit boards. Minimum accuracy plus or minus 0.1 percent of

calibrated span. 40:1 minimum rangeability. Communication system shall be compatible with boiler plant controls and instrumentation.

- C. Shut-off and blowdown valves on all transmitters.
Equalizing/calibration manifold valves on all differential pressure and fluid level transmitters. Connection points to permit calibration of system with a portable pressure calibrator.
- D. Reservoirs for transmitter piping connections where an interface between liquid and steam is present, such as boiler water level sensing and differential pressure steam flow meter applications.
- E. Provide and deliver to Resident Engineer (RE) all hardware and software necessary for field calibrating and programming all transmitters.
- F. Spare Parts: One transmitter of each type utilized in the project.

2.10 BOILER DRAFT GAGES:

- A. For D-type water tube boilers, provide gages for windbox, furnace, boiler outlet, and economizer (if provided) outlet. For flex-tube water tube boilers and for fire tube boilers, provide gages for boiler outlet and economizer (if provided) outlet.
- B. Type: Analog, multiple vertical scale, dry diaphragm, balanced pointers, semi-flush-mounted, zero adjustment.
- C. Scales: Internally illuminated, minimum length 120 mm (5 inches), scale ranges coordinated with equipment furnished and actual operating conditions, scales labeled for the service. If, in operation, indicators go under-range or over-range, the gages shall be replaced with greater ranges, at no additional cost to the Government. Scales for furnace, boiler outlet, and economizer outlet gages must be combination negative and positive pressure.
- D. 3-way cock for each gage to permit shut-off, connection to service, connection to atmosphere.
- E. Mount on boiler/burner control panel.

2.11 TEMPERATURE SENSORS AND TRANSMITTERS:

- A. Provide resistance temperature detectors (RTD).
- B. Provide transmitters or panel-mounted indicator transmitters, transducers, and receivers compatible with the system including the controllers recorders computer workstation.
- C. Minimum accuracy one percent of actual temperature.
- D. Boiler and economizer flue gas temperature sensors shall be averaging type and shall extend across width of stack or breeching.

- E. Provide stainless steel weather hood on outside air temperature sensor, which shields the sensor from direct sunlight.

2.12 RECORDERS:

- A. Provide complete systems to continuously receive and record steam flow, fluid temperatures, fluid pressures and boiler flue gas oxygen percent. System shall also include steam flow totalizing functions.
- B. Identification: Provide engraved plastic or metal plate at each recorder which lists recording and totalizing ranges, units of measurement, multiplying factors, steam flow transmitter differential pressure, steam flow primary element identification data such as steam pressure upon which primary element size was calculated, chart identification number.
- C. Electronic Display-Type Paperless Recorder:
 - 1. Microprocessor-based programmable signal receiving, recording and display. Configure through touchscreen or front keypad. Waterproof and dustproof front panel.
 - 2. Display: 250 mm (10 inch) minimum height and width, XGA 16 bit color with 125 ms trend speed or TFD color LCD. 24 colors minimum.
 - 3. User-editable custom screens.
 - 4. Input channels: Quantity sufficient for requirements stated below or shown on drawings. Each recorder shall be limited to data from two boilers.
 - 5. Minimum of 16 simultaneous real time trending displays shown as selectable trace, bargraph and digital values and identified as to function with scale values, engineering units.
 - 6. Totalizers for all flow functions.
 - 7. Under/over range signal and alarm displays and high and low alarm displays for each input.
 - 8. 32 Mbyte internal flash memory.
 - 9. Standard Ethernet communications - 1/100baseT. Modbus protocol.
 - 10. USB plug and play capability to allow remote connection to perform any operation that can be done directly on the instrument.
 - 11. Recording destinations:
 - a. Data backup static minimum 36 Mbyte RAM.
 - b. Automatically download data directly to in-plant computer workstation hard drive. Provide and install software compatible with workstation operating system.

- c. USB Memory Stick removable media.
- 12. Password protection of parameters. Provide passwords to Resident Engineer (RE).
- D. Recording Functions:
 - 1. Steam Flow:
 - a. Record steam flow rate and totalize steam flow from: each boiler individually, individual steam distribution lines, in-plant uses.
 - b. Provide continuous totalizer for each flow function. Counter shall have six digits minimum.
 - c. Pressure Compensation: Provide system that automatically corrects the steam flow recording and totalization for the actual line pressure. Boiler and distribution steam flow recorders may utilize the main header pressure as the signal for pressure correction if there are no intervening pressure regulators. On boilers with two-element or three-element feedwater level control, provide pressure compensated flow signal to the feedwater level controller.
 - 2. Boiler Flue Gas Oxygen, Stack Temperature, Steam Header Pressure, Outside Air Temperature, Feedwater Temperature.
 - 3. Provide all new sensors and transmitters for each recorder input.
 - 4. All data shall be available via Modbus communications for the computer workstation (present or future workstation).

2.13 GAGES, PRESSURE AND COMPOUND, PIPE OR TANK-MOUNTED:

- A. Construction:
 - 1. Case: Solid armored front between measuring element and dial, blowout back, bottom connection, phenol turret type.
 - 2. Dial: Non-corrosive, 110 mm (4-1/2 inch) diameter face with black markings on white background.
 - 3. Measuring Element: Bourdon tube designed for the required service. Provide bellows designed for service for pressure ranges under 100 kPa (15 psi).
 - 4. Movement: Stainless steel, rotary.
 - 5. Pointer: Micrometer adjustable, black color.
 - 6. Window: Plastic.
 - 7. Liquid Filled Gages: Provide at inlet and outlet of all pumps, on compressed air systems, and on fuel and atomizing media lines at locations closest to burners where bourdon tube gages are utilized. Gage filling shall be glycerin or silicone oil. Purpose of filling

is to provide pulsation dampening. As an option to liquid filling, provide dry gages that have built-in fluid clutch dampeners that are not vulnerable to plugging due to foreign material.

B. Accuracy: ASME B40.100, Grade 2A, ½ percent, on all gages; except Grade A, one percent permitted on diaphragm actuated gages, liquid filled gages, and compound gages.

C. Accessories:

1. Red set hands on gages located at automatic pressure regulator valve outlets.
2. Needle valve or gage cock rated for the service.
3. Syphon on all steam gages.
4. Pulsation snubbers on diaphragm-type gages located adjacent to gas burners.

D. Scale Ranges: Provide English scales:

1. Low pressure steam to 100 kPa (15 psi): 0 to 200 kPa/0 to 30 psi.
2. Medium pressure steam to 407 kPa (59 psi): 0 to 700 kPa/0 to 100 psi.
3. High pressure steam above 407 kPa (59 psi): 0 to 200 psi.
4. Natural and LP gas: 0 to 200 kPa/0 to 30 psi.
5. LP gas at tanks: 0 to 2100 kPa/0 to 300 psi.
6. Gas burner, 125 percent of full load pressure, inches WC.
7. Oil pump suction: 30 inches Hg vacuum to 15 psi.
8. Oil pump discharge: 0 to 200 psi.
9. Oil burner, 125 percent of full load pressure, psi.
10. Compressed air, 345 kPa & higher (50 psi & higher): 0 to 160 psi.
11. Feedwater pump discharge: 0 to 300 psi.
12. Feedwater pump suction: 30 inches Hg vacuum to 30 psi.
13. Pumped condensate: 0 to 60 psi.
14. Condensate transfer pump discharge: 0 to 60 psi.
15. Condensate transfer pump suction: 30 inches Hg vacuum to 15 psi.
16. Feedwater deaerator: 30 inches Hg vacuum to 30 psi.
17. Other services, 200 percent of maximum operating pressure.

E. Boiler Steam Pressure Gages: Refer to Section 23 52 39, FIRE-TUBE BOILERS.

F. Panel-mounted Gages: Refer to Article, MAIN INSTRUMENTATION AND CONTROL PANEL.

2.14 THERMOMETERS, PIPE OR TANK-MOUNTED:

A. General: Thermometer locations are shown on the drawings.

B. Construction:

1. Industrial type, separable well and socket, union connected.
2. Scales: Red reading mercury combination 30 to 300 degrees Fahrenheit/0 to 150 degrees Celsius scales, unless otherwise shown. Scale length 220 mm (9 inch) except 170 mm (7 inch) scale length acceptable on oil burner piping. Mercury sealed under pressure with inert gas to prevent oxidation and separation of column.
3. Case: Corrosion resistant with glass or plastic front.
4. Form: Straight or back form except thermometers located more than 2100 mm (7 feet) above floor or platform shall be adjustable angle.
5. Wells: Sized to suit pipe diameter without restricting flow. Provide snug sliding fit between socket and well.
6. Accuracy: One percent of scale range.

2.15 BOILER PLANT BUILDING DANGEROUS GAS DETECTION SYSTEM; CARBON MONOXIDE AND COMBUSTIBLE GAS:

- A. Automatic microprocessor-based industrial-class system that monitors the concentration levels of carbon monoxide and combustible gases in the boiler room and associated spaces. The system shall include displays of the concentration levels of the gases detected by each sensor and provide audible and visual alarms when these gases are detected. Control/transmitter panels with displays and control functions shall be located 1500 mm (5 feet) above the boiler room floor. Provide 2 combustibles sensors and 3 carbon monoxide sensors at locations shown or as directed. Provide RS485 Modbus communications protocol (i.e. Modbus RTU, etc.) of detected gas concentration levels and alarms to computer workstation and central control panel. Transmit alarm signal to designated location outside the boiler plant:_____ Audible and visual alarm shall be provided at this location.

B. System Description:

1. Carbon Monoxide (CO) Sensors: Transportable calibration, electrochemical plug-in type, range 0-100 ppm, detection limit less than plus or minus 5% of full scale, response time less than 10 seconds, zero drift less than 5% per year, span drift less than 10% per year, repeatability less than plus or minus 5% of full scale, active temperature compensation. Set point: 25 - 50 ppm.
2. Combustible Gas Sensors: Plug-in type, infrared detection, no moving parts, range 0-100% lower explosive limit. On-board storage of

- calibration data, peak values, time and date stamped. Set point: 10% of lower explosive limit.
3. Controller/Transmitters: Separate from sensors, non-intrusive calibration. NEMA 4 enclosure, sensors connected to transmitter with easily operated connection devices. Universal transmitter which can accept infrared, catalytic bead, or toxic sensor and auto-configure when sensor connector is inserted. LED display of gas type and concentration, alarm horn and strobe, output compatible for computer work station, integral non-volatile memory, automatic resume on power failure, sensor and controller diagnostics, menu-driven calibration. Networked with computer work station SCADA program via RS-485 four-wire bus, such as Modbus RTU.
 4. Additional Features:
 - a. Capability to remotely mount sensor from transmitter to allow calibration at convenient point up to 100 feet away.
 - b. Sensor/transmitter display shall indicate all diagnostic check/fault conditions with detailed message displays.
 - c. Full-function keypad or magnetic touch points to allow setting alarm set points, change span gas values and display date of last calibration.
 5. Calibration: Sensor/transmitters shall be calibrated with hand-held calibration devices furnished by system manufacturer. Provide complete calibration kit, including test gases, for commissioning and future calibrations. Provide permanently mounted hose for remote-mounted sensors.
 6. Approvals: NEC and CEC for explosion proof or non-incendive, when required.
 7. Product Support: Supplier shall have organization, located within 150 miles of site, with capability of complete on-site product
 8. Power Supply: Provide protected power supply to protect system from surges, spikes, transients, overloads in the incoming power supply.

2.16 TOOLS:

- A. Portable Deadweight-Type Pressure Gage Tester:
 1. Type: Portable hydraulic deadweight tester with minimum range of 10 to 300 psi.
 2. Accuracy: Within plus or minus 0.1 percent of indicated pressure traceable to National Institute of Standards and Technology (NIST).

3. Construction: Steel or aluminum carrying case, compact design unit with weights and pump fitting within one carrying case, weights replaceable without replacing remainder of apparatus.
 4. Accessories: Gage pointer puller, 6 mm (1/4 inch) and 12 mm (1/2 inch FNPT) pressure gage connectors, sufficient hydraulic fluid to fill tester three times, all tools recommended by manufacturer.
 5. Delivery: Deliver to Resident Engineer (RE) for use by VA personnel only. Deliver prior to boiler tests.
- B. Portable Digital-Type Pressure Gage Tester:
1. Type: Portable digital pressure calibrator with a minimum range of 10 to 200 psi.
 2. Accuracy: Within plus or minus 0.04% of indicated pressure traceable to National Institute of Standards and Technology (NIST).
 3. Construction: Steel or aluminum carrying case, compact design unit with hand pump, fittings for connecting to pressure gages and pump, test leads.
 4. Accessories: Gage pointer puller, 6 mm (1/4 inch) and 12 mm (1/2 inch FNPT) pressure gage connectors, all tools recommended by manufacturer for testing pressure gages.
 5. Delivery: Deliver to Resident Engineer (RE) for use by VA personnel only. Deliver prior to boiler tests.
- C. Calibration Gases for Boiler Flue Gas Oxygen Analyzers and Building Carbon Monoxide and Combustible Gas Detection System:
1. Type: Compressed gases in transportable cylinders, certified analyses. One cylinder of each mixture for each analyzer. Composition of mixtures and quantity of mixtures as recommended in written instructions by analyzer and gas detection system manufacturers.
 2. Cylinders: Minimum capacity 100 liters of gas, approx. 75 x 360 mm (3 x 14 inch) cylinder.
 3. Delivery: Deliver to Resident Engineer prior to initial calibration of instrumentation. Contractor personnel may use gases. Provide new full cylinders, to replace gases used during start-up and testing after boiler plant testing is complete.
- D. Communication Devices for Programming Instrumentation and Controls:
- Furnish all devices necessary to configure all programs and obtain all data from instruments and controls. Deliver to Resident Engineer.

PART 3 - EXECUTION**3.1 INSTALLATION, BOILER PLANT INSTRUMENTATION, AUTOMATIC BOILER CONTROL SYSTEMS, BURNER MANAGEMENT SYSTEMS, COMPUTER WORK STATION (IF PROVIDED):****A. General:**

1. Nameplates, Labels and Identification: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
2. Electrical Work and Safety Requirements: Comply with NFPA 70 and referenced electrical sections of these specifications.
3. Electrical Wiring: Comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS; Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS; Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW); and Section 26 27 26, WIRING DEVICES. The term "wiring" includes furnishing of wire, conduit, miscellaneous material and labor to install a complete working system as specified.
4. All devices plumbing and wiring shall comply with and be arranged as shown in the most recent edition of the "VHA Boiler Plant Safety Device Testing Manual".
5. Protect all circuits to avoid interruption of service or damage to equipment due to short-circuiting or other conditions. Line-protect from lightning and static electricity all wiring that comes from external sources.
6. Except for short apparatus connections, run conduit and pneumatic tubing parallel to or at right angles to the building structure.
7. Run tubing and wire connecting devices in control cabinets parallel with the sides of the cabinets neatly racked to permit tracing. Rack wiring bridging a cabinet door along the hinge side and protect from damage. Provide grommets, sleeves or vinyl tape to protect plastic tubing or wires from sharp edges of panels, conduit, and other items. Fit all equipment contained in cabinets or panels with service loops; each loop shall be at least 300 mm (12 inches) long. Equipment for fiber optic systems shall be self-supporting, code gage steel enclosure.
8. Permanently mark terminal blocks for identification. Label or code each wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.

9. Cables:

- a. Keep cable runs as short as possible. Allow extra length for connecting to the terminal board.
 - b. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
 - c. Cables shall be supported for minimum sag.
 - d. Splices in shielded and coaxial cables shall consist of terminations and shielded cable couplers. Terminations shall be in accessible location. Cables shall be harnessed with cable ties.
- B. Pressure, Temperature, Level and Flow Transmitters: Mount in locations accessible from floor or platform without use of portable ladders. Provide separate conduit for each transmitter signal if recommended by manufacturer. Protect sensor or controller on steam or water service by an adequate water seal at all times and provide blowdown facilities to permit blowdown of sensing lines. Install temperature sensors with entire temperature sensing surface immersed in media being measured. Locate outside air temperature sensor on north side of building away from heat sources. Provide isolation valves on all transmitters connected to fluid systems. Locate isolation valves so that transmitter can be isolated while main sensing line is being blown down. Provide equalizing valves on all differential pressure transmitters. Provide valved drains on all fluid lines. Valves shall be rated for minimum of 150 percent of system pressure and temperature.
- C. Steam Flow Meter Primary Elements (In-Line Flow Sensors) including Vortex-Shedding Type: Provide straight runs of piping upstream and downstream as recommended by manufacturer to achieve maximum accuracy and rangeability. Verify that stresses in piping system do not exceed allowable stress of flow meter body. Locate meter electronics including read-out devices accessible from floor or platform without the use of portable ladders.
- D. Flue Gas Oxygen Analyzers:
1. Mounting: Provide freestanding floor-mounted steel rack for mounting control panels and read-outs. Position panels and readouts 1500 mm (5 feet) above the boiler room floor.
 2. Sampling point shall be upstream of smoke density monitor in non-turbulent area. Locate probe within 4.5 meters (15 feet) of floor or accessible from platform.

3. Reference Air: Provide dry, filtered, pressure-regulated compressed air service to each unit. Provide isolating valve at each unit.
4. Calibration Gases: Provide permanently installed valved piping connections, pressure regulators and gages in flue gas sampling system for connection of required calibration gases. Locate within 1200 mm (4 feet) of main floor.
5. Interconnection of Instruments: Provide shielded wiring as recommended by instrument manufacturer.
6. Power Circuits: Provide dedicated circuits from a plant panel.
Analyzers shall remain powered when burner control is off.
- E. Wiring and Piping: Is generally not shown on the drawings. All wiring and piping must be provided in accordance with NFPA 70 and ASME B31.1.
- F. Combustion Control Linkage Systems: After completion of burner adjustments, counter sink all lever set screws into shafts or pin levers to shafts to prevent levers from slipping on the shafts.
- G. Boiler Stack Opacity Monitors (if provided): Locate downstream from oxygen sensing systems so that opacity monitor air purge does not affect flue gas oxygen reading. Locate sensor within 4.5 m (15 feet) of floor or accessible from platform without use of portable ladder. Locate air purge blower unit within 2400 mm (eight feet) of floor or accessible from platform without use of portable ladder.
- H. Compressed Air Filters: Pipe drain to nearest floor drain.

3.2 INSTALLATION, NATURAL GAS FLOW METERS:

Entire installation shall conform to recommendations of the meter manufacturer for obtaining the most accurate flow measurements. Arrange meter readout so that it is visible from nearest walkway or service platform.

3.3 INSTALLATION, PRESSURE GAGES:

Orient gages so that dials are upright and visible from the nearest walkway or access platform. Install gages with gage cocks. Provide pig-tail syphons on steam service. Provide compound gages on all pump suction lines and on feedwater deaerator; provide pressure gages elsewhere. Install liquid-filled or equivalent (as specified) gages at inlet and outlet of all pumps, on compressed air systems, and on fuel and atomizing media lines at locations closest to burners. If diaphragm-type gages are used, provide pulsation dampeners instead of liquid-filling.

3.4 INSTALLATION, THERMOMETERS:

Arrange thermometers so that scales are upright and visible from nearest walkway or access platform. Provide adjustable angle thermometers on applications more than 2100 mm (7 feet) above floor or platform. Tilt the angle type thermometers for proper view from floor or platform. Locate wells in flow stream.

3.5 INSTALLATION-WATER AND OIL FLOWMETERS:

Provide strainer upstream with 80-mesh screen liner. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS. Position register for upright viewing from nearest walkway.

3.6 TESTING, BOILER PLANT INSTRUMENTATION, AUTOMATIC BOILER CONTROL SYSTEMS, BURNER MANAGEMENT SYSTEMS, COMPUTER WORKSTATION (IF PROVIDED):

- A. Representatives of the designer of the system shall demonstrate proper operation and calibration of all components, computer programs, and entire systems to the Resident Engineer (RE). If the project includes boiler/burner testing, the demonstration involving boiler/burner data shall be conducted during the boiler/burner tests. Furnish personnel, instrumentation, and equipment necessary to perform calibration and testing. All calibration work must be completed prior to the testing.
- B. Burner Management (Safety Control) Systems: All test shall be based on the most recent edition of the "VHA Boiler Plant Safety Device Testing Manual", also Refer to Section 23 52 39, FIRE-TUBE BOILERS.
- C. Steam Flow Measuring: Demonstrate proper calibration of each flow rate signal and indication and each totalizer signal and indication to Resident Engineer or their representative prior to the start of the final boiler testing.
- D. Pressure test all pneumatic control tubing at one and one-half times the normal operating pressure.
- E. Testing shall demonstrate proper calibration of input and output devices, the proper operation of all equipment, proper execution of the sequence of operation, proper tuning of control loops and maintaining of all set points.
- F. Document all tests with detailed report of test results. Explain in detail the nature of each failure and corrective action taken.
- G. During and after completion of the pretests, and again after the final acceptance tests, identify, determine causes, replace, repair and calibrate equipment that fails to comply with contract requirements or

the standards of the manufacturer. Provide written report to Resident Engineer.

- H. Demonstrate safety and operating interlocks.
- I. Demonstrate that programming is not lost and that the control and instrumentation system performs the correct sequence of control and instrument functions after a loss of power.
- J. Furnish to Resident Engineer graphed trends of control loops to demonstrate that the control loops are stable and that set points are maintained. Trend data shall be instantaneous and the time between data points shall not be greater than one minute.
- K. Signal Transmission System Equipment:
 - 1. Ground Rod Tests: Before any wire is connected to the ground rods, use a portable ground testing instrument to test each ground or group of grounds.
 - 2. Coaxial Cable Tests: Implement NEMA WC 63.2 as a minimum.
- L. Computer Workstation Software Operation Test:
 - 1. Test ability to properly communicate with and operate the control systems.
 - 2. Demonstrate the ability to edit the programs off and on line.
 - 3. Demonstrate operation of all alarm points.
 - 4. Demonstrate the receipt, display, and saving of trend and status reports.
 - 5. Demonstrate display and operation of all graphics.
 - 6. Demonstrate all program calculating functions and report generation.
 - 7. Demonstrate proper operation of all printers.

3.7 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 Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.8 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 -

COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.9 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam, condensate and vent piping inside buildings. Boiler plant and outside steam distribution piping is covered in specification Section 33 63 00, STEAM ENERGY DISTRIBUTION and Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- F. Section 23 07 11, HVAC, - AND BOILER PLANT INSULATION.
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- E. Section 23 22 23, STEAM CONDENSATE PUMPS.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, which includes welding qualifications.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
1. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers.
 2. Pipe and tubing, with specification, class or type, and schedule.
 3. Pipe fittings, including miscellaneous adapters and special fittings.
 4. Flanges, gaskets and bolting.
 5. Valves of all types.
 6. Strainers.
 7. Pipe alignment guides.
 8. Expansion joints.
 9. Expansion compensators.
 10. Flexible ball joints: Catalog sheets, performance charts, schematic drawings, specifications and installation instructions.
 11. All specified steam system components.
 12. Gages.

- 13. Thermometers and test wells.
- 14. Electric heat tracing systems.
- 15. Seismic bracing details for piping. NOT USED
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
 - 1. Heat Exchangers (Steam-to-Hot Water).
 - 2. Flash tanks.
- D. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- E. As-Built Piping Diagrams: Provide drawing as follows for steam and steam condensate piping and other central plant equipment.
 - 1. One wall-mounted stick file for prints. Mount stick file in the chiller plant or adjacent control room along with control diagram stick file.
 - 2. One set of reproducible drawings.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI):
 - B1.20.1-83(R2006).....Pipe Threads, General Purpose (Inch)
 - B16.4-2006.....Gray Iron Threaded Fittings
- C. American Society of Mechanical Engineers (ASME):
 - B16.1-2005.....Gray Iron Pipe Flanges and Flanged Fittings
 - B16.3-2006.....Malleable Iron Threaded Fittings
 - B16.9-2007.....Factory-Made Wrought Buttwelding Fittings
 - B16.11-2005.....Forged Fittings, Socket-Welding and Threaded
 - B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with
Pipe Threads
 - B16.22-2001.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
 - B16.23-2002.....Cast Copper Alloy Solder Joint Drainage
Fittings
 - B16.24-2006.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings, Class 150, 300, 400, 600, 900, 1500
and 2500

B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes
150, 250, and 300

B31.1-2007.....Power Piping

B31.9-2008.....Building Services Piping

B40.100-2005.....Pressure Gauges and Gauge Attachments

Boiler and Pressure Vessel Code: SEC VIII D1-2001, Pressure Vessels,
Division 1

D. American Society for Testing and Materials (ASTM):

A47-99.....Ferritic Malleable Iron Castings

A53-2007.....Pipe, Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless

A106-2008.....Seamless Carbon Steel Pipe for High-Temperature
Service

A126-2004.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings

A181-2006.....Carbon Steel Forgings, for General-Purpose
Piping

A183-2003 Carbon Steel Track Bolts and Nuts

A216-2008 Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service

A285-01 Pressure Vessel Plates, Carbon Steel, Low-and-
Intermediate-Tensile Strength

A307-2007 Carbon Steel Bolts and Studs, 60,000 PSI Tensile
Strength

A516-2006 Pressure Vessel Plates, Carbon Steel, for
Moderate-and- Lower Temperature Service

A536-84(2004)e1 Standard Specification for Ductile Iron Castings

B32-2008 Solder Metal

B61-2008 Steam or Valve Bronze Castings

B62-2009 Composition Bronze or Ounce Metal Castings

B88-2003 Seamless Copper Water Tube

F439-06 Socket-Type Chlorinated Poly (Vinyl Chloride)
(CPVC) Plastic Pipe Fittings, Schedule 80

F441-02(2008) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic
Pipe, Schedules 40 and 80

E. American Welding Society (AWS):

A5.8-2004.....Filler Metals for Brazing and Braze Welding

B2.1-00.....Welding Procedure and Performance

Qualifications

F. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:

SP-67-95.....Butterfly Valves

SP-70-98.....Cast Iron Gate Valves, Flanged and Threaded
EndsSP-71-97.....Gray Iron Swing Check Valves, Flanged and
Threaded EndsSP-72-99.....Ball Valves with Flanged or Butt-Welding Ends
for General ServiceSP-78-98.....Cast Iron Plug Valves, Flanged and Threaded
Ends

SP-80-97.....Bronze Gate, Globe, Angle and Check Valves

SP-85-94.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends

G. Military Specifications (Mil. Spec.):

MIL-S-901D-1989.....Shock Tests, H.I. (High Impact) Shipboard
Machinery, Equipment, and Systems

H. National Board of Boiler and Pressure Vessel Inspectors (NB): Relieving Capacities of Safety Valves and Relief Valves

I. Tubular Exchanger Manufacturers Association: TEMA 18th Edition, 2000

PART 2 - PRODUCTS**2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES**

A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.2 PIPE AND TUBING

A. Steam Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40.

B. Steam Condensate and Pumped Condensate Piping:

1. Concealed above ceiling, in wall or chase: Copper water tube ASTM B88, Type K, hard drawn.

2. All other locations: Copper water tube ASTM B88, Type K, hard drawn; or steel, ASTM A53, Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80.

- C. Vent Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40, galvanized.

2.3 FITTINGS FOR STEEL PIPE

- A. 50 mm (2 inches) and Smaller: Screwed or welded.
1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
 2. Forged steel, socket welding or threaded: ASME B16.11.
 3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron, except for steam and steam condensate piping. Provide 300 pound malleable iron, ASME B16.3 for steam and steam condensate piping. Cast iron fittings or piping is not acceptable for steam and steam condensate piping. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 4. Unions: ASME B16.39.
 5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.
- B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints.
1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
 2. Welding flanges and bolting: ASME B16.5:
 - a. Steam service: Weld neck or slip-on, raised face, with non-asbestos gasket. Non-asbestos gasket shall either be stainless steel spiral wound strip with flexible graphite filler or compressed inorganic fiber with nitrile binder rated for saturated and superheated steam service 750 degrees F and 1500 psi.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

2.4 FITTINGS FOR COPPER TUBING

- A. Solder Joint:

1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.

E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass gate valves or dielectric nipples may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

A. Pipe Thread: ANSI B1.20.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer.

C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2100 mm (7 feet) or more above the floor or operating platform.

D. Shut-Off Valves

1. Gate Valves:

a. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.

b. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.

1) High pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 25 mm (1 inch) factory installed bypass with globe valve on valves 100 mm (4 inches) and larger.

- 2) All other services: MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves:

1. Globe Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Globe valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.

2. Angle Valves

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Angle valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle valves.

F. Swing Check Valves

1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 psig), 45 degree swing disc.
2. 65 mm (2-1/2 inches) and Larger:
 - a Check valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system: Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - b. All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

- G. Manual Radiator/Convactor Valves: Brass, packless, with position indicator.

2.8 STRAINERS

- A. Basket or Y Type. Tee type is acceptable for gravity flow and pumped steam condensate service.
- B. High Pressure Steam: Rated 1034 kPa (150 psig) saturated steam.
1. 50 mm (2 inches) and smaller: Iron, ASTM A116 Grade B, or bronze, ASTM B-62 body with screwed connections (250 psig).
 2. 65 mm (2-1/2 inches) and larger: Flanged cast steel or 1723 kPa (250 psig) cast iron.
- C. All Other Services: Rated 861 kPa (125 psig) saturated steam.
1. 50 mm (2 inches) and smaller: Cast iron or bronze.
 2. 65 mm (2-1/2 inches) and larger: Flanged, iron body.
- D. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
1. 75 mm (3 inches) and smaller: 20 mesh for steam and 1.1 mm (0.045 inch) diameter perforations for liquids.
 2. 100 mm (4 inches) and larger: 1.1 mm (0.045) inch diameter perforations for steam and 3.2 mm (0.125 inch) diameter perforations for liquids.

2.9 PIPE ALIGNMENT

- A. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed on the contract drawings.

2.10 EXPANSION JOINTS

- A. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.
- B. Minimum Service Requirements:
1. Pressure Containment:
 - a. Steam Service 35-200 kPa (5-30 psig): Rated 345 kPa (50 psig) at 148 degrees C (298 degrees F).

- b. Steam Service 214-850 kPa (31-125 psig): Rated 1025 kPa (150 psig) at 186 degrees C (366 degrees F).
- c. Steam Service 869-1025 kPa (126-150 psig): Rated 1375 kPa (200 psig) at 194 degrees C (382 degrees F).
- d. Condensate Service: Rated 690 kPa (100 psig) at 154 degrees C (310 degrees F).
- 2. Number of Full Reverse Cycles without failure: Minimum 1000.
- 3. Movement: As shown on drawings plus recommended safety factor of manufacturer.
- C. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.
- D. Bellows - Internally Pressurized Type:
 - 1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
 - 2. Internal stainless steel sleeve entire length of bellows.
 - 3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
 - 4. Welded ends.
 - 5. Design shall conform to standards of EJMA and ASME B31.1.
 - 6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
 - 7. Integral external cover.
- E. Bellows - Externally Pressurized Type:
 - 1. Multiple corrugations of Type 304 stainless steel.
 - 2. Internal and external guide integral with joint.
 - 3. Design for external pressurization of bellows to eliminate squirm.
 - 4. Welded ends.
 - 5. Conform to the standards of EJMA and ASME B31.1.
 - 6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
 - 7. Integral external cover and internal sleeve.
- F. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.

2.11 FLEXIBLE BALL JOINTS

A. Design and Fabrication: One piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 1720 kPa (250 psig) and a temperature of 232 degrees C (450 degrees F). Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 6 mm (1/4 inch) to 150 mm (6 inch) inclusive, and 15 degrees for sizes 65 mm (2-1/2 inches) to 750 mm (30 inches). Joints through 350 mm (14 inches) shall have forged pressure retaining members; while size 400 mm (16 inches) through 760 mm (30 inches) shall be of one piece construction.

B. Material:

1. Cast or forged steel pressure containing parts and bolting in accordance with Section II of the ASME Boiler Code or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME Section II SA 515, Grade 70.
2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 10 degrees C (50 degrees F) to plus 274 degrees C (525 degrees F).

C. Certificates: Submit qualifications of ball joints in accordance with the following test data:

1. Low pressure leakage test: 41 kPa (6psig) saturated steam for 60 days.
2. Flex cycling: 800 Flex cycles at 3445 kPa (500 psig) saturated steam.
3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.
4. Environmental shock tests: Forward certificate from a recognized test laboratory, that ball joints of the type submitted has passed shock testing in accordance with Mil. Spec MIL-S-901.
5. Vibration: 170 hours on each of three mutually perpendicular axis at 25 to 125 Hz; 1.3 mm to 2.5 mm (0.05 inch to 0.1 inch) double amplitude on a single ball joint and 3 ball joint off set.

2.12 STEAM SYSTEM COMPONENTS

A. Heat Exchanger (Steam to Hot Water): Shell and tube type, U-bend removable tube bundle, steam in shell, water in tubes, equipped with support cradles.

1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).

2. Tube fouling factor: TEMA Standards, but not less than $0.00018 \text{ m}^2\text{K/W}$ ($0.001 \text{ ft}^2\text{hrF/Btu}$).
3. Materials:
 - a. Shell: Steel.
 - b. Tube sheet and tube supports: Steel or brass.
 - c. Tubes: 20 mm (3/4 inch) OD copper.
 - d. Head or bonnet: Cast iron or steel.
4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1.
- B. Optional Heat Transfer Package: In lieu of field erected individual components, the Contractor may provide a factory or shop assembled package of heat exchangers, pumps, and other components supported on a welded steel frame.
- C. Steam Pressure Reducing Valves in PRV Stations:
 1. Type: Single-seated, diaphragm operated, spring-loaded, external or internal steam pilot-controlled, normally closed, adjustable set pressure. Pilot shall sense controlled pressure downstream of main valve.
 2. Service: Provide controlled reduced pressure to steam piping systems.
 3. Pressure control shall be smooth and continuous with maximum drop of 10 percent. Maximum flow capability of each valve shall not exceed capacity of downstream safety valve(s).
 4. Main valve and pilot valve shall have replaceable valve plug and seat of stainless steel, monel, or similar durable material.
 - a. Pressure rating for high pressure steam: Not less than 1034 kPa (150 psig) saturated steam.
 - b. Connections: Flanged for valves 65 mm (2-1/2 inches) and larger; flanged or threaded ends for smaller valves.
 5. Select pressure reducing valves to develop less than 85 dbA at 1500 mm (5 feet) elevation above adjacent floor, and 1500 mm (5 feet) distance in any direction. Inlet and outlet piping for steam pressure reducing valves shall be Schedule 80 minimum for required distance to achieve required levels or sound attenuators shall be applied.

6. Pneumatically controlled valve: May be furnished in lieu of steam-operation. All specification requirements for steam operated valves apply. Valves shall close on failure of air supply.
- D. Safety Valves and Accessories: Comply with ASME Boiler and Pressure Vessel Code, Section VIII. Capacities shall be certified by National Board of Boiler and Pressure Vessel Inspectors, maximum accumulation 10 percent. Provide lifting lever. Provide drip pan elbow where shown.
- E. Steam PRV for Individual Equipment: Cast steel or bronze body, screwed or flanged ends, rated 861 kPa (125 psig), or 20% about the working pressure, whichever is greater. Single-seated, diaphragm operated, spring loaded, adjustable range, all parts renewable.
- F. Flash Tanks: Horizontal or vertical vortex type, constructed of copper bearing steel, ASTM A516 or ASTM A285, for a steam working pressure of 861 kPa (125 psig) to comply with ASME Code for Unfired Pressure Vessels and stamped with "U" symbol. Perforated pipe inside tank shall be ASTM A53 Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80. Corrosion allowance of 1.6 mm (1/16 inch) may be provided in lieu of the copper bearing requirement. Provide data Form No. U-1.
- G. Steam Trap: Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 61 m (200 feet) intervals on the horizontal main lines.
 1. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop as follows:
 - a. For equipment with modulating control valve: 1.7 kPa (1/4 psig), based on a condensate leg of 300 mm (12 inches) at the trap inlet and gravity flow to the receiver.
 - b. For main line drip trap sets and other trap sets at steam pressure: Up to 70 percent of design differential pressure. Condensate may be lifted to the return line.
 2. Trap bodies: Bronze, cast iron, or semi-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping, (4 bolt raised face flange). For systems without relief valve traps shall be 5. Mechanism: Brass, stainless steel or corrosion resistant alloy rated for the pressure upstream of the PRV supplying the system.
 3. Balanced pressure thermostatic elements: Phosphor bronze, stainless

steel or monel metal.

4. Valves and seats: Suitable hardened corrosion resistant alloy.
 6. Floats: Stainless steel.
 7. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.
- H. Thermostatic Air Vent (Steam): Brass or iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 861 kPa (125 psig) working pressure, 20 mm (3/4 inch) screwed connections. Air vents shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure.

I. Steam Humidifiers:

1. Steam separator type that discharges steam into the air stream through a steam jacketed distribution manifold or dispersion tube. Humidifiers shall be complete with Y-type steam supply strainer; modulating, normally closed steam control valve; normally closed condensate temperature switch; and manufacturer's standard steam trap.
2. Steam separator: Stainless steel or cast iron.
3. Distribution manifold: Stainless steel, composed of dispersion pipe and surrounding steam jacket, manifold shall span the width of duct or air handler, and shall be multiple manifold type under any of the following conditions:
 - a. Duct section height exceeds 900 mm (36 inches).
 - b. Duct air velocity exceeds 5.1 m/s (1000 feet per minute).
 - b. If within 900 mm (3 feet) upstream of fan, damper or pre-filter.
 - d. If within 3000 mm (10 feet) upstream of after-filter.

J. Unfired clean steam generator

1. Provide a packaged factory assembled, pre-piped unfired steam generator consisting of stainless steel shell, stainless steel tube coil, stainless steel steam piping, valves and controls. All stainless steel piping shall be type 316 factory-fabricated and provided as a part of the complete package.
2. Shell: Stainless steel ASME code construction with flanged piping connections. (150 psig) maximum WSP.
3. Tubes: Stainless Steel tubes suitable for (150 psig) working pressure.

4. Design: Heated fluid in shell and heating fluid (higher pressure steam) in tubes.
5. Each steam generator shall be furnished with the following accessories:
 - a. Resilient insulation.
 - b. Pilot operated modulating control valve with pressure controller.
 - c. Control pilot to maintain constant steam output.
 - d. Pressure relief valve.
 - e. Vessel and tube side pressure gages.
 - f. Liquid level controller with brass feed water solenoid valve, in check valve and strainer.
 - g. Over-pressure limit system with auto-reset.
 - h. Factory packaging.
 - i. Dual F&T condensate traps.
 - j. Manual blow down valve.
 - k. TDS based automatic blow down
 - l. Low water cut-off and high pressure cut-off.
 - m. Fully wired control box.
 - n. Automatic drain solenoid valve.
6. Provide solid state control module with LED backlit LCD display and LED pilot lights to indicate on-off, high pressure, low pressure, low water and water feed. Control module shall allow the local adjustment of pressure limits on display screen. Control module shall have alarm light and alarm horn with built in alarm silence relay. Control module shall be supplied with dry contact closure outputs to indicate to building automation controls (BAC) the occurrence of power on, high pressure, low pressure, low water and water feed. The control module shall allow the BAC to turn the unfired steam generator on or off through a remote relay suitable for 24 VAC, 1 amp. The control module shall allow the BAC to remotely monitor the operating pressure. Control module shall be supplied with an on-off switch and shall be mounted in a NEMA 1 panel. All solenoids and limits shall be 24 VAC.
- K. Steam Gun Set: Furnish for ready coupling to building steam and cold water and designed for rinsing equipment (such as carts and racks) with hot or cold water, cleaning such articles with detergent-laden hot water or steam, or alternately sanitizing the articles with only live steam.

1. Gun: Fit gun for finger-tip release of steam. Design so siphoning action will automatically mix detergent with gun effluent. Equip gun with hardwood front and rear handgrips. Include a 25 mm (15/16-inch) diameter, double tube butyl hose reinforced with braid and designed for 1034 kPa (150 psig) pressure. Hose shall be 3600 mm (12 feet) long.
 2. Detergent Tank: Furnish 9.5 L (2-1/2 gallon) polyethylene or fiberglass storage tank and fit for wall mounting. Also provide 13 mm (1/2 inch) diameter neoprene double wall detergent hose of the same length as steam hose. Fit hose-to-tank connection with strainer. Fit other end of hose with valve to regulate amount of detergent to be mixed with steam.
 3. Steam/Water Selector: Furnish manifold for wall mounting; design manifold to deliver only steam or water, or steam and water mix to gun. Construct mounting panel of stainless steel. Valves and piping located in panel shall be brass.
 4. Accessories: Provide one pair of protective gloves and three 50 mm (2 inch) diameter brushes, one nylon and two stainless-steel.
- L. Steam Hose and Accessories: Hose shall be sufficiently flexible to be placed in a 100 mm (4 feet) diameter coil.
1. Furnish and install in the mechanical room housing each PRV station a 7500 mm (25 feet) length of 13 mm (1/2 inch) ID steam hose, rated 861 kPa (125 psig) and a hose rack. In one end of the hose install a quick-couple device, suitable for steam service, to match corresponding devices in the PRV blowdown connections.
 2. Hose storage rack: Wall-mounted, steel, iron or aluminum, semi-circular shape, with capacity to store 7500 mm (25 feet) of 13 mm (1/2 inch) ID steam hose.
- M. Steam Flow Meter/Recorder: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- N. Steam Exhaust Head: Cast iron, fitted with baffle plates, to trap and drain condensed water.

2.13 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.1, Accuracy Grade 1A, (pressure, vacuum, or compound), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear

glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.

- B. Provide brass, lever handle union cock. Provide brass/bronze pressure snubber for gages in water service. Provide brass pigtail syphon for steam gages.
- C. Range of Gages: For services not listed provide range equal to at least 130 percent of normal operating range:

Low pressure steam and steam condensate to 103 kPa(15 psig)	0 to 207 kPa (30 psig).
Medium pressure steam and steam condensate nominal 413 kPa (60 psig)	0 to 689 kPa (100 psig).
High pressure steam and steam condensate nominal 620 kPa to 861 kPa (90 to 125 psig)	0 to 1378 kPa (200 psig).
Pumped condensate, steam condensate, gravity or vacuum (30" HG to 30 psig)	0 to 415 kPa (60 psig)

2.14 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Provide one each of the following test items to the Resident Engineer:
1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, 762 mm (30 inches) Hg to 689 kPa (100 psig) range.
 3. 0 - 104 degrees C (32-220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.15 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.16 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
1. Steam piping exposed to weather.
 2. Steam condensate exposed to weather.
 3. Pumped condensate piping exposed to weather.

- C. Heat tracing shall be provided to the extent shown on the drawings (Floor Plans and Elevations). Heat tracing shall extend below grade to below the defined frost line.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
1. Provide end seals at ends of circuits. Wires at the ends of the circuits are not to be tied together.
 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per foot of pipe.
- E. Electrical Heating Tracing Accessories:
1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
 2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
 3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
 4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets

and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

- B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

- I. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, and BOILER PLANT INSULATION.
- J. Where copper piping is connected to steel piping, provide dielectric connections.
- K. Pipe vents to the exterior. Where a combined vent is provided, the cross sectional area of the combined vent shall be equal to sum of individual vent areas. Slope vent piping one inch in 40 feet (0.25 percent) in direction of flow. Provide a drip trap elbow on relief valve outlets if the vent rises to prevent backpressure. Terminate vent minimum 0.3 M (12 inches) above the roof or through the wall minimum 2.5 M (8 feet) above grade with down turned elbow.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.
- B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.
- C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.
- D. Access: Expansion joints must be located in readily accessible space. Locate joints to permit access without removing piping or other

devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding packing.

3.4 STEAM TRAP PIPING

- A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (25 pounds) independently of connecting piping.

3.5 SEISMIC BRACING

- A. Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. NOT USED

3.6 LEAK TESTING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer in accordance with the specified requirements. Testing shall be performed in accordance with the specification requirements.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

3.7 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Steam, Condensate and Vent Piping: No flushing or chemical cleaning required. Accomplish cleaning by pulling all strainer screens and cleaning all scale/dirt legs during start-up operation.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Adjust red set hand on pressure gages to normal working pressure.

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SECTION 23 22 23
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Steam condensate pumps for Heating, Ventilating and Air Conditioning.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. NOT USED

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

F. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

G. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

B. Design Criteria:

1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.

2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.

3. Select pumps so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).

4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.

5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.

6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.

7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
 8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.
 9. Furnish one spare seal and casing gasket for each pump to the Contracting Officer Representative (COR).
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 1. Pumps and accessories.
 2. Motors and drives.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):
AISI 1045.....Cold Drawn Carbon Steel Bar, Type 1045
AISI 416.....Type 416 Stainless Steel
- C. American National Standards Institute (ANSI):
ANSI B15.1-00(R2008)....Safety Standard for Mechanical Power
Transmission Apparatus
ANSI B16.1-05.....Cast Iron Pipe Flanges and Flanged Fittings,
Class 25, 125, 250 and 800
- D. American Society for Testing and Materials (ASTM):
A48-03(2008).....Standard Specification for Gray Iron Castings
B62-09.....Standard Specification for Composition Bronze
or Ounce Metal Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1.6 DEFINITIONS

- A. Capacity: Liters per second (L/s) (Gallons per minute (GPM)) of the fluid pumped.
- B. Head: Total dynamic head in kPa (feet) of the fluid pumped.

PART 2 - PRODUCTS

2.1 CONDENSATE PUMP, PAD-MOUNTED

- A. General: Factory assembled unit consisting of vented receiver tank, motor-driven pumps, interconnecting piping and wiring, motor controls (including starters, if necessary) and accessories, designed to receive, store, and pump steam condensate.
- B. Receiver Tank: Cast iron with threaded openings for connection of piping and accessories and facilities for mounting float switches. Receivers for simplex pumps shall include all facilities for future mounting of additional pump and controls.
- C. Furnish seals for condensate pump with a minimum temperature rating of 121 degrees C (250 degrees F).
- D. Centrifugal Pumps: Bronze fitted with mechanical shaft seals.
 - 1. Designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting.
 - 2. Shafts: Stainless steel, AISI Type 416 or alloy steel with bronze shaft sleeves.
 - 3. Bearings: Regreaseable ball or roller type.
 - 4. Casing wearing rings: Bronze.
- E. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- F. Pump Operation:
 - 1. Float Switches: NEMA 1, mounted on receiver tank, to start and stop pumps in response to changes in the water level in the receiver and adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, bronze or stainless steel.
 - 2. Alternator: Provide for duplex units to automatically start the second pump when the first pump fails in keeping the receiver water level from rising and to alternate the order of starting the pumps. For units 0.25 kW (1/3 horsepower) and smaller, the alternator may be the mechanical type for use in lieu of float switches.
- G. Control Cabinet for 3 Phase (0.37 kW (1/2 hp) and larger) Units: NEMA 1, UL approved, factory wired, enclosing all controls, with indicating

lights, manual switches and resets mounted on the outside of the panel. Attach cabinet to the pump set with rigid steel framework, unless remote mounting is noted on the pump schedule.

1. Motor starters: Magnetic contact types with circuit breakers or combination fusible disconnect switches. Provide low voltage control circuits (120 volt maximum) and "hand-off-automatic" (H-O-A) switches for each pump.
2. Indicating lights for each pump: Green to show that power is on, red to show that the pump is running.

H. Electric Wiring: Suitable for 93 degrees C (200 degrees F) service; enclosed in liquid-tight flexible metal conduit where located outside of control cabinet.

I. Receiver Accessories:

1. Thermometer: 34-216 degrees C (100 - 420 degrees F), mounted below minimum water level.
2. Water level gage glass: Brass with gage cocks which automatically stop the flow of water when the glass is broken. Provide drain on the lower gage cock and protection rods for the glass.

2.2 CONDENSATE PUMP, SUMP TYPE

- A. General: Factory assembled unit consisting of motor-driven pump(s) mounted on a horizontal cover plate bolted to a vented sump-type receiver, interconnecting wiring and piping, motor controls and accessories, designed to receive, store, and pump steam condensate.
- B. Receiver Tank: Vertical, cylindrical, cast iron sides and bottom, designed for service underground or below the floor. Inlet connection shall be located nine inches below the cover plate. Provide floor mounting gasket.
- C. Receiver Cover Plate: Heavy gage steel designed to support weight of pumps, motors, and accessories and support foot traffic with no deflection. Provide for mounting of pumps, motor and accessories by bolting to the cover. Provide threaded openings for piping connections and a bolted inspection plate for viewing interior of receiver. All bolted connections to cover plate, and between cover plate and receiver, shall be gasketed so that no vapor will escape into the room.
- D. Furnish seals for condensate pump with a minimum temperature rating of 121 degrees C (250 degrees F).
- E. Pumps: Centrifugal type, vertical extended shaft, bronze fitted, flexible-coupled, designed for submerged operation.

1. Shaft: Stainless steel, AISI Type 416.
 2. Shaft bearings: Bronze, water lubricated.
 3. Shaft seal at cover plate: Packed type with bronze packing gland.
 4. Thrust bearings: Regreaseable ball type located above the cover plate.
 5. Discharge pipes: Terminate above the cover plate.
 6. Pump-motor mounting: Bolted to brackets bolted to the cover plate.
- Removal of one pump shall not affect operation of the second pump.

F. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

G. Pump Operation:

1. Float Switches: NEMA 1, mounted on receiver tank, to start and stop pumps in response to changes in the water level in the receiver, and adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, bronze or stainless steel.
2. Alternator: Provide for duplex units to automatically start the second pump when the first pump fails in keeping the receiver water level from rising and to alternate the order of starting the pumps. For units 0.25 kW (1/3 horsepower) and smaller, the alternator may be the mechanical type for use in lieu of float switches.

H. Electric Wiring: Suitable for 93 degrees C (200 degrees F) service; enclosed in liquid-tight flexible metal conduit where located outside of control cabinet.

2.3 VACUUM PUMP, HEATING

- A. General: Factory assembled unit consisting of water storage and air separating facilities, duplex water pumps, duplex air pumps, motors, controls and accessories, designed to receive, store, and pump the steam condensate from a vacuum return system. The unit shall also produce the required vacuum.
- B. Receiver Tank: Cast iron or galvanized steel and shall include water storage and air separation chambers.
- C. Water and Air Pumps: Centrifugal type, bronze fitted, with mechanical shaft seals.
1. Performance: Rating based on condensate at 71 degrees c (160 degrees F) and 20 kPa (5-1/2 inches of mercury vacuum). Perform test in accordance with factory instructions.

2. Design pump to allow removal of rotating elements without disturbing connecting piping or pump casing mounting.
 3. Shafts: Stainless steel.
 4. Bearings: Grease-lubricated ball or roller type.
 5. Casing Wear Rings: Bronze.
- D. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- E. Air and Water Pump Operation:
1. Adjustable float switches: Mounted on receiver tank, to start and stop water pumps in response to changes in the water level in the receiver. Floats and connecting rods shall be copper, stainless steel, or bronze.
 2. Adjustable vacuum switches: Mounted on receiver tank, to start and stop air pumps in response to vacuum requirements of the heating system.
 3. Alternators of water pumps and for air pumps: To alternate the sequence of starting the pumps and to automatically start the second air or water pump when the first pump fails to meet the air or water demand.
- F. Control Cabinet for 3 Phase (0.37 kW (1/2 Hp) and Larger) Units: NEMA 1, UL approved, factory wired, enclosing all controls, with indicating lights, manual switches and resets mounted on the outside of the panel. Attach cabinet to the pump set with rigid steel framework, unless remote mounting is noted on the pump schedule.
1. Motor starters: Magnetic contactor types with circuit breakers or combination fusible disconnect switches. Provide low voltage control circuits (120 volt maximum) and "hand-off-automatic" (H-O-A) switches for each pump.
 2. Indicating lights for each pump: Red to show that the pump is running, green to show pump is off.
- G. Electric Wiring: Suitable for 93 degrees C (200 degrees F) service; enclosed in liquid tight flexible metal conduit where located outside of control cabinet.
- H. Accessories Required:
1. Thermometer: Mounted on receiver below minimum water level.
 2. Water level gage: Mounted on each compartment of receiver. Provide gage cocks which automatically stop the flow of water when the glass

is broken. Provide gage glass protection rods and a drain on the lower gage cock.

3. A compound gage. Refer to Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
4. Temperature limit switch: To automatically admit cooling water to the air separation chamber when air separation water temperature exceeds the manufacturer's recommended limit.
5. Automatic water make-up control to the air separation changes: Float switch and solenoid valve. Provide manual by-pass valve.
6. Muffler: When required to prevent the air vent sound from exceeding 90 db on the A scale at a distance of 2 m (6 feet) from the unit.
7. Vacuum breaker: Minimum adjustment range 20 to 50 kPa (5 to 15 inches of mercury), to protect the pump unit from excessive vacuum.

2.4 PRESSURE POWERED CONDENSATE PUMP

A. Pressure-Powered Pump Packages:

1. Pump packages shall be furnished and installed as a packaged assembly of the types, sizes, capacities, and characteristics as shown on the drawings. Pump package shall be rated for 185 degrees C (365 degrees F), maximum condensate temperatures.
2. Pump package(s) shall come completely piped and mounted on a steel skid including (1) receiver/reservoir, two positive displacement pressure-powered pumps as scheduled, interconnecting piping and valves, and all accessories as hereafter specified below:
 - a. The receiver shall be of a steel elevated design, warranted for 1 year against defects in material and workmanship. Receiver shall be 150 PSIG ASME labeled and coded. Receiver shall be sized for the required condensate storage volume and flash steam capacity. Receiver shall be horizontally mounted and have openings of the appropriate size and number including: (2) inlets, (1) vent opening, (1) NPT drain with pipe plug, (1) NPT anode opening with anode, and gauge glass openings with gauge glass set consisting of (2) brass isolation valves and guard rods, and red-line tubular glass. Replaceable magnesium anode, which retards the corrosive action of most waters and adds to the service life of the tanks, shall be furnished with each receiver for corrosion protection.

- b. Pressure-powered pumps shall be non-electric as shown on the drawings. Units shall be constructed of 1034 kPa (150 psig) ASME labeled and coded fabricated steel body, shall be float operated, and contain a condensate inlet baffle. Each unit shall have (1) inlet check valve, (1) outlet check valve, and gauge glass set with isolation valves.
- c. The float operating mechanism shall have all moving components constructed of stainless steel and be of a snap acting design with no external seals or packing. The float mechanism shall contain a reinforced stainless steel float, (2) 300 series stainless steel open coil design springs, and spring calibration pins.
- d. Pressure-powered pumps shall be of a non-cavitating design capable of operation on systems up to the maximum working pressure of the tank rating using steam, compressed air, or other compatible inert gas as the supply (motive) pressure. Units shall be capable of operating at temperatures up to 365 F when pumping from a 'closed' system using a compatible motive gas. Balance and fine tune motive pressure to be 138 kPa (20 psig) higher than the static backpressure.
- e. Package shall include interconnecting piping between receiver/reservoir and the positive displacement pressure-powered pump(s). Interconnecting suction (fill) line shall be provided to each unit and each suction (fill) line shall include a gate valve for isolation.
- f. Manufacturer shall provide the following for field installation on each pressure-powered pump:
 - 1) Cycle counter
 - 2) Removable insulation jacket
 - 3) Pressure gauge
 - 4) Drain piping
- g. Provide the following components for each pump:
 - 1) Motive pressure reducing valve
 - 2) Safety relief valve(s)
 - 3) Motive pressure inlet strainer
 - 4) Pressure gauge with pigtail, as required
 - 5) Motive pressure drip trap(s)
 - 6) Motive pressure line check valve(s)

3. The package shall be factory tested as a complete unit using steam as the motive pressure. The pump manufacturer shall furnish appropriate assembly and parts drawings, and installation and operation manuals. The package shall be shipped completely assembled, or with connection match marks if package must be shipped as sub-assemblies.

B. Removable Insulation Jacket:

1. The insulation jacket should be of sewn construction with Velcro fasteners and have openings for inlet, outlet, drain, and gauge glass.
2. Materials:
 - a. Liner and jacket shall be silicone impregnated heavy duty glass fiber rated for a maximum temperature of 260 degrees C (500 degrees F).
 - b. Insulation shall be 25 mm (1 inch) minimum thickness, Type E needled glass fiber mat rated for a maximum temperature of 650 degrees C (1200 F).
 - c. Jacket shall be sewn with Nomex thread with a UV inhibitor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Permanently support in-line pumps by the connecting piping only, not from the casing or the motor eye bolt.
- C. Sequence of installation for base-mounted pumps:
 1. Level and shim the unit base and grout to the concrete pad.
 2. Shim the driver and realign the pump and driver. Correct axial, angular or parallel misalignment of the shafts.
 3. Connect properly aligned and independently supported piping.
 4. Recheck alignment.
- D. Pad-mounted Condensate Pump or Vacuum Pump: Level, shim, bolt, and grout the unit base onto the concrete pad.
- E. Sump Type Condensate Pump: Apply two coats of asphalt or bituminous compound on the exterior of the receiver tank, and mount level and flush in the floor with waterproofing gaskets and grouting to prevent ground water from entering the building from around the receiver.

- F. Coordinate location of thermometer and pressure gauges as per Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.

3.2 START-UP

- A. Verify that the piping system has been flushed, cleaned and filled.
- B. Lubricate pumps before start-up.
- C. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.
- D. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- E. Field modifications to the bearings and or impeller (including trimming) are not permitted. If the pump does not meet the specified vibration tolerance send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.

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SECTION 23 52 39
FIRE-TUBE BOILERS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies packaged fire tube boiler with trim (accessories), dual fuel (natural gas and No. 2 oil) burner, fuel valve and piping trains, flue gas economizer, and other accessories.

1.2 RELATED WORK:

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Section 09 91 00, PAINTING.
- C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. NOT USED
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- E. Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
- I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- H. Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.
- G. Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- E. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- F. Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.
- J. Section 26 05 33, RACEWAY and BOXES for ELECTRICAL SYSTEMS.

1.3 QUALITY ASSURANCE:

- A. Coordinate all new and existing equipment and conditions. This includes, but is not limited to: boiler, boiler trim, burner, fuel valve and piping trains, gas pressure regulators and available gas pressure, required fuel oil train pressures and fuel oil header back pressure regulator on house oil pump set, compressed air system for oil atomization, control systems, economizer (if provided), breeching and stacks.
- B. Provide written certification that the entire assembly has been coordinated to achieve the required performance and to provide the required features.
- C. The model and size of the proposed burner shall have been applied to at least three fire tube boilers which are similar in size, proportion, number of passes and furnace dimensions to the proposed boiler. In each of the three installations, burner performance shall have conformed to requirements specified in the Subparagraph, "Performance" under the Article, BURNER, AND FUEL TRAINS of Part 2. Provide list of these

installations, and name, address, and telephone number of person familiar with each project who will serve as a reference source.

- D. Regardless of fuel input rating, the equipment, installation and operation shall conform to NFPA 85. Where conflicts exist between NFPA 85 and this specification, this specification will govern.

1.4 SUBMITTALS:

- A. Before executing any work, submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Boiler:

1. Complete catalog information and outline drawings of boiler, burner, and accessories with dimensions including tube removal space and access door opening space.
 2. Catalog cuts showing arrangement and construction of pressure parts, casing, internals, and support frame.
 3. Piping connection sizes, locations, types (threaded or flanged).
 4. Technical data including temperature rating and arrangement of refractory and insulation.
 5. Steam nozzle construction. Capability of steam nozzle and attachment to boiler shell to withstand forces and moments imposed by connecting piping.
 6. Amount of heating surface and combustion volume.
 7. Weight of boiler empty and flooded including burner and boiler and burner accessories.
 8. Design pressures and temperatures.
 9. Loading diagram of support frame. Evidence that boiler support requirements have been coordinated with foundation design.
 10. Recommended anchorage of boiler support frame to foundation.
 11. Furnace viewport construction, locations.
 12. Dimensioned location of normal water line, lowest and highest permissible water level, set points of water level alarms and cutoffs.
 13. Predicted external surface temperature of front, rear and sides of boiler.
 14. Seismic design data on boiler and anchorage of boiler to foundation. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. NOT USED
- C. Boiler Trim: Includes bottom blowoff valves, water level alarm and cutoff devices, water level gage, low water cutoffs, piping, all valves

and fittings furnished by boiler manufacturer, feedwater control system, steam safety valves, steam pressure gage, stack thermometer, draft gage, and steam pressure switches.

1. Design, construction, arrangement on the boiler.
2. Pressure and temperature limitations.
3. ASTM numbers and schedule numbers of piping.
4. Type and pressure ratings of pipe fittings.
5. Flow and pressure drop data on feedwater regulating valves.
6. Technical data on water level control system.
7. Scale ranges of gages, thermometers and pressure switches.
8. Location of water level sensing and indicating device set points in relation to normal water line and lowest and highest permissible water levels of boiler.
9. Set pressure and capacity of safety valves.

D. Burner and Fuel Valve and Piping Trains:

1. Catalog data and drawings showing burner assembly and fuel train arrangement.
2. Outline drawings of flue gas recirculation (FGR) ductwork (if applicable).
3. Outline drawings of sound attenuators on forced draft fan intake or discharge.
4. Drawings showing assembly of throat refractory into furnace.
5. Type and temperature rating of throat refractory.
6. Drawings and catalog data on all equipment in igniter (pilot) train, main fuel trains, and atomizing media train. Include data on pressure and temperature ratings, flow versus pressure drop, performance characteristics. Include complete data on air compressors (for oilatomizing) with sound attenuators and motors.
7. ASTM numbers and schedule numbers on all piping.
8. Type and pressure ratings of pipe fittings.
9. Burner flow and pressure data:
 - a. Main burner fuel and atomizing air pressures and flows at maximum required firing rate.
 - b. Igniter (pilot) fuel flow and burner pressure.
 - c. Natural gas main fuel pressure at inlet and outlet of main burner pressure regulator.
 - d. Igniter (pilot) fuel pressures (natural gas and LP gas) at inlet and outlet of burner-mounted pressure regulators.

- e. Forced draft fan static pressure, power and air flow at maximum firing rate.
 - f. Oil pressure required at boiler fuel oil pump inlet (if applicable).
- 10. Full load efficiency and power factor of all motors.
- 11. Predicted sound level at maximum firing rate on each main fuel.
- 12. Weight of burner assembly.
- E. Burner Management (Flame Safeguard) System: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- F. Flue Gas Economizer:
 - 1. Drawings showing arrangement and dimensions of unit and all accessories.
 - 2. Design and construction of unit and accessories including soot blowers and safety relief valve. Written recommendations of soot blower manufacturer on type and quantity of soot blowers.
 - 3. Weight of entire unit, empty and flooded.
 - 4. Pressure and temperature limitations of unit and accessories.
 - 5. Performance data on safety relief valve.
 - 6. Manufacturer's support requirements.
- 7. Seismic data. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. NOT USED
- G. Boiler, Burner, Economizer Predicted Performance Data:
 - 1. At Maximum Required Output: On each fuel at site altitude, with and without economizer (if applicable) in service, at 15 percent excess air. Data must include fuel and steam flow, boiler flue gas outlet temperature, economizer (if provided) flue gas outlet temperature, steam quality, boiler efficiency, windbox and furnace pressures, predicted boiler radiation and unaccounted losses, feedwater and flue gas pressure losses in the economizer (if provided).
 - 2. At low fire, 25%, 50%, 75% of Maximum Required Output. Excess air, CO ppm, NOx ppm on each fuel.
- H. ASME "P" Forms, Manufacturer's Data Report, on boiler and economizer construction - submit after boiler and economizer are fabricated.
- I. Pretest Data - Boiler, Burner, Controls: As required by Part 3.
- J. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician

and dated on the date of completion in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 PROJECT CONDITIONS

- A. Fuels to be Fired, Main Burner: Natural gas, No. 2 fuel oil.
- B. Igniter (Pilot) Fuels: Natural Gas and LP gas (propane).
- C. Natural Gas: High heating value is reported as ____MJ per cubic meter (____Btu per cubic foot) at gas company base pressure and temperature. Pressure provided to the inlet of the boiler-mounted regulators will be ____kPa (____ psi) gage as maintained by main regulator station.
- D. Fuel Oil: Will be furnished under Government contract. House pumping system is designed to provide ____ kPa (____ psi) gage nominal to the fuel train entrance on each burner. Pressure will vary in accordance with characteristics of backpressure regulator on oil pump set (Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT. Oil grade (No. 2) refers to ASTM D396. No burner-mounted pump or relief valve is required.
- E. Oil Atomizing Media: Low-pressure air atomizing burners are required and each boiler must include a dedicated air compressor system furnished by burner manufacturer.
- F. LP Gas: Propane furnished directly to the Government for igniter (pilot) fuel by a local supplier. Regulators at tank area will be set at 35 kPa (5 psi) gage. Serves as igniter fuel when there is an interruption to the natural gas supply.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. ASTM International (ASTM):
 - A106/A106M-08.....Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
 - A178/178M-02(2007).....Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes
 - A269-10.....Standard Specification for Seamless and Austenitic Welded Stainless Steel Tubing for General Service
 - C612-10.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

- D396-09a.....Standard Specification for Fuel Oils
- C. American Society of Mechanical Engineers (ASME):
- Boiler and Pressure Vessel Code - 2007 Edition with Amendments.
- Section I.....Power Boilers
- Section II.....Material
- Section VII.....Recommended Rules for Care of Power Boilers
- Section IX.....Welding and Brazing Qualifications
- Performance Test Code (PTC):
- PTC 4-2008.....Fired Steam Generators
- Code for Pressure Piping:
- B31.1-2007.....Power Piping
- D. National Fire Protection Association (NFPA):
- 85-2007.....Boiler and Combustion Systems Hazards Code.
- E. Underwriters Laboratories (UL):
- 50-2007.....Enclosures for Electrical Equipment
- F. Department of Health and Human Services, Food and Drug Administration (FDA):
- CFR 21, 173.310, Boiler Water Additives Permitted in Plants Where Steam Contacts Food
- G. Environmental Protection Agency (EPA):
- CFR 40, PART 60, Appendix A, Method 9, Visual Determination of the Opacity of Emissions from Stationary Sources

PART 2 - PRODUCTS

2.1 BOILER:

- A. Type: Factory-assembled packaged Scotch marine horizontal fire tube high pressure steam boiler. Three or four pass wet back design with internal furnace located below center of boiler shell. Designed for natural gas and No. 2 fuel oil firing.
- B. Service: Continuous long term generation of steam throughout the burner firing range in conformance to the specified performance requirements with feedwater supply at 100 degrees C (212 degrees F).
- C. Performance:
1. Steam Output Quantity and Pressure: Refer to schedules on drawings.
 2. Steam Output Quality: 99 percent minimum at all steam flow rates.
Based on water quality in boiler of 2200-ppm maximum total solids, 15-ppm maximum suspended solids, 440-ppm maximum alkalinity.

3. Minimum Efficiency at Required Maximum Output:
 - a. Natural Gas Fuel (37.3 MJ/cu. meter) (1000 Btu/cu. ft.): 82 percent at 15 percent excess air.
 - b. Fuel Oil (ASTM D396, Grade 2): 85 percent at 15 percent excess air.
- D. Heating Surface: Heating surface is defined as the fireside area of the furnace and combustion chamber plus inside (gas side) circumferential area of all convection tubes. Minimum surface shall be 470 square centimeters per kW (5 square feet per boiler horsepower).
- E. Design Pressure: 1375 kPa (200 psi) gage. Purpose of high design pressure is to provide additional corrosion allowance.
- F. Construction:
 1. Codes: Comply with ASME Boiler and Pressure Vessel Code, Sections I, II, VII, and IX.
 2. Tubes: ASTM A178 Grade A, smooth wall inside and outside. Minimum thickness 2.7 mm (0.105 inches). Flue gas spinners or turbulators are not allowed.
 3. Manway: Cover and yokes shall be forged steel. Manway shall seal tight with no leakage. Provide non-asbestos gaskets.
 4. Handholes: Covers and yokes shall be forged steel. Handholes shall seal tight with no leakage. Provide non-asbestos gaskets.
 5. Access to Tubes and Furnace: Provide hinged and davited doors and access panels to permit access to all tubes and furnace for cleaning, repairs and replacement. Doors wider than the radius of the boiler shell shall be davited and shall be operable by one person. Hinges or davits are not required for access panels less than 610 mm (two feet) in width and height. All doors and panels shall have non-asbestos gaskets and shall be sealed tight with capscrews threaded into brass nuts. Panels shall have handles.
 6. Shell Piping Connections: Flanged, except threaded is permitted for pipe sizes under 65 mm (2-1/2 inches). Connections shall include, but not be limited to:
 - a. Steam nozzle shall be 2050 kPa (300 psi) ASME flanged. Design nozzle and shell assembly to withstand forces and moments imposed by connected piping. Studding nozzle will not be permitted.
 - b. Locate manual steam vent on top of boiler shell to permit access to vent gate valve from platform located above boiler.

- c. Locate safety valve outlets to permit straight run of vents through roof and to permit valve handle access from platform located above boiler.
 - d. Connections for water level control, alarm and indication devices.
 - e. Connections for boiler feed water, chemical admission, combined continuous blowdown and water sampling. Locate below normal water level and as shown.
 - f. Bottom blowoffs. Locate to permit complete collection of sediment and complete drainage.
 - g. Pressure gage and pressure switch connections. (May be connected to water level controller steam piping.)
7. Support System: Provide proper support of all elements of the boiler, burner, and accessories during shipment, rigging, and in final installation. Arrange supports to permit thermal expansion and to resist seismic shocks (in seismic areas). No element of the boiler or accessories shall be overstressed, displaced, have cracks, broken welds, or excessive deflection. All vertical elements of the boiler and accessories shall be plumb, and all horizontal elements shall be level.
- a. Base Frame: Design for mounting on flat concrete base. All elements shall be level. Provide attachments for anchorage to the concrete foundation.
 - b. Rigging and Jacking: Provide lifting lugs and provisions for jacking. Painted stencils shall identify jacking locations.
 - c. Platform Support Brackets: Provide brackets attached to boiler shell to support field-installed valve and manway access catwalk alongside top of boiler.
8. Refractory and Insulation: Boiler manufacturer's standard and experience proven design except insulation on the boiler shell shall be a minimum of 50 mm (two inches) thick. No part of the external casing shall exceed 33 degrees C (60 degrees F) above ambient, except for areas within 300 mm (one foot) of the casing penetrations.
9. Casing: Sheet steel covering all areas of boiler shell. Flash or seal all openings at top of boiler at piping and flue connections to prevent leakage of water into insulation. Provide a 300 mm (one

- foot) minimum width section of heavy gage reinforced casing or heavy density insulation (minimum 96 kg per cubic meter, six pounds per cubic foot) along the top centerline of the entire length of the boiler to permit walking on top of the boiler without denting the casing.
10. Observation Port: Provide single port at rear of furnace located to permit flame observation. Furnish with one clear and one tinted interchangeable heat resisting glass, gas-tight operable metal closure between furnace and glass, forced air cooling to reduce moisture condensation on glass.
- G. Factory Inspection and Certification: Inspect the completed boiler assembly in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section I, RULES FOR CONSTRUCTION OF POWER BOILERS. The boiler inspection shall be certified. Submit four copies of ASME Form P-2 for each boiler.
- H. Finish: Provide surface preparation, heat-resistant prime and finish coats using standard color of the boiler manufacturer. Refer to Section 09 91 00, PAINTING.

2.2 BOILER TRIM (ACCESSORIES):

- A. Conform to ASME Boiler and Pressure Vessel Code, Section I
- B. Steam Safety Valves:
1. Capacities certified by National Board of Boiler and Pressure Vessel Inspectors (NB).
 2. Type: Bronze or cast iron bodies, side outlet, flanged or threaded inlet and outlet, lifting lever, dual control rings, stainless steel trim, o-ring EPDM seats on bronze valves.
 3. Settings and Adjustments: Factory set, sealed, and stamped on nameplate. Set pressures as shown. Set pressure of lowest pressure valve shall not exceed normal boiler plant operating pressure by more than 210 kPa (30 psi). Provide 30 kPa (5 psi) difference in setting between each of the valves.
- C. Steam Pressure Gage:
1. Case: Turret-style, bottom connection, threaded ring, blowout disc in rear.
 2. Dial: 200 mm (8 inch) minimum diameter, non-corrosive, black markings on white background.
 3. Measuring Element: Bourdon tube designed for steam service.
 4. Movement: Stainless steel, rotary.

5. Pointer: Micrometer adjustable, black color.
6. Window: Laminated safety glass, or plastic.
7. Accuracy: One half percent of the full span.
8. Range: 0 - 300 psi gage.
9. Installation: Stop valve, steel piping, valved blowdown, siphon, union at gauge, valved connection for inspector's gauge. Refer to Detail, FIRETUBE BOILER.

D. Water Level Safety and Operating Controls and Indicators:

1. Provide high and low water warning alarms, primary and auxiliary low water burner cutoffs, automatic electronic modulating feedwater level control system, gage glass.
 - a. High and low water warning alarms shall operate bell and separate high and low water level indicating lights on boiler control panel and shall not shut down the burner.
 - b. Primary and auxiliary low water burner cutoff devices shall be in two separate water columns, piped individually to the boiler water spaces. One device shall be float-type, the other device shall be conductivity probes. Primary and auxiliary cutoffs shall require manual reset. Auxiliary cutoff shall shut down power to the burner management system. Non-latching shunt switches shall allow blowdown of water columns without shutting down the burner.
 - c. Water level set points for all devices shall be as recommended by boiler manufacturer.
 - d. Water level control system shall maintain the water level within limits established by boiler manufacturer for normal water level with no tripping of high and low level alarms with instantaneous load swings of 25 percent of boiler capacity. Feedwater pump will operate continuously.
 - e. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT for detailed operation of all indication, monitoring, alarm and control devices.
2. Water Column Unit with Water Level Controller, Gage Glass, Water Level Sensor for Primary Low Water Cutoff:
 - a. Float-type electric or electronic modulating water level control device and primary low water cutoff. As an option to the float type device, electronic self-checking magnetostrictive or capacitance devices may be provided.

- b. Height of water column and gage glass shall be sufficient to show water level in the gage glass at least 12 mm (0.5 inches) above high water alarm set point and at least 12 mm (0.5 inches) below auxiliary low water cutoff set point.
 - c. Control system shall automatically modulate an electric feedwater flow control valve. Feedwater pump will operate continuously.
 - d. Gage Glass and Gage Valves: Single vertical tubular gage glass, tempered borosilicate, red line, rated for 315 degrees C (600 degrees F). Provide automatic off-set gage valves with ball checks to prevent fluid flow if gage breaks. Provide gage rods to protect glass.
3. Auxiliary Water Column with Water Level Sensors for High and Low Level Alarms and Auxiliary Low Water Cutoff:
- a. Conductivity probe type high and low level alarm sensors and auxiliary low water cutoff sensor.
 - b. UL listed, factory-built probe and chamber unit mounted externally from the boiler.
 - c. Stainless steel conductivity probes and grounding probe. Virgin Teflon insulation.
4. Water columns shall be rated for 1400 kPa (200 psi) minimum saturated steam and have boiler and drain connections.
5. Water Column Piping to Boiler and to Drains: ASTM A106 Grade B, seamless or ERW piping, Schedule 80 threaded. Fittings shall be 300 lb. malleable iron or forged steel. All changes in direction shall be with crosses, no ells. Provide valved drain piping connected to the lowest part of each of the water columns.
6. Electrical: Provide circuit breakers, transformers, all devices for complete control system. All control electronics and relays shall be in waterproof NEMA 4X panels.
7. Modulating Feedwater Control Valve:
- a. Characterized rotary or sliding gate valve. Operated by electric drive unit actuator with top mount integrated digital positioner. Equal-percent valve flow characteristics. Modified linear valve flow characteristics shall be utilized when digital positioner is furnished.
 - b. Performance: Refer to schedules on the drawings for pressure, temperature and flow requirements. If not shown on the drawings, the valve shall be designed for maximum flow rate of 125% of the

maximum boiler steam output with 70 kPa (10 psi) pressure drop, maximum inlet pressure of 2000 kPa (300 psi), maximum temperature of 138 °C (280 °F). Shut-off seat leakage less than 0.0001 percent of valve CV.

- c. Rotary Valve: Three-piece carbon steel body, 316 SS ball and stem, Polyfil seat, TFE coated SS seal, 2000 kPa (300 psi) 138 °C (280 °F) minimum ratings. Flanged ends or wafer type for pipe sizes over 50 mm (2 inches), threaded ends for pipe sizes 50 mm (2 inches) and under.
 - d. Sliding Gate Valve: Stainless steel body, head section, actuator springs valve stem and fixed disc. Triballoy (STN2) self-aligning sliding disc. Carbon filled PTFE packing. Minimum ratings 2000 kPa (300 psi), 138 degrees C (280 degrees F).
 - e. Sound Levels: Conform to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
 - f. Electric Drive Unit for Rotary Valve: Shall have sufficient power to operate valve under all operating conditions. All parts of linkage between drive unit and valve shall be free-working, securely attached, and shall not distort under all operating conditions.
8. Shunt Switches for Primary Low Water Cutoff and Auxiliary Low Water Cutoff: Provide separate non-latching shunt switches for each of the low water cutouts to allow manual blowdown of water column without tripping burner. Locate each switch adjacent to the drain valve for the low water cutout that is affected by the switch.
9. Low Water Cutout Operation: Manual reset of primary low water cutoff shall be combined with the burner management manual reset. The burner management system annunciator and associated alarm horn shall indicate the primary and auxiliary low water cutoff operation. Operation of auxiliary low water cutoff shall shut down power to burner management system.
- E. Stack Thermometer: Dial-type, bi-metal element, stainless steel case and stem, adjustable angle, one percent of full scale accuracy, dual scale, 100 - 550 °C and 200 - 1000 °F, minimum diameter 125 mm (5 inches). Locate at flue gas outlet.
- F. High Steam Pressure Burner Cutouts:

1. Provide two UL listed, FM approved units with different set points. Unit with lowest set point shall be automatic reset; unit with highest set point shall be manual reset.
2. Bellows actuated sealed snap-acting switch or mercury switch with adjustable set point and adjustable differential pressure (automatic reset unit); switch position indicator.
3. Rated for 1375 kPa (200 psi) minimum emergency pressure.
4. Set pressure range: To 150 percent of required set pressure.
5. Provide indicators with graduated scales for set point and differential pressure.
6. Mounting: Connect to water column piping. There shall be no valves between cutoff and boiler shell. Provide siphons at each switch to protect bellows from high temperature.
7. Set Points:
 - a. Automatic Reset Unit: Refer to boiler schedule shown on the drawings. If not shown, set at 35 kPa (5 psi) below the set pressure of the manual reset unit.
 - b. Manual Reset Unit: 35 kPa (5 psi) below lowest safety valve set pressure. Subtractive differential not to exceed 70 kPa (10 psi).
8. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT for the operation of the cutouts.

2.3 BURNER AND FUEL TRAINS:

- A. Burner Type: Combination natural gas and fuel oil, packaged, forced draft, modulating firing. Design for low NOx emissions.
 1. Gas Burner: Ring type with multiple ports or spuds.
 2. Oil Burner: Gun type, inside mix, low pressure air atomizing.
 3. Igniter (Pilot): Interrupted, electrically ignited, natural gas and propane.
- B. Service:
 1. Continuous operation at all firing rates on each fuel listed under Article, PROJECT CONDITIONS of Part 1. 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.

C. 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 single igniter.
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 deposits of unburned fuel or carbon at any location.
 - d. No carryover of flame beyond the end of the first pass (furnace tube).
4. Operation:
 - a. Minimum turndown 10/1.
 - 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:

Boiler Steam Output, Percent of Maximum Required Capacity	Percent Excess Air Allowable Range
Below 25	15 minimum
25 - 39	15 - 35
40 - 100	15 - 25

- 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: Refer to Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT for requirements on forced

draft fan and oil atomization system. Burners shall operate without pulsation.

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5. Flue Gas Emissions Limits:

- a. Carbon Monoxide: Shall not exceed 200 PPM.
- 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: Local NOx emissions limits ppm maximum, corrected to 3 percent oxygen, dry basis on natural gas and low nitrogen No. 2 fuel oil.

D. 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 manufacturer. Refer to Section 09 91 00, PAINTING.
4. Combustion Air System and Flue Gas Recirculation (FGR) System (if provided):
 - a. Air flow rates controlled by forced draft fan inlet or outlet dampers.
 - b. Symmetrical, balanced distribution of combustion air into the burner.
 - c. Provide induced type flue gas recirculation (FGR) system if FGR is necessary to achieve specified NOx limits. All FGR ductwork shall comply with Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.
 - d. Forced Draft Fan: Airfoil or backwardly inclined 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.

- e. Motor: TEFC or open drip proof, non-overloading under all fan operating conditions, design for 40 °C ambient, premium efficiency type. Motors for variable speed service shall be rated inverter-ready. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- f. 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.
- g. Motor Starter Panel: Provide motor starter mounted in NEMA 4 enclosure, readily accessible. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT, for burner management system motor power interlocks.
- h. Sound Attenuators: Provide attenuators on forced draft air intakes to reduce sound levels to allowable limits. Refer to Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
- 5. Provide 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. Electrical Conduit: Provide liquid-tight flexible metal conduit with sealing fittings for all power and control services to fuel trains and burners. Refer to Section 26 05 33, RACEWAY and BOXES FOR ELECTRICAL SYSTEMS.
- 8. Factory Testing: Mount burner and controls on boiler at factory and fire-test at all load points.

E. Natural Gas Main Fuel 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 sequence: plug valve, filter, 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, plug valve, pressure gage, burner. Provide tee connection for vent between the automatic

- safety shut off valves. Vent line shall include valved leak test connection, automatic vent valve, valved leak test connection, lockable plug valve, vent thru roof. 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. Filter: Replaceable fiberglass or cellulose cartridge, 10 micron or smaller particle retention. Static pressure capability two times the maximum lock-up pressure of nearest upstream pressure regulator. Maximum pressure loss at high fire 1.3 kPa (5 inches water column). Provide vent with cock for relieving pressure in filter.
 3. 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 droop 5 percent 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.
 - d. Construction, Main Valve: Cast iron body, replaceable plug and seat. Downstream pressure-sensing line.
 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 of two times the highest pressure at entrance to boiler-mounted regulators.
 - c. Performance: Timed opening of six seconds or less to safely and smoothly ignite main flame, and close within one second.

- d. Construction: Valves 65 mm (2-1/2 inches) and larger, flanged ends; valves 50 mm (2 inches) and below threaded ends; position indicator showing open and shut, visible from front or side of boiler. Aluminum seating surfaces not permitted. Closed position interlock switch on each valve. Valved leak test fittings before and after each valve.
 - e. Approval: FM approved, UL listed for burner service.
 - f. 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. Automatic Vent Valve:
- a. Type: Motorized or solenoid closing, spring opening, full port, controlled by burner control system.
 - b. Service: Provide open-shut control of vent line that is connected between the two safety shut-off valves. 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. Valve shall be open whenever safety shut-off valves are closed.
 - c. Approval: UL listed for burner service.
6. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
7. Pressure Switches: Refer to the article on burner management system in Section 23 09 11, INSTRUMENTATION CONTROL FOR BOILER PLANT. 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.
8. Fuel Flow Control Valve:
- a. Type: Throttling, controlled by combustion control system (Refer to Section 23 09 11, INSTRUMENTATION and CONTROL for BOILER PLANT).

- 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.
 - c. Valve Requirement for Single Point Positioning Jackshaft Control Systems: Valve shall have adjustable characterization cam shaped by at least twelve adjustment screws.
9. Pressure Gages, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
- F. 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, filter, pressure gage, pressure regulator (if required by burner furnished), low pressure switch, high pressure switch, flow meter (if specified), oil flow control valve, thermometer, 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.
 - 2. Filter: Permanent edge-type elements, cleanable by rotation of a handle without interruption of flow. Filter element spacing 0.1 mm (0.0035 inch). Pressure rating shall exceed upstream safety relief valve set pressure plus accumulation. Maximum pressure loss 20 kPa (3 psi) at high fire. 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: FM approved, 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: Refer to the article on burner management system in Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT. 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 (Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT).
 - 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.
 - c. Valve Requirement for Single Point Positioning Jackshaft Control Systems: Valve shall have adjustable characterization cam shaped by at least twelve adjustment screws.
7. Pressure Gages, Thermometers, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
8. Boiler/Burner-Mounted Oil Pump and Relief Valve: Do not provide. House pumps are provided that include relief valves.
- G. Low Pressure Air Atomizing System:
- 1. Complete system for each burner, furnished by burner manufacturer, including compressor and drive, air filter, after cooler, low pressure switch and all piping systems.
 - 2. Motor: Premium efficiency type. Refer to the Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

3. Motor Controls: Provide motor starter in NEMA 4 enclosure. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT, for burner management control interlock proving power supply to motor.
 4. Shaft couplings: All metal, flexible.
 5. Sound Attenuators: Provide compressor enclosure, air intake silencer, or other means to reduce sound levels to those required. Refer to the Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
 6. Pressure Gages and Pressure Switches: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
- H. 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: Arrange the system to allow selection of either natural gas or propane for the ignition fuel. Provide separate piping with plug valve, pressure gage, filter and pressure regulator for natural gas and for propane. Connect to the main burner natural gas service downstream of the main burner pressure regulator. Join the natural gas and propane 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.
 2. Filters: Replaceable elements, five micron or smaller particle retention. Static pressure capability two times the maximum lockup pressure of nearest upstream pressure regulator. Maximum pressure loss, at full flow, 1.3 kPa (5 inches water column). Provide unions for filter removal.
 3. Pressure Regulators:
 - a. Type: Single-seated, diaphragm-operated. Provide separate regulators for natural gas service and for LP gas service
 - 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.
- d. Construction: Propane regulator must be designed for LP gas.
- 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 140 kPa (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. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
- 6. 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.
- 7. Igniter fuel train pipe and fittings: ASME B31.1 requirements do not apply. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

- 8. Pressure Switch and Pressure Gages: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT

2.4 BURNER MANAGEMENT (FLAME SAFEGUARD) SYSTEM AND ACCESSORIES:

- A. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- B. Control Panel: Controls shall be mounted in NEMA 4 enclosure on side of boiler or on burner. There shall be no power wiring in this enclosure.
- C. Factory Testing: Install controls on boiler and burner at factory and test operation of all devices.

2.5 FLUE GAS ECONOMIZER:

- A. Heat exchangers to transfer heat from boiler flue gases to boiler feedwater.
- B. Type: Rectangular configuration, replaceable finned tubes, up flow flue gas, parallel flow water, insulated casing with removable panels allowing access to all tubes for cleaning and replacement. Arrange tubes to permit lane-type soot blowing.
- C. Performance: Refer to schedules on drawings. Coordinate input flue gas temperatures with data from boiler manufacturer.
- D. Construction:
 - 1. Comply with ASME Boiler and Pressure Vessel Code, Section 1. Design unit to permit operation with no water in the tubes at the temperature listed below.
 - 2. Design Pressure:
 - a. Water Tubes, 2050 kPa (300 psi) minimum.
 - b. Inner Casings, 2.5 kPa (10 inches water column) minimum.
 - 3. Design Temperature, 370 °C (700 °F).
 - 4. Tubes and Headers: ASTM A254, Type 316 Stainless steel. Helically wound non-serrated stainless steel fins continuously welded to tubes. 2050 kPa (300 psi) flanged piping connections. Drainable by gravity. Return bend areas shall be exposed to the bulk temperature of the flue gas. Headers shall be external to the casing. Fin density shall not exceed 157 fins per meter (48 fins per foot). Maximum fin height, 13 mm (0.5 inches).
 - 5. Casing: Double wall, removable panels, with insulation between walls. 80 mm (3 inch) angle flanges on flue gas inlet and outlet for attachment of breeching and stack.
 - a. Inner Casing, stainless steel, all welded. Steel angles for breeching attachment to casing. Entire casing systems must be gas tight.
 - b. Insulation: Mineral fiber, ASTM C612, 50 mm (2 inches) thick.
 - c. Outer Casing: Galvanized or painted steel, 0.4 mm (0.016 inches) thick.
- E. Accessories:
 - 1. Safety Relief Valve: Valve designed for steam and water service, ASME - National Board certified, selected by economizer manufacturer

in accordance with ASME Code requirements. Set pressure 1900 kPa (275 psi) gage.

2. Soot Blowers: Steam-operated, rotating valve-in-head. Provide sufficient number of blowers to clean all tube areas. Location, arrangement and quantity based on recommendations of soot blower manufacturer for type and size of economizer furnished. Soot blowing shall be lane-type.
3. Inlet and Outlet Transitions: Designed and furnished by economizer manufacturer.

F. Factory Test and Inspections: Inspect the completed economizer assembly in accordance with the ASME Boiler and Pressure Vessel Code, Section I. Certify the inspection and submit four copies of completed ASME Form P-3 for each economizer.

2.6 TOOLS:

- A. Oil Burner Vise and Wrenches: Deliver to Contracting Officers Technical Representative (COTR)/ Resident Engineer (RE) for mounting by VA personnel. Furnish only if burners require vise and wrenches not stocked by local tool suppliers.
- B. Boiler Tube Brushes: Furnish hand brushes of sizes, and with handle lengths, to clean full length of all tubes in boiler. Provide handle and extension sections 1800 mm (6 feet) long or less to permit storage. Coupled lengths shall be suitable for use from front of boiler.

2.7 SPARE PARTS:

- A. Fuel Trains:
 1. One of each type and size of main and pilot fuel motorized and solenoid automatic safety shut-off valves and automatic vent valves.
 2. Complete set of filter elements and gaskets for each gas filter for each boiler.
 3. Complete set of all gaskets for each edge-type oil filter for each boiler.
- B. Boiler, Burner, Trim, Feedwater Control System:
 1. One assembly of electrodes, transformer, and high voltage lead with end connectors for igniters.
 2. Two complete sets of gaskets, for each boiler, to fit all doors, handholes, manholes.
 3. One clear lens and one tinted lens for each furnace and burner observation port on each boiler.

4. Sufficient tubular glass inserts and gaskets to re-equip water level gage glasses on each boiler.
5. One set of drive belts for each belt-driven apparatus for each boiler.
6. One gallon oil for atomizing air compressor.
7. Complete set of air compressor intake filter elements for each compressor, for each boiler, if disposable filters are provided.
8. One complete feedwater control valve and actuator.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. 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.
- C. 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.
- D. 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.
- E. 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. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. 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 Article INSPECTIONS AND TESTS for requirements for cleaning boiler after operational tests are completed.
- C. 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. This organization shall provide on-site supervision to maintain the required water quality during periods of boiler storage, operating, standby and test conditions. Furnish monthly reports by the water treatment organization, to the Resident Engineer (RE). The Contractor shall provide all chemicals, labor and professional services until the Government has accepted the boilers for operation. All chemicals utilized must conform to FDA guidelines applicable for steam used in food preparation.

3.3 INSPECTIONS AND TESTS:

- A. The following tests and demonstrations must be witnessed by the Resident Engineer (RE) or his/her representative, and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements. Refer to Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT for general requirements. When test results are not acceptable, make corrections and repeat tests at no additional cost to the Government. Pretests do not require the presence of the RE.
- 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 RE 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 provide inspector certified by National Board of Boiler and Pressure Vessel Inspectors to conduct tests 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 inspector. Correct any deficiencies discovered during the testing, and retest equipment until satisfactory results are achieved and are accepted by the inspector.
2. Boiler External Piping (as defined by ASME B31.1, Power Piping):
 - a. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
 - b. 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) gage.
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. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
 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 NOx and carbon monoxide. Test firm shall be acceptable to emissions authorities.
 3. Test No. P-1:
 - 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 (Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
 - c. When flue gas oxygen trim is provided, conduct tests with trim control on manual at the zero trim (null) position. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT. After completion of tests with trim control on manual control, repeat the tests on one fuel with the trim control on automatic control.
 4. Test No. P-2:
 - 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.

- c. Refer to sound level requirements in Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
5. Test No. P-3:
- a. Check current draw of forced draft fan motor at prepurge 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 Test No. P-1.
6. Test Methods:
- a. Utilize permanent instrumentation systems for data. All systems shall be operable and in calibration.
 - b. Utilize portable thermocouple pyrometer furnished and retained by Contractor to measure stack temperature as a verification of permanent stack temperature recorder.
 - c. 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.
 - d. In Test No. P-1 retain boiler at each load point for a time period sufficient to permit stabilization of flue gas temperature and other parameters.
 - e. Steam loads for tests may be furnished by the hospital systems, by operation of the steam silencer vent system, or by a combination of the above. If variable hospital loads interfere with testing, conduct tests at night or on weekends when loads are more stable.
 - f. Utilize dry bulb and wet bulb thermometers furnished and retained by Contractor for checking combustion air.
 - g. Smoke testing shall be by visual observation of the stack and by smoke density monitor (permanent instrument - if provided). If smoke density monitor is not provided, utilize Bacharach Model 21-7006 Smoke Test Kit. If there is disagreement with the results of these tests, provide qualified observation person and tests in

compliance with EPA Reference Method 9 (CFR 40, Part 60, Appendix A).

- h. Sound level instruments will be Government furnished.
 - i. 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.
 - j. 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, and the abbreviated input-output and heat balance methods.
7. Pretesting:
- a. Perform pretest at the final stage of the burner fine-tuning process.
 - b. Prior to scheduling final test, submit evidence of pretest. Evidence shall consist of start-up data sheets signed and dated by personnel representing burner manufacturer, combustion controls manufacturer, burner controls manufacturer.
 - c. Pretest data sheets shall list the following data for each fuel and at each fuel valve controller position, starting at minimum position, proceeding to the maximum position and returning to the minimum position.
 - 1) Fuel flow and air flow controller position.
 - 2) Fuel pressures: At burner and also upstream of fuel flow control valve.
 - 3) Fuel flow rate.
 - 4) Boiler feed pressure, upstream of feedwater regulator (at minimum, 50 percent, maximum firing positions only).
 - 5) Boiler feed temperature (at minimum, 50 percent, maximum firing positions only).
 - 6) Stack temperature: Boiler outlet, economizer (if provided) outlet.
 - 7) Flue gas oxygen and carbon monoxide (utilize flue gas analyzer which has been calibrated with certified test gases).
 - 8) Steam flow rate (at minimum, 50 percent, maximum firing position only).

- 9) Steam pressure - Boiler, Header (at minimum, 50 percent, maximum positions only).
 - 10) Opacity of flue gas.
 - 11) Flue gas NO_x (if limit specified).
 - 12) Combustion air temperature - dry bulb and wet bulb.
 - 13) Barometric pressure (one reading).
- d. Calibrate all pressure gages prior to pretest.
- G. Internal Inspection of Pressure Parts and Furnace:
1. After all operational tests are satisfactorily completed, a Government retained, licensed boiler inspector will determine if the boiler is free from corrosion, deposits, and any other type of damage or defect.
 2. In preparation for the inspection, open all manways, handholes, and access doors or panels at the ends of the boiler. Drain and clean the interior of all pressure parts and clean all soot and debris from furnace and fire tubes.
 3. Any corrosion, damage or defect shall be corrected to a like new condition in the judgment of the boiler inspector.
 4. After the boiler inspector has approved the boiler, all manways, handholes, and the access doors shall be closed with new gaskets.
- H. If burner operation results in deposits of carbonaceous materials in the furnace or tubes clean the furnace and tubes, modify the burners as necessary, and retest the burner performance.

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 Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

SECTION 26 24 19
MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the motor control centers.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components. NOT USED
- C. Section 25 10 10, ADVANCED UTILITY METERING: Electricity meters installed in motor control centers.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- G. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY. Short circuit and coordination study, and requirements for a coordinated electrical system.
- H. Section 26 29 11, MOTOR CONTROLLERS: Control and protection of motors.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Prior to fabrication of motor control centers, submit the following data for approval:

- 1) Single line diagram showing each bus, instrument and control power transformer, relay, motor starter, circuit breaker, fuse, motor circuit protector, overload, and other components.
 - 2) Control wiring diagram for each motor starter.
 - 3) Complete electrical ratings for all components.
 - 4) Interrupting ratings.
 - 5) Safety features.
 - 6) Accessories and nameplate data.
 - 7) Dimensioned exterior views of the motor control centers.
 - 8) Dimensioned section views of the motor control centers.
 - 9) Floor plan of the motor control centers.
 - 10) Approximate design weights.
- c. Certification from the manufacturer that a representative motor control center has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods. NOT USED
2. Manuals:
- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Schematic control diagrams, with all terminals identified, matching terminal identification in the motor control centers.
 - 2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended periodic maintenance procedures and their frequency.
 - 3) Provide a replacement and spare parts list. Include a list of tools, and instruments for testing and maintenance purposes.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Test Reports:
- a. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the COR.
4. Certifications: Two weeks prior to final inspection, submit the following.

- a. Certification by the manufacturer that the motor control centers conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the motor control centers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
IBC-12.....International Building Code
- C. National Electrical Manufacturers Association (NEMA):
ICS 1-08.....Industrial Control and Systems: General Requirements
ICS 2-05.....Industrial Control and Systems: Controllers, Contactors and Overhead Relays Rated 600 volts
ICS 6-06.....Industrial Control and Systems: Enclosures
FU 1-07.....Low-Voltage Cartridge Fuses
250-08.....Enclosures for Electrical Equipment (1000 Volts Maximum)
- D. National Fire Protection Association (NFPA):
70-11.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
845-05.....Motor Control Centers

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Motor control centers shall comply with NFPA, NEMA, UL, and as shown on drawings.
- B. Motor control centers shall be complete, free-standing, floor-mounted, dead-front, and metal-enclosed.
- C. Ratings shall be not less than shown on drawings. Interrupting ratings shall be not less than the maximum short circuit currents available at the motor control center location, as shown on drawings or as calculated as specified in Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.
- D. Enclosure shall be NEMA-type rated 1, 3R, or 12 as indicated on drawings or as required per the installed environment.

E. Motor control centers shall conform to the arrangements and details of drawings and to the spaces designated for installation.

F. Wiring: The motor control centers shall be NEMA Standard, Class 1, Type B.

G. Finish:

1. All metal surfaces shall be thoroughly cleaned, phosphatized and factory primed prior to applying baked enamel or lacquer finish.

2. Provide a light gray finish for indoor motor control centers.

3. Outdoor motor control centers:

- a. Finish shall be light gray.

- b. The underside of the motor control centers shall be treated with corrosion resistant compounds, epoxy resin, or rubberized sealing compound.

H. All steel parts shall be factory-phosphatized, painted with primer, and baked enamel or lacquer finishes, except for ground connections. I.

Vertical Sections:

1. Approximately 2-1/4 M (90 inches) high.

2. Shall be designed to permit connection of future additional vertical sections, and installation of future motor controller units in available space in each vertical section.

3. Spaces within the vertical sections shall be suitable and adequately sized for motor controller units and accessories as indicated on drawings.

4. End panels shall be removable to facilitate future additions.

5. All vertical section parts shall be accessible from the front for maintenance rearrangement.

6. Screws in the removable panels shall remain in the panels when the panels are removed. Self-aligning, self-retaining nuts, which are parts of the screw assembly, shall remain intact.

7. Each vertical section shall have a minimum 300 mm (12 inches) high horizontal wireway at the top, section and a minimum 150 mm (6 inches) high horizontal wireway at the bottom.

8. Each vertical section shall have minimum 100 mm (4 inches) wide vertical full height wireways. Vertical wireways shall connect with both the top and bottom horizontal wireways.

9. Each vertical section for motor controller units shall be equipped with all necessary hardware and busing for the units to be added or

relocated. All unused space shall be covered by hinged doors and equipped to accept future units.

2.2 BUS BARS AND INTERCONNECTIONS

- A. Horizontal and vertical bus ratings shall be as shown on drawings.
Horizontal bus bars shall be fully rated for the entire length of the motor control centers.
- B. Bus bars shall be tin-plated copper.
- C. All bolts, nuts, and washers shall be cadmium-plated steel, torqued to the values recommended by the manufacturer.
- D. A ground bus shall extend across the entire length of the motor control centers.
- E. Bus bars and interconnections shall include provisions to extend the motor control center horizontal bus into additional future vertical sections.
- F. Provide shutter mechanism to isolate vertical bus when the motor controller unit is withdrawn.

2.3 MOTOR CONTROLLERS

- A. Product of the same manufacturer as the motor control centers.
- B. Shall conform to the applicable requirements in Section 26 29 11, MOTOR CONTROLLERS.
- C. Plug-in, draw-out type up through NEMA size 4. NEMA size 5 and above require bolted connections.
- D. Doors for each space shall be interlocked to prevent their opening unless disconnect is open. A "defeater" mechanism shall be incorporated for inspection by qualified personnel.

2.4 FEEDER UNITS

- A. Circuit breaker: shall conform to the applicable portions of Section 26 24 16, PANELBOARDS.
- B. Fusible Switches: shall conform to the applicable portions of Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.

2.5 METERS

- A. Meters shall be provided as shown on the plans. Meters shall be in accordance with Section 25 10 10, ADVANCED UTILITY METERING.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install motor control centers in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor motor control centers with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. In seismic areas, motor control centers shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed. NOT USED
- D. Exterior Location. Mount motor control centers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Interior Location. Mount motor control centers on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical, electrical, and mechanical condition.
- c. Verify appropriate anchorage and required area clearances.
- d. Verify that circuit breaker, fuse, motor circuit protector, and motor controller sizes and types correspond to approved shop drawings.
- e. Use calibrated torque-wrench method to verify the tightness of accessible bolted electrical connections, or perform a thermographic survey after energization.
- f. Vacuum-clean motor control center enclosure interior. Clean motor control center enclosure exterior.
- g. Inspect insulators for evidence of physical damage or contaminated surfaces.
- h. Exercise all active components.
- i. Verify the correct operation of all indicating devices.
- j. If applicable, inspect control power transformers.

2. Electrical Tests:

- a. Perform insulation-resistance tests on each bus section.
- b. Perform insulation-resistance test on control wiring. Do not perform this test on wiring connected to electronic components.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the motor control centers are in good operating condition and properly performing the intended function.

3.4 TRAINING

A. Furnish the services of a competent, factory-trained engineer or technician for a 2-hour period to instruct VA personnel in operation and maintenance of the equipment, including review of the operation and maintenance manual, on a date requested by the COR.

---END---

**SECTION 26 29 11
MOTOR CONTROLLERS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of motor controllers, including all low- and medium-voltage motor controllers and manual motor controllers, indicated as motor controllers in this section, and low-voltage variable speed motor controllers.
- B. Motor controllers, whether furnished with the equipment specified in other sections or otherwise (with the exception of elevator motor controllers specified in Division 14 and fire pump controllers specified in Division 21), shall meet this specification and all related specifications.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, weights, mounting details, materials, overcurrent protection devices, overload relays, sizes of enclosures, wiring diagrams, starting characteristics, interlocking, and accessories.
 - 2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - 2) Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.
 - 3) Elementary schematic diagrams shall be provided for clarity of operation.
 - 4) Include the catalog numbers for the correct sizes of overload relays for the motor controllers.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the manufacturer that the motor controllers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the motor controllers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 519-92.....Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
 - C37.90.1-02.....Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- C. International Code Council (ICC):
 - IBC-12.....International Building Code
- D. National Electrical Manufacturers Association (NEMA):
 - ICS 1-08.....Industrial Control and Systems: General Requirements

- ICS 1.1-09.....Safety Guidelines for the Application,
Installation and Maintenance of Solid State
Control
- ICS 2-05.....Industrial Control and Systems Controllers,
Contactors, and Overload Relays Rated 600 Volts
- ICS 4-05.....Industrial Control and Systems: Terminal Blocks
- ICS 6-06.....Industrial Control and Systems: Enclosures
- ICS 7-06.....Industrial Control and Systems: Adjustable-
Speed Drives
- ICS 7.1-06.....Safety Standards for Construction and Guide for
Selection, Installation, and Operation of
Adjustable-Speed Drive Systems
- MG 1 Part 31.....Inverter Fed Polyphase Motor Standards
- E. National Fire Protection Association (NFPA):
- 70-11.....National Electrical Code (NEC)
- F. Underwriters Laboratories Inc. (UL):
- 508A-07.....Industrial Control Panels
- 508C-07.....Power Conversion Equipment
- UL 1449-06.....Surge Protective Devices

PART 2 - PRODUCTS

2.1 MOTOR CONTROLLERS

- A. Motor controllers shall comply with IEEE, NEMA, NFPA, UL, and as shown on the drawings.
- B. Motor controllers shall be separately enclosed, unless part of another assembly. For installation in motor control centers, provide plug-in, draw-out type motor controllers up through NEMA size 4. NEMA size 5 and above require bolted connections.
- C. Motor controllers shall be combination type, with magnetic controller per Paragraph 2.3 below and with circuit breaker, fused switch, or motor circuit protector disconnecting means, with external operating handle with lock-open padlocking positions and ON-OFF position indicator.
1. Circuit Breakers:
- a. Bolt-on thermal-magnetic type with a minimum interrupting rating as indicated on the drawings.
- b. Equipped with automatic, trip free, non-adjustable, inverse-time, and instantaneous magnetic trips for less than 400A. The magnetic

trip shall be adjustable from 5x to 10x for breakers 400A and greater.

c. Additional features shall be as follows:

- 1) A rugged, integral housing of molded insulating material.
- 2) Silver alloy contacts.
- 3) Arc quenchers and phase barriers for each pole.
- 4) Quick-make, quick-break, operating mechanisms.
- 5) A trip element for each pole, a common trip bar for all poles, and one operator for all poles.

2. Fused Switches:

- a. Quick-make, quick-break type.
- b. Minimum duty rating shall be NEMA classification General Duty (GD) for 240 Volts and NEMA classification Heavy Duty (HD) for 480 Volts.
- c. Horsepower rated, and shall have the following features:
 - 1) Copper blades, visible in the OFF position.
 - 2) An arc chute for each pole.
 - 3) Fuse holders for the sizes and types of fuses specified or as shown on the drawings.

3. Motor Circuit Protectors:

- a. Magnetic trip only.
- b. Bolt-on type with a minimum interrupting rating as indicated on the drawings.
- c. Equipped with automatic, adjustable magnetic trip. Magnetic trip shall be adjustable up to 1300% of the motor full load amperes.

D. Enclosures:

1. Enclosures shall be NEMA-type rated 1, 3R, or 12 as indicated on the drawings or as required per the installed environment.
2. Enclosure doors shall be interlocked to prevent opening unless the disconnecting means is open. A "defeater" mechanism shall allow for inspection by qualified personnel with the disconnect means closed. Provide padlocking provisions.
3. All metal surfaces shall be thoroughly cleaned, phosphatized, and factory primed prior to applying light gray baked enamel finish.

E. Motor control circuits:

1. Shall operate at not more than 120 Volts.
2. Shall be grounded, except where the equipment manufacturer recommends that the control circuits be isolated.

3. For each motor operating over 120 Volts, incorporate a separate, heavy duty, control transformer within each motor controller enclosure.
4. Incorporate primary and secondary overcurrent protection for the control power transformers.

F. Overload relays:

1. Devices shall be NEMA type.
2. One for each pole.
3. External overload relay reset pushbutton on the door of each motor controller enclosure.
4. Overload relays shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
5. Thermal overload relays shall be tamperproof, not affected by vibration, manual reset, sensitive to single-phasing, and shall have selectable trip classes of 10, 20 and 30.
6. Induction overload relays shall have changeable heater elements, manual reset, ambient temperature compensation, sensitivity to single-phasing, and shall have selectable trip classes of 10, 20 and 30.
7. Temperature probe relays shall be connected to thermistors or resistance temperature detectors (RTD) embedded in the motor winding.
8. Electronic overload relays shall utilize internal current transformers and electro-mechanical components. The relays shall have ambient temperature compensation, single-phase protection, manual or automatic reset, and trip classes of 10, 15, 20 and 30. The relay shall provide fault cause indication, including jam/stall, ground fault, phase loss, and overload.

G. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular controller. H-O-A switch shall be operable without opening enclosure door. H-O-A switch is not required for manual motor controllers.

H. Incorporate into each control circuit a 120 Volt, electronic time-delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time-delay relay is not required where H-O-A switch is not required.

- I. Unless noted otherwise, equip each motor controller with not less than two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts.
- J. Provide green (RUN) and red (STOP) pilot lights.
- K. Motor controllers incorporated within equipment assemblies shall also be designed for the specific requirements of the assemblies.
- L. Additional requirements for specific motor controllers, as indicated in other specification sections, shall also apply.

2.2 MANUAL MOTOR CONTROLLERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Manual motor controllers shall have the following features:
 - 1. Controllers shall be general-purpose Class A, manually operated type with full voltage controller for induction motors, rated in horsepower.
 - 2. Units shall include thermal overload relays, on-off operator, red pilot light, normally open and normally closed auxiliary contacts.
- C. Fractional horsepower manual motor controllers shall have the following features:
 - 1. Controllers shall be general-purpose Class A, manually operated type with full voltage controller for fractional horsepower induction motors.
 - 2. Units shall include thermal overload relays, red pilot light, and toggle operator.

2.3 MAGNETIC MOTOR CONTROLLERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Controllers shall be general-purpose, Class A magnetic controllers for induction motors rated in horsepower. Minimum NEMA size 0.
- C. Where combination motor controllers are used, combine controller with protective or disconnect device in a common enclosure.
- D. Provide phase loss protection for each controller, with contacts to de-energize the controller upon loss of any phase.
- E. Unless otherwise indicated, provide full voltage non-reversing across-the-line mechanisms for motors less than 75 HP, closed by coil action and opened by gravity. For motors 75 HP and larger, provide reduced-voltage or variable speed controllers as shown on the drawings. Equip controllers with 120 VAC coils and individual control transformer unless otherwise noted.

2.4 REDUCED VOLTAGE MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall have closed circuit transition.
- C. Shall limit inrush currents to not more than 70 percent of the locked rotor current.
- D. Provide phase loss protection for each motor controller, with contacts to de-energize the motor controller upon loss of any phase.

2.5 MEDIUM-VOLTAGE MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above, and in accordance with applicable provisions of Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR.
- B. Interrupting ratings shall be not less than the maximum short circuit currents available as shown on the drawings.
- C. Shall have the following additional features:
 - 1. Metal enclosed, free-standing, vacuum break, reduced-voltage, primary reactor, drawout type combined with non-load break fused disconnect switch.
 - 2. Shall include the following components:
 - a. Three pole, magnetically held, drawout type, with start/run contactor(s).
 - b. Equipped for the number of motor speeds as shown on the drawings.
 - c. Primary reactor with taps for 50, 65 and 80 percent of line voltage.
 - d. Definite time transfer relay.
 - e. Three current limiting, type "R" power type fuses with 50,000 amperes interrupting capability or as indicated on drawings.
 - f. Control power transformer (CPT), protected with current limiting fuses. The CPT shall be rated shall be rated 60kV BIL.
 - g. Three current transformers and overcurrent protective devices.
 - h. Zero-sequence current transformers and associated devices for ground fault protection.
 - i. Under-voltage protection.
 - j. Protection against single phasing.
 - k. Stator thermal protection.
 - l. Indicating-type ammeter and selector switch.
 - m. Red and green indicating lights.
 - 3. A separate enclosure for each motor controller.

4. Shall be isolated by an externally operated mechanism. The secondary of the control power transformer shall also be opened by this device.
5. Suitable and adequate compartments and barriers for medium-voltage components. Isolate the power bus from the normally accessible compartments.
6. Medium-voltage line connections shall be automatically shuttered closed when the motor controller is in the racked-out position. The disconnection shall be clearly indicated.
7. Interlocks shall prevent:
 - a. Inadvertent operation of the isolating mechanism under load.
 - b. Opening the medium-voltage compartment before the controller is isolated.
 - c. Closing of the line contactor while the enclosure door is open.
8. Current and potential transformers for operating remote recording watt-hour and demand meters and the indicating meters at the motor controller.
9. Provide lock-open padlocking provisions.
10. Furnish accessories as recommended by the manufacturer of the motor controllers to facilitate convenient operation and maintenance of the controllers.

2.6 LOW-VOLTAGE VARIABLE SPEED MOTOR CONTROLLERS (VSMC)

- A. VSMC shall be in accordance with applicable portions of 2.1 above.
- B. VSMC shall be electronic, with adjustable frequency and voltage, three phase output, capable of driving standard NEMA B three-phase induction motors at full rated speed. The control technique shall be pulse width modulation (PWM), where the VSMC utilizes a full wave bridge design incorporating diode rectifier circuitry. Silicon controlled rectifiers or other control techniques are not acceptable.
- C. VSMC shall be suitable for variable torque loads, and shall be capable of providing sufficient torque to allow the motor to break away from rest upon first application of power.
- D. VSMC shall be capable of operating within voltage parameters of plus 10 to minus 15 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.
- E. Minimum efficiency shall be 95 percent at 100 percent speed and 85 percent at 50 percent speed.

- F. The displacement power factor of the VSMC shall not be less than 95 percent under any speed or load condition.
- G. VSMC current and voltage harmonic distortion shall not exceed the values allowed by IEEE 519.
- H. Operating and Design Conditions:
 - 1. Temperatures: Maximum +90°F Minimum -10°F
 - 2. Relative Humidity: 95%
- I. VSMC shall have the following features:
 - 1. Isolated power for control circuits.
 - 2. Manually resettable overload protection for each phase.
 - 3. Adjustable current limiting circuitry to provide soft motor starting. Maximum starting current shall not exceed 200 percent of motor full load current.
 - 4. Independent acceleration and deceleration time adjustment, manually adjustable from 2 to 2000 seconds. Set timers to the equipment manufacturer's recommended time in the above range.
 - 5. Control input circuitry that will accept 4 to 20 mA current or 0-10 VDC voltage control signals from an external source.
 - 6. Automatic frequency adjustment from 1 Hz to 300 Hz.
 - 7. Circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The VSMC shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected. The VSMC shall be able to restart into a rotating motor operating in either the forward or reverse direction and matching that frequency.
 - a. Incorrect phase sequence.
 - b. Single phasing.
 - c. Overvoltage in excess of 10 percent.
 - d. Undervoltage in excess of 15 percent.
 - e. Running overcurrent above 110 percent (VSMC shall not automatically reset for this condition.)
 - f. Instantaneous overcurrent above 150 percent (VSMC shall not automatically reset for this condition).
 - g. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, and automatic transfer switch operations.)

8. Provide automatic shutdown upon receiving a power transfer warning signal from an automatic transfer switch. VSMC shall automatically restart motor after the power transfer.
9. Automatic Reset/Restart: Attempt three restarts after VSMC fault or on return of power after an interruption and before shutting down for manual reset or fault correction, with adjustable delay time between restart attempts.
10. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
11. Bidirectional Autospeed Search: Capable of starting VSMC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to VSMC, motor, or load.
- J. VSMC shall include an input circuit breaker which will disconnect all input power, interlocked with the door so that the door cannot be opened with the circuit breaker in the closed position.
- K. VSMC shall include a 5% line reactor and a RFI/EMI filter.
- L. Surge Suppression: Provide three-phase protection against damage from supply voltage surges in accordance with UL 1449.
- M. VSMC shall include front-accessible operator station, with sealed keypad and digital display, which allows complete programming, operating, monitoring, and diagnostic capabilities.
 1. Typical control functions shall include but not be limited to:
 - a. HAND-OFF-AUTOMATIC-RESET, with manual speed control in HAND mode.
 - b. NORMAL-BYPASS.
 - c. NORMAL-TEST, which allows testing and adjusting of the VSMC while in bypass mode.
 2. Typical monitoring functions shall include but not be limited to:
 - a. Output frequency (Hz).
 - b. Motor speed and status (run, stop, fault).
 - c. Output voltage and current.
 3. Typical fault and alarm functions shall include but not be limited to:
 - a. Loss of input signal, under- and over-voltage, inverter overcurrent, motor overload, critical frequency rejection with selectable and adjustable deadbands, instantaneous line-to-line

and line-to-ground overcurrent, loss-of-phase, reverse-phase, and short circuit.

- b. System protection indicators indicating that the system has shutdown and will not automatically restart.
- N. VSMC shall include two N.O. and two N.C. dry contacts rated 120 Volts, 10 amperes, 60 Hz.
- O. Hardware, software, network interfaces, gateways, and programming to control and monitor the VSMC by control systems specified in other specification sections, including but not limited to Divisions 22 and 23.
- P. Network communications ports: As required for connectivity to control systems specified in other specification sections, including but not limited to Divisions 22 and 23.
- Q. Communications protocols: As required for communications with control systems specified in other specification sections, including but not limited to Divisions 22 and 23.
- R. Bypass controller: Provide contactor-style bypass, arranged to bypass the inverter.
 - 1. Inverter Output Contactor and Bypass Contactor: Load-break NEMA-rated contactor.
 - 2. Motor overload relays.
 - 3. HAND-OFF-AUTOMATIC bypass control.
- S. Bypass operation: Transfers motor between inverter output and bypass circuit, manually, automatically, or both. VSMC shall be capable of stable operation (starting, stopping, and running), and control by fire alarm and detection systems, with motor completely disconnected from the inverter output. Transfer between inverter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
- T. Inverter Isolating Switch: Provide non-load-break switch arranged to isolate inverter and permit safe troubleshooting and testing of the inverter, both energized and de-energized, while motor is operating in bypass mode. Include padlockable, door-mounted handle mechanism.

PART 3 - EXECUTION

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3.1 INSTALLATION

- A. Install motor controllers in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Install manual motor controllers in flush enclosures in finished areas.

- C. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and electronic overload relay pickup and trip ranges.
- D. Program variable speed motor controllers per the manufacturer's instructions and in coordination with other trades so that a complete and functional system is delivered.
- E. Adjust trip settings of circuit breakers and motor circuit protectors with adjustable instantaneous trip elements. Initially adjust at six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficiency motors if required). Where these maximum settings do not allow starting of a motor, notify COTR before increasing settings.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify that circuit breaker, motor circuit protector, and fuse sizes and types correspond to approved shop drawings.
 - e. Verify overload relay ratings are correct.
 - f. Vacuum-clean enclosure interior. Clean enclosure exterior.
 - g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - h. Test all control and safety features of the motor controllers.
 - i. For low-voltage variable speed motor controllers, final programming and connections shall be by a factory-trained technician. Set all programmable functions of the variable speed motor controllers to meet the requirements and conditions of use.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor

controllers are in good operating condition and properly performing the intended functions.

3.4 SPARE PARTS

- A. Two weeks prior to the final inspection, provide one complete set of spare fuses for each motor controller.

3.5 INSTRUCTION

- A. Furnish the services of a factory-trained technician for two 4-hour training periods for instructing personnel in the maintenance and operation of the motor controllers, on the dates requested by the COTR.

---END---

SECTION 26 29 21
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground faults.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- E. Section 26 24 16, PANELBOARDS: Molded-case circuit breakers.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.
 2. Manuals:
 - a. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.

- 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.
- 2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
 - IBC-12.....International Building Code
- C. National Electrical Manufacturers Association (NEMA):
 - FU 1-07.....Low Voltage Cartridge Fuses
 - KS 1-06.....Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- D. National Fire Protection Association (NFPA):
 - 70-11.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
 - 98-07.....Enclosed and Dead-Front Switches
 - 248-00.....Low Voltage Fuses
 - 489-09.....Molded Case Circuit Breakers and Circuit Breaker Enclosures

SPEC WRITER NOTE: Delete between // ----
 // if not applicable to project. Also delete any other item or paragraph not applicable to the section and renumber the paragraphs.

PART 2 - PRODUCTS**2.1 FUSED SWITCHES RATED 600 AMPERES AND LESS**

- A. Switches shall be in accordance with NEMA, NEC, UL, as specified, and as shown on the drawings.
- B. Shall be NEMA classified General Duty (GD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 480 V switches.
- C. Shall be horsepower (HP) rated.
- D. Shall have the following features:
 - 1. Switch mechanism shall be the quick-make, quick-break type.
 - 2. Copper blades, visible in the open position.
 - 3. An arc chute for each pole.
 - 4. External operating handle shall indicate open and closed positions, and have lock-open padlocking provisions.
 - 5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.
 - 6. Fuse holders for the sizes and types of fuses specified.
 - 7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 - 8. Ground lugs for each ground conductor.
 - 9. Enclosures:
 - a. Shall be the NEMA types shown on the drawings.
 - b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.
 - c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel.
 - 10. Electrically operated switches shall only be installed where shown on the drawings.

2.2 UNFUSED SWITCHES RATED 600 AMPERES AND LESS

- A. Shall be the same as fused switches, but without provisions for fuses.

2.3 FUSED SWITCHES RATED OVER 600 AMPERES TO 1200 AMPERES

- A. Shall be the same as fused switches, and shall be NEMA classified Heavy Duty (HD).

2.4 MOTOR RATED TOGGLE SWITCHES

- A. Type 1, general purpose for single-phase motors rated up to 1 horsepower.

- B. Quick-make, quick-break toggle switch with external reset button and thermal overload protection matched to nameplate full-load current of actual protected motor.

2.5 CARTRIDGE FUSES

- A. Shall be in accordance with NEMA FU 1.

2.6 SEPARATELY-ENCLOSED CIRCUIT BREAKERS

- A. Provide circuit breakers in accordance with the applicable requirements in Section 26 24 16, PANELBOARDS.
- B. Enclosures shall be the NEMA types shown on the drawings. Where the types are not shown, they shall be the NEMA type most suitable for the ambient environmental conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - d. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 SPARE PARTS

- A. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver the spare fuses to the COTR.

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