SECTION 23 09 11
INSTRUMENTATION AND CONTROL FOR BOILER PLANT
11-10

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 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATIONB. Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.

B. Section 23 21 11, BOILER PLANT PIPING SYSTEMS: Piping for controls and instrumentation panel.

C. Section 23 52 39, FIRE-TUBE BOILERS: Feedwater controls and instrumentation furnished with fire tube boilers.

D. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT Automatic controls for water level in the feedwater deaerator storage tank and the condensate storage tank.

E. Section 23 10 00, FACILITY FUEL SYSTEMS: Tank level monitors and leak detection systems for oil tanks and underground oil piping systems (diesel fuel, burner fuel).

F. Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.

G. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training

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. 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.

C. 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 specifications 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.

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.

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.

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.

6. Submit 4 fuel/air combustion curves: 2 for VFD operation (one of each fuel), and 2 for constant full speed fan operation (one for each fuel).

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 or charts. For paper chart recorders, submit ranges for charts that will be furnished.

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.

      d. Flue gas recirculation (FGR).

e. Boiler water level, 1 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 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 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. Lead lag control systems are not allow within 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. Bumpless 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 shutdown 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 setpoint 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, Feedwater 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.

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. Limit VFD turn down to 40 hertz.

8. 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, variable frequency forced draft fan drives (VFD), feedwater control valves: Refer to Section 23 52 39, FIRE-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 submaster controller for each boiler/burner. Submaster 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 100psi.
   Individual set point adjustment range: +/- 140 kPa (20 psi).

   c. Control Stations: Individual control stations for master and submaster 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, 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 submaster 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 submaster controller. Software shall be factory-programmed for the specific application. Only tuning and scaling shall be performed in the field. Provide 4 fuel/air combustion curves: 2 for VFD operation (one of each fuel), and 2 for constant full speed fan operation (one for each fuel).

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.

3. Automatic Flue Gas Oxygen Trim System:

a. Boiler/burner submaster 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 submaster 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 NOx 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 Water Level Control:

    a. Automatically modulate the position of feedwater 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.

    c. Boiler Water Level Sensors:

        1) Water Level Sensing and Safety Control Systems: Provide on fire tube boilers. Refer to Section 23 52 39, FIRE-TUBE BOILERS.

        2) 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. Feedwater 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 feedwater 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.

6. 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 (see below for limited exceptions), 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 third edition of the VHA Boiler Plant Safety Device Testing Manual.

1. Controller shall be manufactured separately from the Burner Control System controller. Combined boiler control and flame safeguard systems are not acceptable.

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. **(FSMFO – flame scanner for main flame out)**. The automatic fuel shutoff valve shall close in less than 4 seconds upon detection of flame failure.

5. Ten seconds trial for ignition **(IT – igniter timing)** except 15 seconds permitted on heavy oil fuel.

6. **Main Flame Ignition Timing – MFIT**, maximum timing shall be 14 seconds.

7. **Pre-purge and post purge timing – PPT**, set for 4 air changes on fire 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.

      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.

      r. Flue gas recirculation (if provided) improper damper position.

    s. Low flue gas oxygen.

    t. 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.

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. Clearly identify each terminal lead. Only one wire shall be under a given terminal.

    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 or updated where it 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 third edition of the VHA Boiler Plant Safety Device Testing Manual.

    e. Provide written step by step safety device test procedures that follow the third 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. Additionally, 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 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. Switch setpoint: opens at 80% of maximum pressure differential.

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 switch opens if pressure drops to 80% 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. Provide ¼" NPT internal thread.

    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. Not used.

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. Switches for each boiler's two valves shall be wired in
    series so that an indicated failure in either valve will prevent the
    boiler from starting.
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 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. Not used.

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. Not used.

19. Building Combustion Air Interlock: Provide devices to prove 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. Not Used.

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. Not used.

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 Submaster Control Stations: Refer to Paragraph, AUTOMATIC BOILER AND BURNER CONTROL SYSTEMS. Units shall be flush mounted on panel front.

E. Not used.

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. Not used.

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.

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. Low feedwater pressure (1 function per header): Actuated by pressure switches on feedwater headers.

i. 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 i7 4770, 8 MB L3 cache, 3.4 GHz, 8 GB

DDR3 SDRAM memory ECC(2 DIMMS); dual hard drives each 1 TB 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, minimum 27 inch diagonal (nominal) screen with 4K Ultra HD capability of 3840 x 2160 pixels resolution and response time of 1ms. 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 with in 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).

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 scfh; gpm. 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) Boiler feed header pressure – each header, psi.

      12) LP igniter gas header pressure psi.

      13) 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.

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) 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. 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. Transmit flow data to computer work station.

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. 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. Meter shall be designed for natural gas at job site characteristics. Meters shall be RS-485 MODbus compatible with RS-485 two wire communication architecture.

    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 as follows with minimum accuracy one percent of flow rate over the entire range.

        a. Plant meters: 20/1.

        b. Boiler meters: 10/1.

    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:

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 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 main instrumentation 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 and 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 NOT USED.

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 1400 kPa 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, kPa/inches WC.

7. Oil pump suction: 100 kPa vacuum to 100 kPa/30 inches Hg vacuum to 15 psi.

8. Oil pump discharge: 0 to 1400 kPa/0 to 200 psi.

9. Oil burner, 125 percent of full load pressure, kPa/psi.

10. Feedwater pump discharge: 0 to 2100 kPa/0 to 300 psi.

11. Feedwater pump suction: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 30 psi.

12. Pumped condensate: 0 to 400 kPa/0 to 60 psi.

13. Condensate transfer pump discharge: 0 to 400 kPa/0 to 60 psi.

14. Condensate transfer pump suction: 100 kPa vacuum to 100 kPa/30 inches Hg vacuum to 15 psi.

15. Feedwater deaerator: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 30 psi.

16. 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 6 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. Transmit alarm signal to the

boiler plant Control Room. 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, adjustable.

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. Test gas for CO sensor shall be 50ppm. Test gas for combustible sensor shall be 10% LEL.

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. Not used.

B. Not used.

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 21, 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.

Safety and Control wiring shall be in separate cabinets and pathways from motor and load wiring.

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 - - -