

**SECTION 23 09 11
INSTRUMENTATION AND CONTROL FOR BOILER PLANT**

SPEC WRITER NOTES:

1. Delete between // // if not applicable to project. Also delete any other item or paragraph not applicable in the Section and renumber the paragraphs.
2. References to pressure in this section are gauge pressure unless otherwise noted.
3. Specification requirements are based on single burner boilers that operate on natural gas and/or fuel oil.
4. All references to pneumatic control components have been removed from this section. If working in existing plants where pneumatic systems are still existing and are to be reused, it is the design engineers' responsibility to add to these specifications all required pneumatic components.
5. Provide the year of latest edition to each publication listed in Article 1.3 APPLICABLE PUBLICATIONS.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. 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.
- B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. //Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.//
- E. //Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//
- F. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
- G. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

- H. //Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//
- I. //Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.//
- J. Section 23 10 00, FACILITY FUEL SYSTEMS.
- K. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- L. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
- M. Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.
- N. Section 23 52 33, WATER-TUBE BOILERS.
- O. Section 23 52 39, FIRE-TUBE BOILERS.
- P. Section 26 05 11, REQUIREMENTS for ELECTRICAL INSTALLATIONS.
- Q. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
- R. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- S. Section 26 27 26, WIRING DEVICES.
- T. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

SPEC WRITER NOTE:

1. Make material requirements agree with requirements specified in the referenced Applicable Publications. Verify and update the publication list to that which applies to the project unless the reference applies to all mechanical systems. Publications that apply to all mechanical systems may not be specifically referenced in the body of the specification, but, shall form a part of this specification.
2. Insert the year of approved latest edition of the publications between the brackets and delete the brackets // // if applicable to this project.

- 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. Where conflicts occur these specifications and the VHA standards will govern.
- B. International Committee for Information Technology Standards (INCITS):
154-//1988(S2019)//.....Office Machines and Supplies - Alphanumeric
Machines - Keyboard Arrangement
- C. American Society of Mechanical Engineers (ASME):
B31.1-//2020//.....Power Piping
B40.100-//2013//.....Pressure Gauges and Gauge Attachments
PTC 4-//2013//.....Fired Steam Generators
- D. National Electrical Manufacturers Association (NEMA):
ICS 6-//1993(R2016).....Industrial Control and Systems: Enclosures

WC63.2-//1996(R2003)//..Performance Standard for Coaxial Premise Data
Communications Cables

- E. National Fire Protection Association (NFPA):
 - 70-//2020//.....National Electrical Code
 - 85-//2019//.....Boiler and Combustion Systems Hazards Code
- F. Underwriters Laboratories Inc. (UL):
 - 508-//2018//.....Standard for Industrial Control Equipment
 - 1449-//2021//.....Standard for Surge Protective Devices
 - 1998-//2013//.....Standard for Software in Programmable
Components
- G. Department of Veterans Affairs (VA)
 - 2008.....VHA Boiler Plant Safety Devices Testing Manual,
Third Edition

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

SPEC WRITER NOTE: Complete pertinent project information on attached VA Form Past Performance Questionnaire and include with this section of specifications.
- D. Certificates of compliance with paragraph, QUALITY ASSURANCE of this section (subparagraphs 1.5.A, B, D & F). In addition, submit Past Performance Questionnaire (form attached) for five (5) past projects of the same class (scope & complexity) as this project.
- E. Submit information sufficient to verify compliance with all contract requirements as specified and shown on project drawings.
- F. Automatic Boiler Control and Burner Management and Safety Interlock Systems:
 - 1. Catalog cuts and specification sheets providing description and performance data on: Controllers, control and indicating stations,

sensors and transmitters, signal conditioners, electric switches and relays, indicators and annunciators, safety interlock devices, drive units and actuators, control valves, mechanical linkage systems, compressed air filters and regulators.

2. Statement from controller manufacturer that the type and model submitted is the current generation and that the manufacturer will support the units with parts and service for at least ten years, and that the equipment submitted meets all VA specifications.
3. Information on all the specific systems that is sufficient to allow complete troubleshooting. As a minimum, this should include explanation of the control logic, and wiring diagrams of equipment and systems to include locations and wire numbers of all safety device test points that will be required to complete safety device testing in accordance with VA requirements, and sequence of operation of all components of the system.
4. Hardware systems schematics showing field and panel equipment interface block diagram.
5. Location of interlock devices on the burners, boilers, fuel trains and accessory equipment, all safety devices shall be easily accessible for testing...

G. 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. Paper chart recorders are prohibited.
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.

H. 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.

SPEC WRITER NOTE: Delete the following paragraph if not applicable.

4. //Seismic restraint design data for freestanding instrument or control panels. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//
- I. 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.
- J. As-built Logic and Wiring Diagrams: One set of reproducible prints and CAD disks delivered to COR prior to turning systems over to VA for operation. Supply revised drawings if changes are made during the startup and commissioning process.
- K. 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).
- L. Pressure Gauges and Thermometers:
1. Catalog cuts showing design, construction, dimensions of gauges and accessories.
 2. Accuracy.
 3. Pressure and temperature limitations of gauges and accessories.
 4. List of scale ranges to be provided.
- M. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation, and maintenance.
- N. //Completed System Readiness Checklist provided by the CxA 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.//
- O. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

1.5 QUALITY ASSURANCE

- A. The boiler and burner control, monitoring, data gathering, instrumentation and associated systems specified in this section shall be provided by one company that has been in business at least three years engineering, designing, and servicing industrial and institutional boiler control and instrumentation systems similar to those specified herein, as a primary business. That company shall furnish all components and provide complete calibration, programming, start-up, testing, demonstrations, instructions, and training services.
- B. Submit documented evidence, including start-up and acceptance test data, and references, that the company has performed satisfactory work on at least six systems similar to those specified, list any VA boiler plant projects completed in the past. For instance, submit experience information on systems involving parallel positioning combustion control and on variable speed forced draft fan drives, if these systems are specified. Submit in writing that all specifications were read and fully understood.
- C. If new burners are part of the contract, the burner manufacturer shall be responsible for the burner management system (flame safeguard), including interlocks, all accessories and for coordination with other control and monitoring systems.
- D. Equipment Experience Requirements: Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
- E. Code Approval:
 1. All burner management and combustion control systems and devices shall comply with NFPA 85, regardless of boiler type or size. Locations and arrangements of safety devices on fuel trains shall

- comply with diagrams included in "Annex A" in the code, as modified by the VA standard details and the VHA Boiler Plant Safety Devices Testing Manual 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.
 6. The use of wire nuts is prohibited. All wire connections must be made at terminal blocks and terminal strips.
 7. The use of liquid tight or other flexible conduit systems is limited to 900 mm (3 foot) in length unless longer runs are required for door swings or other equipment access.
 8. All wire runs are required to be in conduit.
- 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.

1.6 AS-BUILT DOCUMENTATION

SPEC WRITER NOTE: Coordinate O&M Manual requirements with Section 01 00 00, GENERAL REQUIREMENTS. O&M manuals shall be submitted for content review as part of the close-out documents.

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be //in electronic version on CD or DVD// inserted into a three-ring binder. All aspects of system operation and maintenance

procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

SPEC WRITER NOTE: Select and edit one of the bracketed options after the paragraph below to indicate the format in which the contractor must provide record drawing files. Select the hand-marked option only when the designer has been separately contracted to provide the record drawings from the contractor's mark-ups. Select the BIM option only when a BIM model will be generated, which is typically only performed by the designer on some Design-Bid-Build projects or by the contractor on some Design-Build projects.

- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
1. //Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.//
 2. //As-built drawings are to be provided, with a copy of them on AutoCAD version // // provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.//
 3. //As-built drawings are to be provided, with a copy of them in three-dimensional Building Information Modeling (BIM) software version // // provided on CD or DVD.//
- D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and

pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

- E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

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 programmable logic controllers (PLC).
2. Controllers shall be manufactured separate from and shall be separate assemblies, in a separate electrical cabinet from the Burner Management (Flame Safeguard System).
3. Control functions:

SPEC WRITER NOTE: Edit the following list of control functions to suit the project requirements.

- a. Control of burner firing rates to maintain steam header pressure.

SPEC WRITER NOTE: Oxygen trim can be included with parallel-positioning systems at minimal additional cost since there is no additional hardware.

- b. Parallel-positioning combustion control (air/fuel ratio, excess air) //with flue gas oxygen trim//.

SPEC WRITER NOTE: Jack-shaft combustion controls can be used for new fire-tube boilers less than 300 bhp.

c. //Jack-shaft type combustion control (fuel/air ratio).//

SPEC WRITER NOTE: FGR shall be required only where localities require low NOx emissions.

d. Flue gas recirculation (FGR).

SPEC WRITER NOTE: Boiler outlet draft control required only on installations with common flue gas breeching among boilers and tall chimney.

e. Boiler outlet draft.

SPEC WRITER NOTE: Utilize one element water level system on fire tube boilers, two elements system on D-type water tube boilers, three elements system on flex-tube boilers with small diameter steam drums 600 mm (24 inches) diameter and less.

f. Boiler water level, //1// //2// //3// element system.

4. Control features:

SPEC WRITER NOTE: The requirement for touchscreens is the option of the VAMC.

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, and signal to actuator, process status and controller status. Touch screens have additional display requirements; refer to the following paragraph.

b. Provide separate dedicated controllers/panels for each boiler and for the master steam pressure control. Fuel/air control loops, including FGR and oxygen trim shall be incorporated into one station for each boiler. Boiler/economizer outlet draft and boiler water level control shall have separate stations for each item on each boiler. //All control items for one boiler shall be shown on one touchscreen for that boiler. Each boiler shall have its own touch screen located in the panel for that boiler.//

c. VA Boiler Plants PROHIBIT any boiler to be automatically or remotely started and lead lag control systems are prohibited within the VA boiler plants, regardless of the size or type of boiler. The boiler shall be started by an operator standing at the boiler.

SPEC WRITER NOTE: The requirement for VFDs is the option of the VAMC based on cost effectiveness.

- d. Variable frequency drives on forced draft fan motors.
- 5. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES for burner management controls.

SPEC WRITER NOTES:

1. The controllers specified are non-proprietary. These controllers, when they become obsolete, often can be replaced by those of another manufacturer and can be serviced by any properly trained controls technician.
2. The system specified is a separate control "platform" from the burner management system. This simplifies the control arrangement, servicing, and testing.

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 percent analog inputs and outputs.
2. Resolution: 16-bit input and output.
3. Environment: 0 to 50 degrees C (32 to 122 degrees F), 15 percent to 95 percent 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 to 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 COR.
 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"; Toshiba "LC500"; and Fireye Nexus "PPC 4000". All controllers with integrated flame safeguard are prohibited.
- C. Power Supplies: Provides 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.
- SPEC WRITER NOTE: Include the following paragraph if touch screen operator interface is required.
- 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 Supervisory Control and Data Acquisition (SCADA) program on computer work station.
 - d. Multiple RS485 Modbus communication interfaces.
 - e. Field-replaceable backlight, real-time clock, battery-backed clock time stamps critical data, 8 MB on-board flash application memory, 512 MB memory-card, application expanded memory-card for historical, alarm and event storage, resistive analog touch screen with free formable to fit target shape.
 - f. Operation interaction shall be touch-based allowing easy selection of screens, manual/automatic status changes, start/stop functions, set point changes, output changes and PID tuning parameters without any special programming skills. Screen selection shall also be available through tactile feedback function keys.
 - g. Show facsimiles of each controller and clearly labeled English language and engineering unit display of the control parameters.
 - h. Graphic X/Y curve data plotting capability. When used in conjunction with fuel/air ratio control, provide automated fuel/air ratio curve and oxygen trim set point curve adjustment for rapid, error free burner tune-up. Only a single operator action shall be required to store commissioning data into multiple characterizer curves for a particular load point.
 - i. Configuration software Microsoft Windows based. Provide all necessary software to allow field modification or expansion of the system including graphics drawing programs and data base builders. Systems based on "run time only" programs are prohibited.
- 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 percent.
 - 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 prohibited to perform this function within the VA. Belt-type drive units are prohibited.
 - 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. Plastic gears of any kind are prohibited.
4. Boiler outlet damper drive units may be different model than drive units for fuel valves and forced draft damper. Drive units shall be capable of 136 Nm (100 ft-lb.) torque minimum. Less powerful drive units may be utilized if certified as adequate by the burner manufacturer.

SPEC WRITER NOTE: Variable frequency drives shall be applied on forced draft fans if cost effective. 15 hp and less should be carefully evaluated. Forced draft fan damper will be utilized in conjunction with the variable frequency drive and will control the air flow at lower firing rates.

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

1. Refer to Section 26 29 11, MOTOR CONTROLLERS, 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. The minimum speed is limited to 40 Hz.
2. Provide feedback system including motor speed and direction of rotation to combustion controller. Feedback transmitter will have no-drift guarantee. Feedback system shall not be affected by position of HOA 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 to 100 percent.
 5. Provide constant speed feature and operator-selectable air/fuel program in the controller for constant speed operation maintaining specified air/fuel ratios at all firing rates or positions (excess air).
 6. Forced draft fan damper operation is required in conjunction with operation of the VFD at the lower firing rates.
 7. Provide a means of proving fan RPM to control set point at any firing rate. Deviation from set point RPM or greater than 10 percent will cause a safety shutdown of the boiler. As an option the contractor may install a fully metered system where air flow is proven at all firing rates and a shutdown will occur if the airflow varies by greater than 10 percent.
- G. Transmitters: See paragraphs, PRESSURE SENSORS AND TRANSMITTERS and TEMPERATURE SENSORS AND TRANSMITTERS.
- H. Final Control Elements:
1. Fuel flow control valves, forced draft fan dampers, FGR dampers (if provided), variable frequency forced draft fan drives (VFD) (if provided), feedwater control valves: Refer to //Section 23 52 39, FIRE-TUBE BOILERS// //Section 23 52 33, WATER-TUBE BOILERS//.
 2. Dampers in stacks and breechings: Refer to Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.
- I. Uninterrupted Power Supplies:
1. Provide separate complete protected power conditioners for each boiler control and for master control. Power supply shall protect all computers, controls, instruments, and accessories from damage due to ground leakage, spikes, sags, surges, transients, and overloads in the incoming power supply.
 2. Line interactive, UL 1449 rated, interactive digital display. Automatic internal bypass. Smooth sine wave output.
 3. Suitable for ambient temperature of 43 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 60 second period. System oscillations shall be minimal. Set point // // kPa (// // psig). //Second set point // // kPa (// // psig).// Individual set point adjustment range: +/- 138 kPa (20 psig).
 - 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.

SPEC WRITER NOTE: Edit the following to include or exclude reference to fan speed depending on whether VFD will be provided on forced draft fans.

- 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.

SPEC WRITER NOTE: Edit the following to include or exclude reference to fan speed and outlet dampers depending on whether VFD will be provided on forced draft fans and whether boiler outlet dampers will be provided.

- f. Interlocks to prove proper positions of forced draft fan damper//, forced draft fan speed// //, boiler/economizer outlet damper//, and fuel flow control valves for ignition and running cycles. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) 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 greater than 138 kPa (20 psig) 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):
- SPEC WRITER NOTE: Include variable frequency drive for the forced draft fan if required for the project.
- 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 by the controller manufacturer only, for the specific application. Only tuning and scaling shall be performed in the field. Any and all other field adjustments are prohibited.
 - b. Hardware, firmware, and software shall comply with UL 1998. 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 shutdown 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 or time to the Government. Only tuning and scaling shall be performed in the field. Any and all other field adjustments are prohibited.

- 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 prohibit 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 shutdown 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 percent control position shall be 20 percent firing rate (20 percent 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 shall be minimized and submitted for approval as a deviation to the contract.
- i. Excess Air and Emissions Limits - New Burners: Refer to the boiler and burner specification.
- j. Excess Air and Emissions Limits - Existing Burners:

SPEC WRITER NOTE: Revise the following excess air requirements as necessary to

suit the capabilities of the existing burners.

- 1) Minimum excess air at all loads: 15 percent
- 2) Maximum excess air at 20 to 39 percent of maximum firing rate: 35 percent
- 3) Maximum excess air at 40 to 100 percent of maximum firing rate: 25 percent
- 4) Consult COR if flue gas carbon monoxide will exceed 200 ppm within the excess air limits specified above.

SPEC WRITER NOTES:

1. Oxygen trim must be provided for low excess air burners (operating at less than 10 percent excess air). The purpose is to automatically prevent excess air from dropping below safe levels due to changes in air density, fuel pressures or other factors.
2. Oxygen trim is normally applied on parallel positioning systems because no additional hardware is needed to implement it.

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 prohibited. 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 ppm at any time.
 - 3) At firing rates less than 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.

SPEC WRITER NOTE: FGR is applied only when low-NOx burners are specified.

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 149 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 (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

SPEC WRITER NOTE: Outlet draft control must be provided for boilers that exhaust into a stack/breeching system that will cause the outlet draft to vary significantly. An example is a common breeching system serving multiple boilers that discharges into a single tall stack. The tall stack will create a significant draft that will vary with outside temperature and with the firing rates (varying stack temperatures) of the connected boilers.

5. Boiler Outlet Draft Control:

- a. Automatically modulate position of boiler or economizer outlet damper to maintain constant negative pressure (draft) at the flue gas outlet of the boiler. Utilize feed forward signal from the boiler/burner submaster air/fuel controller to enhance control response. Position damper open and closed during boiler start-up and shut-down cycles.

- b. Maintain draft at negative 25 Pa (0.1 inches WG) plus or minus 10 Pa (0.05 inches WG). Provide local gauge with remote indication at operator interface.
 - c. Panel-mounted automatic controller, with manual/automatic feature and set point adjustment, for each boiler. Locate on main instrumentation panel unless otherwise shown.
 - d. Draft sensor, transmitter, and outlet damper actuator for each boiler. Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS.
 - e. Automatically position damper as required for pre-purge, burner ignition and shutdown. Provide damper position switch interlocked with burner management system. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
6. 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.
 - 2) Two-Element System: Utilize boiler steam flow signal and boiler water level signal. Adjustable signal gain. Provide single-element (drum level) operation from low fire to 20 percent of maximum boiler load. Provide automatic switchover from single-element to two-element operation.
 - 3) Three-Element System: Utilize boiler steam flow signal, boiler water level signal and boiler feedwater header pressure signal. Adjustable signal gain. Provide single-element (drum level) operation from low fire to 20 percent of maximum boiler load. Provide automatic switchover from single-element to three-element operation and vice-versa at 20 percent load.

- c. Boiler Water Level Sensors:
- 1) Differential Pressure Transmitters: Provide on water tube boilers. Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS.
 - 2) Water Level Sensing and Safety Control Systems: Provide on fire tube boilers. Refer to Section 23 52 39, FIRE-TUBE BOILERS.
 - 3) Probe-Type Capacitance Systems: Optional control for fire tube and water tube boilers. Dual probes mounted in water column controlled by microprocessor system. Provisions to compensate for shrink and swell of water level due to load changes. Self-checking function comparing the signals from each probe and causing burner shutdown if water level movement is not detected.
- d. Steam Flow Sensors: Refer to paragraph, FLOW METERS.
- e. 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.
7. Boiler and Economizer Efficiency Calculation and Display: If not provided on the computer workstation, 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, HEAT LOSS EFFICIENCY form, with no consideration for boiler radiation and unaccounted losses.

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

SPEC WRITER NOTES:

1. The system specified is a separate control "platform" from the boiler operating controls specified in

paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD). VA requirements for regular testing of burner control devices favors this control arrangement.

2. Combined burner management and boiler control systems are offered by some boiler control specialty manufacturers. They have features that make the VA test procedures more difficult and less effective.
- A. Complete automatic safety control and monitoring system for burner ignition sequencing, operating cycle, and shut-down sequencing. System shall include microprocessor programmer, self-checking ultraviolet (UV) flame scanner and amplifier, burner cycle display, first-out diagnostic annunciation display, burner safety shutdown 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 VHA Boiler Plant Safety Devices Testing Manual.
1. Controller shall be manufactured separately from the Burner Control System controller.
 2. Controller shall be a separate and individual assembly from any other controller.
 3. Controller shall have its own mounting and wiring base to permit the controller to be replaced without disturbing any wiring or other components.
- B. Code Compliance: Conform to NFPA 85. All components UL listed, FM approved.
- C. Operate on 102 to 132 volts; 60 Hertz ac. Operating ambient temperature range 0 to 52 degrees C (32 to 125 degrees F).

SPEC WRITER NOTE: VA requires self-checking ultraviolet (UV) flame scanners. Newer types of infrared (IR) flame scanners and amplifiers that "learn" unique flame characteristics and reject background radiation can be accepted for burner types and fuels for which UV has proven to be unreliable.

- D. Flame Scanners: Provide self-checking ultraviolet (UV) scanners. 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 shall be non-reflective to avoid the scanner detecting the reflection of the ignition spark. UV non-self-checking scanners are prohibited because they can fail in an unsafe mode on continuously operated burners.
- E. Control Features:
1. Automatic recycling on high steam pressure only.
 2. Interrupted ignition.
 3. Electronically prevent UV scanner sensing ignition spark. Methods include early spark termination or by phasing the firing of the ignition spark off cycle from the scanner activation.
 4. Flame failure response time four seconds maximum.
 5. Ten seconds trial for ignition except 15 seconds permitted on heavy oil fuel.
 6. Pre-purge timing set for 4 air changes on fire tube boilers and 8 air changes on water tube boilers per NFPA 85. The exact timing will 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. Once purge time has been determined and set it becomes burnt into the program and cannot be changed.
- 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 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 VAMC DDC control system.//
- I. Burner cycle indication on face of panel: Separate display from the touch screen. Show instantaneous status of startup, run and shutdown

program. Provide indicator for control power on, ignition, main fuel valve open, and flame failure.

J. Reset button on face of panel. Separate display from the touch screen.

K. Annunciator Display and Alarm:

1. Separate display from the touch screen.
2. Locate display on outside face of panel between 1200 mm and 1500 mm (4 feet and 5 feet) above the floor.
3. 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.
4. Indicate burner status in English messages: control on, pre-purge, trial for ignition, igniter flame signal, main flame signal, post purge, burner off.
5. Continuously indicate flame signal strength.
6. Provide first-out annunciation, including English language message, and audible alarm (horn) for each of the following interlocks:
 - a. Flame failure.
 - b. Purge airflow low.
 - c. Combustion air low.
 - d. False combustion air (switch activated with combustion air flow).
 - e. High main gas fuel pressure.
 - f. Low main gas fuel pressure.
 - g. High oil pressure.
 - h. Low oil pressure.
 - i. Low igniter (pilot) gas pressure.
 - j. Low oil temperature (heated oil systems only).
 - k. Fuel safety shut-off valves not closed prior to ignition cycle.
 - l. Low fire position not attained prior to ignition cycle.
 - m. Low atomizing media (steam or air) static pressure at atomizing media service connection to burner piping.
 - n. Low atomizing steam/oil differential pressure. Where burner does not maintain differential pressure provide low atomizing media pressure at burner.
 - o. High steam pressure.
 - p. Low water cutoff.
 - q. FGR (if provided) improper damper position.
 - r. Low flue gas oxygen.
 - s. High furnace pressure.

- t. Building combustion air intake louver closed or make-up air ventilation system not operating.
- 7. 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 shutdown and manual reset required for, but not limited to:
 - 1. Flame signal detected prior to ignition cycle.
 - 2. Pre-ignition interlock open during pre-purge.
 - 3. High fire purge interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to high fire.
 - 4. Low fire interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to low fire.
 - 5. Igniter (pilot) or main burner fails to ignite.
 - 6. Malfunction of flame detector.
 - 7. Malfunction of programmer.
 - 8. Malfunction of flame signal amplifier.
 - 9. Combustion air proving switch actuated prior to start-up of forced draft fan.
 - 10. Lock-out interlock open during pre-purge (after 15 seconds), ignition or run period.
 - 11. Interlock open.
 - 12. Flame failure.
 - 13. Building combustion air intake louvers closed or make up air ventilation system not operating.
- P. Burner Safety Shutdown Interlock Devices:
 - 1. Basic Requirements:
 - a. Adjustable Set Points.
 - b. Maximum Set Point Deviation: 5 percent of full scale.
 - c. Minimum Repeatability: 2 percent of full scale.
 - d. Minimum Set Point Accuracy: 10 percent of full scale or 20 percent of set point.

- e. Scale range shall allow set points to be within 30 to 70 percent 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 safeguard 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 gauges, 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. All test points shall be easily accessible from the floor or permanent work platform without the use of step ladders.
 - b. All override switches for testing of interlocks shall be non-latching, push to test, and spring-loaded release when not being manually held in.
 - c. 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. Wiring should be done in a manner that allows for ease of access with minimal PPE as required by NFPA 70.
 - d. Safety devices are prohibited to be PLC dependent or be included in any program where the input or output can be forced, or if the program is changed, updated, etc., could have any effect on the safety device setting or function. All safety devices shall be hard wired from the device or sensor to the flame safeguard controller directly. Wiring shall pass through terminal strip(s).
 - e. Provide all necessary control system passwords, wiring diagrams, and step-by-step written instructions specific to that facility to COR to facilitate all interlock testing required by the VHA Boiler Plant Safety Devices Testing Manual. The written

instructions shall include terminal and wire numbers for specific test where required.

- f. If the system installed cannot be tested in accordance with the VHA Boiler Plant Safety Devices Testing Manual the contractor shall provide a written step by step safety device test procedure(s) for the devices(s) that follow and meet the intent of the VHA Boiler Plant Safety Devices Testing Manual, submitted to VA CFM CSS and VHA HEFP for review and approvals. The Government reserves the right to reject any procedure and require the system device be replaced at no addition cost or time to the Government.
3. Forced Draft Fan Motor Operation Interlock: Provide split ring current relays on each phase of power circuits to fan motor, required on all systems.
 - a. Provide a separate NEMA 4 cabinet for the current relays. The high voltage lines only pass through this cabinet with no exposed wires or terminal points. The only terminal points are for the control wiring or the current relays.
 - b. 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. Contractor to provide test procedure for review and approval.
 - c. Fully metered systems that measure and prove actual air flow at all firing rates shall be used as a substitution. The contractor shall provide test procedures to prove the burner shuts down if proper air flow is not maintained or achieved. The procedures shall be reviewed and approved by VA CFM CSS and VHA HEFP.
 - d. Any disconnects or other power shut-off devices between the location of the interlock devices and the motor shall also shutdown the power supply to the burner management control system.
 4. Atomizing Air Compressor (when provided) Motor Energized Interlock:
 - a. Provide split ring 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.

- b. Provide push buttons to test each leg of the fan motor leads. The push buttons shall be mounted on the face of the cabinet, momentary contacts, and wired in parallel with the current relays. The current drop through the current relay when the push buttons contacts are closed shall trip the burner off at any firing rate.
5. Forced Draft Fan Damper, Boiler or Economizer Flue Gas Outlet Damper (if provided) Pre-Purge Position Interlock: Prove dampers wide open for pre-purge. Actuate sealed snap-action switches by levers attached directly to dampers or to damper linkages, which are pinned to prevent slippage. Parallel positioning systems may have the interlock switches in the drive units. The switches are dedicated for the flame safeguard system and perform no other function or purpose and are make or break switches.
6. 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 shall be no intervening dampers. This is typically between the wind-box and boiler outlet.
 - b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.
 - c. UL listed, FM approved.
 - d. Provide air pressure sensing connections for test manometer so that air flow switch settings can be verified.
 - e. Trip point shall prove at least 80 percent of maximum airflow.
8. Combustion Air Proving Interlock:
 - a. Sense differential air pressure across the forced draft fan with no intervening dampers.
 - b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.

- c. UL listed, FM approved. Provide switch designed for "false combustion air" feature on start-up interlock.
 - d. Provide air pressure sensing connections for test manometer so that switch settings can be verified. Demonstrate that trip point is within 10 percent 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. Approvals: UL listed, FM approved assembly.
 - b. Snap acting 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.
 - c. Gas pressure switch ratings: Sustained pressure capability shall exceed two times lock-up of nearest upstream regulator.
 - d. 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.
 - e. Low gas pressure switches shall include integral impulse dampener to reduce the effects of pressure dips during start-up. Use of external dampeners or snubbers is prohibited.
 - f. 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.
 - g. Set points shall be within 20 percent of the normal operating pressure.
 - h. High pressure switches shall be piped to the service with lockable isolation valve and valved test connection so that switch can be set and tested using compressed air.
10. Low Oil Temperature Interlock (Heated Oil Only):
- a. Type: Solid-state sensor or sealed snap-acting switch, automatic reset. Provide graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirement either on the switch or as part of the controller.
 - b. Ratings: Sustained temperature capability shall exceed maximum oil temperature requirement.
 - c. Approvals: UL listed.

- d. Location: Ahead of safety shut off valves.
11. Low Atomizing Media Pressure, Differential Pressure and Flow Interlocks:
- a. Type: Snap acting switch, graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements, automatic reset.
 - 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, and FM approved.
 - e. Locations and types of switches on atomizing media piping: Two switches required for each burner, a static pressure switch on atomizing media supply ahead of differential pressure control valve, and differential pressure flow switch with flow meter orifice on atomizing piping adjacent to burner. On burners that maintain an approximately constant differential pressure between the atomizing steam and oil, provide a steam/oil differential pressure switch instead of the flow switch at the oil burner. Burners with individual air compressors for air atomization shall be provided with one air pressure switch and compressor motor interlocks as specified above.
12. Main Fuel (Gas and Oil) Automatic Safety Shut-Off Valves Proof-Of-Closure (Over Travel) Interlocks. Provide on all automatic safety shut off valves to prove closure prior to igniter (pilot) ignition. Provide manually-actuated test circuits through the proof-of-closure switches that will demonstrate that the switches close and open properly and that the circuit is connected to the burner management system.
13. Low Fire Position of Fuel Flow Control Valves Interlocks: Sealed snap-acting switches. Actuate switches by levers attached directly to fuel valves. As an option, the switch lever may be pinned to the jackshaft to which the fuel valve proportioning cams are also pinned or provide UL listed and FM approved position sensor (internal snap acting switches within the actuator a feedback signal will not act as any part of this safety device.) on the motor which positions the jackshaft to which all the operating levers are pinned.

14. High Boiler Steam Pressure Limit and Interlock: Operating limit switch allowing burner recycling and safety shutdown interlock switch. Refer to paragraph, BOILER TRIM, in //Section 23 52 39, FIRE-TUBE BOILERS// //Section 23 52 33, WATER-TUBE BOILERS//. On hot water boilers provide dual high temperature limit aquastats. The first low setting will alarm the boiler operator and the second high setting will turn off the boiler.
 15. Low Boiler Water Level Interlocks: Primary and auxiliary low water burner shutdown interlocks. Refer to paragraph, BOILER TRIM, in //Section 23 52 39, FIRE-TUBE BOILERS// //Section 23 52 33, WATER-TUBE BOILERS//. Operation of auxiliary low water cutoff shall interrupt the power supply to the burner management control system. On hot water boilers provide dual prove flow devices wired in series so that either device will turn off the boiler and alarm the boiler operator. The devices shall be of two different types, i.e. flow switch and pressure differential transducer. Series wiring will not take place at the devices; it shall take place at the control panel terminal strip so that it can be wired for independent confirmation of failed device.
 16. Low Flue Gas Oxygen Alarm and Interlock: Signals from flue gas oxygen analyzer providing low oxygen alarm and low oxygen burner shutdown. Refer to paragraph, FLUE GAS OXYGEN ANALYZERS.
 17. High Furnace Pressure Interlock:
 - a. Sense static pressure in furnace.
 - b. Diaphragm-actuated snap-action switch, adjustable set point, set point indicating scale, designed for maximum system pressure.
 - c. UL listed, FM approved.
 - d. Connect to the service with a lockable isolation valve and valved test connection to allow the switch to be set and tested with pressurized air source.
 18. Building Combustion Air Intake Interlock: Provide devices to prove outside air building wall louvers are open or H&V unit is in operation.
- Q. Automatic Programming Sequence:
1. After personnel select the fuel to be burned and operate the burner start switch, the control system shall automatically perform the following operations:

2. Prove proper operation of all interlocks except purging interlocks or prevent further progress.
 3. Open all air dampers fully. This includes all dampers in the boiler outlet breeching and stack system.
 4. Position FGR damper (if provided) as required by burner manufacturer to purge flue gas from recirculation duct.
 5. Prove 80 percent of maximum air flow through the boiler and prove all air dampers open wide and FGR 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. Retain outlet damper wide open. If outlet draft damper modulating control system is provided and excessive draft due to wide-open damper is incompatible with the burner, automatically position the outlet damper to an acceptable position for burner ignition.
 9. Prove low fire start position.
 10. Sensing of flame prior to this shall cause shutdown.
 11. Energize igniter and open igniter fuel automatic safety shut-off valves. Prove igniter flame in ten seconds or provide shutdown.
 12. On systems with ultraviolet flame scanners, terminate ignition spark five seconds before main fuel valves open.
 13. Open main fuel safety shut-off valves for fuel selected. Close igniter fuel valves within ten seconds after main fuel valves open (15 seconds on heated oil).
 14. Prove main flame or provide shutdown.
 15. Place FGR damper (if provided) in modulating or in fixed position as required by design of burner furnished.
 16. If provided, release boiler/economizer outlet draft control damper to modulation.
 17. Release burner from low fire position to automatic or manual firing rate control.
 18. Provide 15 second post purge at end of burner firing cycle.
 19. Close all dampers upon completion of post purge.
- R. Spare Parts:
1. One flame control programmer chassis complete.
 2. One flame control amplifier complete.

3. One flame scanner complete with connecting leads.
4. Twelve lamps for each type of replaceable lamp.
5. Two of each type of relay and timer.

2.3 MAIN INSTRUMENTATION AND CONTROL PANEL

SPEC WRITER NOTE: Master steam pressure control function is usually located on the main panel. Individual boiler control stations may be located on the main panel or on the individual boiler control panels. Burner management controls should be on the individual boiler/burner control panels.

- 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 4 rating. Refer to drawings for arrangement and overall dimensions.
- B. Panel Construction:
 1. Minimum 3.5 mm (0.14 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-volt GFI receptacle inside the panel.
 7. Provide fan-type or panel mounted air-conditioning units for ventilation as necessary to protect equipment from overheating. The internal panel temperature shall be maintained at 32 degrees C (90 degrees F) or less. Assume boiler room temperature of 38 degrees C (100 degrees F). Compressed air coolers are prohibited.

- C. Master Steam Pressure Control Station: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD). Unit shall be flush mounted on panel front.
- D. Boiler/Burner Submaster Control Stations: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD). Units shall be flush mounted on panel front.

SPEC WRITER NOTE: Recorders and temperature indication devices are not needed if computer workstation programming provides these functions.

- E. Recording Systems: Refer to paragraph, RECORDERS.
- F. Touch Screens: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD).
- G. Pressure Gauges: 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 gauge cock within panel for each gauge. Provide gauges for steam header pressure, boiler feed header pressure for each boiler, fuel header pressures.

SPEC WRITER NOTE: List the number and function of each push button station and indicating light.

- H. Push Button Stations and Indication Lights for Pump Control: Refer to Section 26 29 11, MOTOR CONTROLLERS. Lights shall be oil-tight, standard industrial construction, 120 volts, 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.

SPEC WRITER NOTE: Indicator system is not needed if this data is on a computer workstation.

- I. Boiler Economizer Temperature Indicator Systems:
1. Resistance Temperature Detectors (RTD) system measuring temperature at four points: feedwater in and out, flue gas in and out. Separate indicators graduated -18 to 315 degrees C (0 to 600 degrees F).
 2. Accuracy: Plus or minus 5 degrees F.
 3. Mounting: Mount indicators on instrumentation panel.

4. Include Modbus communication with computer workstation (present or future).
5. Pressure gauges on feedwater, in and out.
6. Thermometers at four points; feedwater in and out, and flue gas in and out.

J. Annunciator:

1. Provide system for monitoring alarm functions listed below.
Annunciator shall include alarm lights, alarm bell, integral test and acknowledge push buttons. Include Modbus communications for use with computer workstation.
2. Type: Multiple rectangular back-lighted windows on which alarm functions are engraved; separate window for each function. Provide test and acknowledge controls. All alarm lights shall operate independent of the PLC or if PLC fails all indicator lights will still function.
3. Construction:
 - a. Window Size: 45 x 75 mm (1-3/4 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.

SPEC WRITER NOTE: List other alarm systems as applicable such as emergency generator malfunction, medical gases and medical vacuum. Provide the necessary input/output modules (I/O) for the other alarm systems.

- 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 276 to 1241 kPa (40 to 180 psig), 34 kPa (5 psig) 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/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD).
 - 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 6.9 to 69 kPa (1 to 10 psig), emergency rating 30 psig.
 - h. Fuel Oil Temperature - High and Low (Heated Oil Only): Actuated by temperature switches located on the fuel oil header. Automatic reset, adjustable set point and dead band, UL listed, set point range 10 to 65 degrees C (50 to 150 degrees F). UL listed, removable without draining system, set point indicator.
 - i. Low feedwater pressure (1 function per header): Actuated by pressure switches on feedwater headers.
 - j. Input/Output (I/O) Modules: Provide 20 percent (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, control room, and at all

personnel doorways, or routes of egress from the operating floor. The shut-off shall shutdown the main and igniter emergency safety shut-off valves from power source on the natural gas, and shutdown all other fuel sources. Turn off the fuel oil pumps. Valves shall remain closed and pumps remain off when switch is pulled out. Shall require a manual reset or restart.

SPEC WRITER NOTE: Remote registers are not needed if this information is available at the computer work station.

- L. Remote Registers for Fuel Meters: Refer to paragraph, FLOW METERS.
- M. Clock: Microprocessor-driven digital, 65 mm (2-1/2 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 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS and CABLES.
 - 4. Piping: Stainless steel tubing, securely mounted, terminate in fittings at top of the cabinets.

SPEC WRITER NOTE: Delete the following paragraph where not applicable.

R. Spare Parts Required:

1. Lamps: Six of each type in panel and instruments.
2. Touch-up paint for panel: One pint.

S. //Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//

2.4 BOILER/BURNER CONTROL PANELS

SPEC WRITER NOTE: Control panels for fire tube boilers and flex-tube multi-pass water tube boilers are typically boiler-mounted. Panels for D-type water tube boilers are typically free-standing.

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 //freestanding// //boiler-mounted//.

B. Panel Construction:

1. NEMA ICS 6, Type 4. Freestanding panels shall be minimum 3.5 mm (0.14 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 or panel mounted air-conditioning units for ventilation as necessary to protect equipment from overheating. The internal panel temperature shall be maintained at 32 degrees C (90

degrees F) or less. Assume boiler room temperature of 38 degrees C (100 degrees F). Compressed air coolers are prohibited.

- C. Burner Management System with Annunciator: See paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
- D. Boiler Control Stations or Touch Screens, burner management displays and resets: See paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD) and paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
- E. Draft Gauges: See paragraph, BOILER DRAFT GAUGES.
- 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 shutdown annunciator specified above may be used. Standard water level alarm display of water level control manufacturer may be used.
 - 3. Alarm bell: 150 mm (6 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 previous paragraph).
- 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 and numbered at both ends. Wiring in series from one safety device to the next device is prohibited at the devices. Series wiring will take place at the terminal strip in the main cabinet.
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, and 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.

SPEC WRITER NOTE: Edit computer specifications to current professional-level technology.

2. Desktop Computer: Comply with requirements published by SCADA software supplier for optimum performance of software furnished. System shall include hardware as recommended by Microsoft for installation of Windows 10 operating system. Minimum requirements are Intel Xeon processor, 8 MB L2 cache, 2.4 GHz, 1066 FSB; 16 GB 600 MHz DDR2 SDRAM memory ECC (2 DIMMS); dual hard drives each 400 GB SATA, Nvidia QUADROFX4400 512 MB graphics, DVD+/-RW optical drive, integrated gigabit Ethernet, sound card, 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, 483 mm (19 inch) diagonal (nominal) screen with capability of 1600 by 1280 pixels resolution, non-interlaced, dot pitch 0.31 maximum. Minimum of True 16bit colors supported. Energy-Star compliant.
4. Keyboard: ASCII standard, QWERTY-style, enhanced 101-key consisting of at least 32 dedicated function keys and a 12-key numeric data entry section. Keys shall have tactile feedback and be permanently and clearly labeled. In addition, a set of arrow keys shall be provided for moving from the current screen of data to "next screen". Function keys shall have custom legends for each key to allow report generation, graphic display selection, alarm silencing, and data retrieval with single keystrokes. Provide removable continuous Mylar faceplate to exclude dust and spills.
5. Mouse: The operator interface shall minimize the use of the typewriter style keyboard through the use of a mouse and "point and click" approach to menu selection. Users shall be able to access features of the program from graphical displays through the use of the mouse.
6. Alarm Printer: Impact printer, 9-pin dot-matrix type. The printer shall have a minimum 96-character ASCII character set based on ANSI INCITS 154. The printer shall have tractor feed with adjustable sprockets for paper width up to 381 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 (1 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 dB(A) 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 762 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 shall 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 shall display the number of new messages, retries, time-outs, and any occurrences of error.
9. The system shall 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 shall support tiling and cascading. Tiling shall have horizontal and vertical support and no overlapping when the graphic screens are viewed.
 - d. Size shall be based on logical units; not pixels and any logical unit shall 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 shall 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 shall be performed on objects or groups of objects shall 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 pre-built line makers and a customizable line marker.
- k. Dynamic properties for objects shall 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 shall support configuration from a dialog box, pop-up menu and user customizable dialog boxes or forms. Positioning property changes shall support a method to get screen coordinates and automatically fill in the required coordinates for positioning. The user customizable dialog boxes or forms shall be customizable through VBA. The system shall 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 shall allow for bitmaps created by other systems to be imported into the graphics. Bitmaps shall support a transparent mode and Metafiles shall import as objects, not just bitmaps. As a minimum, the system shall import .bmp, .msp, .jpg, wmf, pcx, ico, cur, psd, epr, and wpg.
 - r. MS Word and Excel documents shall be able to live within a graphic screen, running with the graphic, not as an external call. Word and Excel toolbars shall 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 shall 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 shall use MS IntelliSense feature, exposing all methods and properties of graphic objects. Editing shall 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 shall allow import and export capability, there shall be a link from the graphic editor to the VBE, VBA or VBE is launched from within the system without any commands, all properties method and event of graphic object created within the graphic editor of third party Active X controls used in the graphic screen shall 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 shall be controlled at the block level. The system shall 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 shall 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 shall 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 shall 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 shall 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 shall contain values for multiple, named variables. The files can be placed on the hard disk or CD/DVD. Provide a mechanism for on-line maintenance and automatic purging of files.
- c. The data to be collected by the archiving program shall be identified through an interactive, menu-based configuration. The user shall 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 shall 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 shall 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 shall 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 shall 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 shall act as a time cursor on the display. The date, time, and values of the trends corresponding to that time shall 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 shall be supported. A transparent option for the trend shall 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 shall have a refresh rate selectable in 0.10 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, shall allow for the creation of users with certain rights and/or privileges. These rights shall 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 shall be also assigned additional rights.
 - c. The system shall 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 shall support at least twenty separate security areas, assignable on a per-tag basis. Each tag can be assigned all 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 shall be up to twenty characters in length.
 - e. The following functions shall be supported: enable/disable user-based security; define users, passwords, and login names; define groups to which users shall 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 shall 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 shall 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 shall 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:

SPEC WRITER NOTE: Edit the list of
controllers below to suit the project.

- 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.

SPEC WRITER NOTES:

1. Verify with VAMC personnel the preference for metric or English measurement units and edit accordingly.
2. List all required sensors and transmitters on drawings or in the specifications.
3. Edit this paragraph to suit the requirements.

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), //kg/sec// //lb/hr//.
 - 3) Steam output flow totalization (pressure compensated), //kg// //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, //kPa// //psig//.
 - 5) Boiler flue gas outlet temperature, //°C// //°F//.
 - 6) Boiler flue gas oxygen percent. Set point of oxygen trim system (if trim provided).
 - 7) Boiler stack opacity (if opacity monitors are provided).
 - 8) Boiler flue gas outlet draft (if outlet draft control system is provided), //Pa// //inches WG//.

- 9) Economizer flue gas outlet temperature, //°C// //°F//.
 - 10) Economizer feedwater inlet temperature, //°C// //°F//.
 - 11) Boiler feedwater inlet (economizer outlet) temperature, //°C// //°F//.
 - 12) Signal to feedwater control valve.
 - 13) Water level in boiler plus or minus //mm// //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 //standard cubic meters/second; standard cubic meters// //liters/second; liters// //scfh; mscf// //gpm; gallons//. 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 //liters/second; liters// //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.
- b. Boiler Plant:
- 1) Feedwater deaerator storage tank water level, //mm of water// //inches of water//.
 - 2) Condensate storage tank water level, //mm of water// //inches of water//.
 - 3) Oil tanks oil level, //liters of oil// //gallons of oil//.
 - 4) Pumps in operation.
 - 5) Chemical feeders in operation.
 - 6) Steam header pressure, //kPa// //psig//.
 - 7) Feedwater deaerator steam pressure, //kPa// //psig//.
 - 8) Emergency gas valve status (open or closed).
 - 9) Natural gas header pressure, //kPa// //psig//.
 - 10) Fuel oil header pressure, //kPa// //psig//.
 - 11) Fuel oil header temperature (if heated oil), //°C// //°F//.
 - 12) Boiler feed header pressure - each header, //kPa// //psig//.
 - 13) LP igniter gas header pressure //kPa// //psig//.

- 14) Instrument air pressure //kPa// //psig//.
- 15) Fuel oil tank and piping leak detection in operation.

19. Specific Requirements - Historical Trending:

SPEC WRITER NOTES:

- 1. Verify with VAMC personnel the preference for metric or English measurement units and edit accordingly.
- 2. List all required sensors and transmitters on the drawings or in the specifications.

- a. Display No. 1 (one display per boiler): Individual boiler pressure-compensated steam flow rate, //kg/sec// //lb/hr//; flue gas oxygen, percent; boiler stack temperature, //°C// //°F//; economizer flue gas outlet temperature, //°C// //°F//; percent opacity (if opacity monitor is provided); fuel flow rate (if fuel meters are provided on the boilers), //standard cubic meters/second// //liters/second// //scfh// //gpm//, feedwater flow rate (if feedwater meters are provided on the boilers) //gpm// //liters/second//.
- b. Display No. 2: Pressure-compensated steam flow rate for: total of all boilers; in-plant steam line; and each distribution steam line, //kg/sec// //lb/hr//; total plant fuel flow rate, //standard cubic meters/second, liters/second// //scfh, gpm//.
- c. Display No. 3: Outside air temperature, //°C// //°F//; feedwater temperature, //°C// //°F//; steam header pressure, //kPa// //psig//.

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:

SPEC WRITER NOTE: List all required
sensors and transmitters on the drawings
or in the specifications.

 - 1) Burner management safety control system alarms.
 - 2) Boilers high and low water level.
 - 3) Boilers low flue gas oxygen.
 - 4) Boilers high stack opacity (if opacity monitors are provided).
 - 5) Condensate storage tank high and low water level.
 - 6) Feedwater deaerator high and low water level.
 - 7) Feedwater deaerator high and low steam pressure.
 - 8) High and low steam header pressure.
 - 9) Low feedwater pressure to each boiler.
 - 10) Emergency gas valve closed.
 - 11) High and low natural gas header pressure.
 - 12) High and low fuel oil header pressure.
 - 13) High and low fuel oil temperature (if heated oil is provided).
 - 14) Propane igniter gas header pressurized (normal is zero pressure).
 - 15) High and low oil level in each oil tank.
 - 16) Oil tank and piping system leak detected.
 - 17) Carbon monoxide (CO) or combustible gas in building.
 - 18) Control system faults.

SPEC WRITER NOTE: Add the following (and other) alarms as required by the project.

- 19) Medical gases.
- 20) Medical vacuum.
- 21) Emergency generator status.

SPEC WRITER NOTES:

- 1. Verify with VAMC personnel the preference for metric or English measurement unit and edit accordingly.
- 2. List all required sensors and transmitters on the drawings or in the specifications.

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, //kg/sec// //lb/hr//.
 - b. Minimum simultaneous instantaneous steam flow rate, combination of all boilers, //kg/sec// //lb/hr//.
 - c. Totalization of steam produced, each boiler and combination of all boilers, //kg// //lb//.
 - d. Totalization of steam used in boiler plant, //kg// //lb//.
 - e. Separate totalization of steam exported into each distribution system, //kg// //lb//.
 - f. Totalization of oil consumed, //liters// //gallons//.
 - g. Totalization of natural gas consumed, //standard cubic meters// //mscf//.
 - h. Totalization of feedwater consumed, each boiler, //liters// //gallons//.
 - i. Overall boiler efficiency, fuel vs. steam (combination of all boilers).
 - j. Electricity used, kWh.
 - k. Make-up water used, //liters// //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.

SPEC WRITER NOTE: Provide a listing of all sensors and transmitters including fluid characteristics.

- D. Sensors and Transmitters: Provide as necessary to satisfy programming requirements. Refer to paragraphs, PRESSURE SENSORS AND TRANSMITTERS and TEMPERATURE SENSORS AND TRANSMITTERS.

2.6 FLUE GAS OXYGEN ANALYZERS

SPEC WRITER NOTE: Special-purpose boiler control systems such as "Autoflame" may utilize systems that do not conform to these requirements. If a special-purpose system is to be applied, revise this paragraph accordingly.

- 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// //boiler operations recorder// //computer workstation//. 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 shall be increased if necessary to suit the requirements of the oxygen trim system (if provided).
- C. Field-replaceable cell, heater, and cell temperature sensor. COR 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 paragraph, 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 gauges, and flow meters to permit connection of gas bottles to unit. Locate all gas bottle connections, regulators, gauges, 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 the //boiler/burner submaster controller for flue gas oxygen trim// //boiler operation recorders// //computer workstation//.
 2. Low flue gas oxygen alarm //on computer workstation// //on main panel annunciator//. 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 (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

2.7 FLOW METERS

SPEC WRITER NOTES:

1. Provide schedule for each flow meter listing flow meter type, fluid type and characteristics, temperature and pressure of fluid, flow range (maximum and minimum flows), maximum pressure loss, minimum meter accuracy, English or metric measurement units.
2. Utilize vortex meters for steam flow and feedwater flow. They can also be utilized for natural gas flow for individual boilers. Utilize turbine meters for boiler plant natural gas flow (turbine meter has higher turndown capability).

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 the //computer workstation// //and// //recorders//. As an option, pressure compensation and the compensated flow rate shall 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 percent of flow rate. Repeatability 0.2 percent 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 percent of flowrate over 4/1 turndown.

4. Meter Construction:

- a. Bronze or iron cases, threaded pipe connections, designed for 1034 kPa (150 psig) maximum pressure.
- b. Registers: Hermetically sealed, magnetic coupling, digital flow rate readout or sweep hand registering one or ten //liters// //gallons// per revolution and digital register for totalizer with at least five digits. Provide horizontal register box with gasketed viewing glass and hinged cover. Register shall have capability of being positioned to any of the four cardinal points for readability. //Provide remote flow indication on main instrument panel with flow rate and totalization.// //Transmit flow data to computer 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 121 degrees C (250 degrees F) if utilized for heated oil. Accuracy plus or minus 0.1 percent of flow rate over required flow range.
2. Meter Registers: Hermetically sealed flow computer with digital flow rate readout and digital register for totalizer with at least five digits located at meter, positioned for easy viewing. //Provide remote flow rate and totalization readout device.// //Transmit flow data to computer workstation.//

D. Turbine-Type Natural Gas Flow Meters:

1. Type: Turbine-type with volume totalizing digital readout that is continuously updated and corrected for the line pressure and temperature. Meter readouts shall be located on meter //and in computer workstation// //and on main instrument panel//. Meter shall be designed for natural gas at job site characteristics.

SPEC WRITER NOTE: Choose 20/1 flow turndown range for plant meter and 10/1 for individual boiler meters.

2. Performance: Maximum flow rate as scheduled. Pressure drop shall not exceed 1.25 kPa (5 inches WG). Accurate flow minimum turndown range

shall be //20/1// //10/1// with minimum accuracy one percent of flow rate over the entire range.

3. Construction:

- a. Meter: Design for 861 kPa (125 psig). Pipe connections flanged 861 or 1034 kPa (125 or 150 psig) 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 meters// //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 //ten cubic meters// //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:

SPEC WRITER NOTE: Delete the following paragraph where remote register is not required.

- a. //Remote Digital Register: Provide a remote digital register system including pulse generator and all wiring and accessories for proper functioning. Remote register shall have a digital //cubic meters// //cubic feet// volume readout corrected to the local contract base temperature and pressure from actual varying line conditions. Smallest indication shall be //ten cubic meters// //one thousand cubic feet//, and indicator shall have at least six digits. Provide 120-volt power supply from panel. Main plant register shall be located on main instrument panel;

individual boiler registers shall be located on boiler control panels.//

- b. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.
- c. Filter: Shall have replaceable glass fiber or cellulose cartridge with ten micron or smaller particle retention. Filter enclosure shall be the pipe size of the meter or greater 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 WG) at maximum design flow rate of meter. Plug all drains or instrumentation outlets. Provide vent with cock for relieving pressure in filter.

SPEC WRITER NOTE:

- 1. Include/add boiler stack opacity monitors only where needed by local emissions laws.
- 2. When adding opacity monitor to existing plants ensure the additional compressed air usage of the monitor does not over burden the N+1 capacity of the compressed air system

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.

SPEC WRITER NOTE: Consider providing the following if a computer work station with printer is not available.

- 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.

SPEC WRITER NOTE: List all sensors and transmitters required along with function and operating parameters.

2.9 PRESSURE SENSORS AND TRANSMITTERS

- A. Transmitters for gauge 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 COR 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 GAUGES

- A. For D-type water tube boilers, provide gauges for windbox, furnace, boiler outlet, and economizer (if provided) outlet. For flex-tube water

tube boilers and for fire tube boilers, provide gauges 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 125 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 gauges shall be replaced with greater ranges, at no additional cost or time to the Government. Scales for furnace, boiler outlet, and economizer outlet gauges shall be combination negative and positive pressure.
- D. 3-way cock for each gauge to permit shut-off, connection to service, connection to atmosphere.
- E. Mount on //boiler/burner control panel// //main instrumentation panel//.

SPEC WRITER NOTE: List all sensors and transmitters required along with operating parameters.

2.11 TEMPERATURE SENSORS AND TRANSMITTERS

- A. Provide resistance temperature detectors (RTD).
- B. Provide transmitters or panel-mounted indicator transmitters, transducers, and receivers compatible with the system including the controllers //recorders// //computer workstation//.
- C. Minimum accuracy one percent of actual temperature.
- D. Boiler and economizer flue gas temperature sensors shall be averaging type and shall extend across width of stack or breeching.
- E. Provide stainless steel weather hood on outside air temperature sensor, which shields the sensor from direct sunlight.

SPEC WRITER NOTES:

1. Recorders should not be necessary when a computer workstation is provided for data processing.
2. List all recorders and include list of all inputs and recording ranges, fluid types and temperature/pressure characteristics.

2.12 RECORDERS

- A. Provide complete systems to continuously receive and record steam flow, fluid temperatures, fluid pressures and boiler flue gas oxygen percent. System shall also include steam flow totalizing functions.

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

- b. Provide continuous totalizer for each flow function. Counter shall have six digits minimum.
 - c. Pressure Compensation: Provide system that automatically corrects the steam flow recording and totalization for the actual line pressure. Boiler and distribution steam flow recorders shall utilize the main header pressure as the signal for pressure correction if there are no intervening pressure regulators. On boilers with two-element or three-element feedwater level control, provide pressure compensated flow signal to the feedwater level controller.
2. Boiler Flue Gas Oxygen, Stack Temperature, Steam Header Pressure, Outside Air Temperature, Feedwater Temperature.
 3. Provide all new sensors and transmitters for each recorder input.
 4. All data shall be available via Modbus communications for the computer workstation (present or future workstation).

2.13 GAUGES, 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, 115 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 less than 103 kPa (15 psig).
 4. Movement: Stainless steel, rotary.
 5. Pointer: Micrometer adjustable, black color.
 6. Window: Plastic.
 7. Liquid Filled Gauges: 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 gauges are utilized. Gauge filling shall be glycerin or silicone oil. Purpose of filling is to provide pulsation dampening. As an option to liquid filling, provide dry gauges that have built-in fluid clutch dampeners that are not vulnerable to plugging due to foreign material.
- B. Accuracy: ASME B40.100, Grade 2A, 1/2 percent, on all gauges; except Grade A, one percent permitted on diaphragm actuated gauges, liquid-filled gauges, and compound gauges.**

C. Accessories:

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

SPEC WRITER NOTE: Verify with VAMC personnel the preference for metric or English gauge measurement units and edit accordingly.

D. Scale Ranges: Provide //English// //metric// //dual English/metric// scales:

1. Low pressure steam up to 103 kPa (15 psig): 0 to 200 kPa/0 to 29 psig.
2. Medium pressure steam up to 407 kPa (59 psig): 0 to 690 kPa/0 to 100 psig.
3. High pressure steam greater than 407 kPa (59 psig): 0 to 1380 kPa/0 to 200 psig.
4. Natural and LP gas: 0 to 200 kPa/0 to 29 psig.
5. LP gas at tanks: 0 to 2070 kPa/0 to 300 psig.
6. Gas burner, 125 percent of full load pressure, kPa/inches WG.
7. Oil pump suction: 100 kPa vacuum to 103 kPa/30 inches Hg vacuum to 15 psig.
8. Oil pump discharge: 0 to 1380 kPa/0 to 200 psig.
9. Oil burner, 125 percent of full load pressure, kPa/psig.
10. Compressed air, 345 kPa & higher (50 psig & higher): 0 to 1104 kPa/0 to 160 psig.
11. Feedwater pump discharge: 0 to 2070 kPa/0 to 300 psig.
12. Feedwater pump suction: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 29 psig.
13. Pumped condensate: 0 to 414 kPa/0 to 60 psig.
14. Condensate transfer pump discharge: 0 to 414 kPa/0 to 60 psig.
15. Condensate transfer pump suction: 100 kPa vacuum to 103 kPa/30 inches Hg vacuum to 15 psig.
16. Feedwater deaerator: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 29 psig.
17. Other services, 200 percent of maximum operating pressure.

E. Boiler Steam Pressure Gauges: Refer to //Section 23 52 39, FIRE-TUBE BOILERS// //Section 23 52 33, WATER-TUBE BOILERS//.

F. Panel-mounted Gauges: Refer to paragraph, MAIN INSTRUMENTATION AND CONTROL PANEL.

2.14 THERMOMETERS, PIPE OR TANK-MOUNTED

A. General: Thermometer locations are shown in the contract documents.

B. Construction:

1. Industrial type, separable well and socket, union connected.
2. Scales: Red reading mercury combination 0 to 150 degrees Celsius/30 to 302 degrees Fahrenheit scales, unless otherwise shown. Scale length 225 mm (9 inch) except 175 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 greater 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

SPEC WRITER NOTES:

1. The location of sensors shall be determined in the field based on the arrangement of the boiler plant facilities.
2. Carbon monoxide sensors should be located where personnel are most likely to encounter the fumes from flue gas leaks. This includes near the fronts of the boilers if there are nearby gasketed connections between the boiler flue gas outlet and the stack. Control rooms or restrooms that have exhaust ventilation that could draw gases into the room should have sensors. Sensors should be placed at breathing height and positioned to cover a surveillance area radius of 50 feet or 5000 minimum square feet
3. Combustibles sensors shall be located at ceiling height for natural gas (lighter than air). If propane (heavier than air) is a main fuel, the sensors should be located at low points in the building, positioned 457

mm (18 inches) from the floor. It is suggested that combustible gas sensors be limited in quantity to perhaps two at high or low points, depending on plant arrangement and fuel that is utilized.

4. The sensors of at least one and perhaps two manufacturers have a feature that automatically determines remaining sensor life. This could be added to the spec but it shall reduce competition. This feature would reduce the frequency of calibrations and thus require fewer personnel hours for maintenance.
 5. Alarm shall be transmitted to location outside the boiler plant. Provide information on this location in paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD).
 6. When sensors are located at heights above 6 feet the design shall include permanently affixed ladders and / or platforms with safety cage to access the sensors for calibration.
- A. Automatic microprocessor-based industrial-class system that monitors the concentration levels of carbon monoxide and combustible gases in the boiler room and associated spaces. The system shall include displays of the concentration levels of the gases detected by each sensor and provide audible and visual alarms when these gases are detected. Control/transmitter panels with displays and control functions shall be located 1500 mm (5 feet) above the boiler room floor. Provide //2// combustibles sensors and //3// //4// //5// //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 //and central control panel//. Transmit alarm signal to designated location outside the boiler plant: // // . Audible and visual alarm shall be provided at this location.

B. System Description:

1. Carbon Monoxide (CO) Sensors: Transportable calibration, electrochemical plug-in type, range 0 to 100 ppm, detection limit less than plus or minus 5 percent of full scale, response time less than 10 seconds, zero drift less than 5 percent per year, span drift less than 10 percent per year, repeatability less than plus or minus

- 5 percent of full scale, active temperature compensation. Set point: 25 to 50 ppm.
2. Combustible Gas Sensors: Plug-in type, infrared detection, no moving parts, range 0 to 100 percent lower explosive limit. On-board storage of calibration data, peak values, time, and date stamped. Set point: 10 percent 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 //or central control panel// via RS485 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 30 m (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 stainless steel tubing for remote-mounted sensors.
 6. Approvals: NEC and CEC for explosion proof or non-incendive, when required.
 7. Product Support: Supplier shall have organization, located within 242 kilometers (150 miles) of site, with capability of complete onsite product.
 8. Power Supply: Provide protected power supply to protect system from surges, spikes, transients, overloads in the incoming power supply.

2.16 TOOLS

SPEC WRITER NOTES:

1. The portable pressure gauge tester should be provided only if requested by VAMC engineering personnel.
2. Choose deadweight type or digital type.
3. Verify with VAMC personnel the preference for metric or English gauge measurement units and edit accordingly.

A. Portable Deadweight-Type Pressure Gauge Tester:

1. Type: Portable hydraulic deadweight tester with minimum range of //48 to 2070 kPa// //7 to 300 psig//.
2. Accuracy: Within plus or minus 0.1 percent of indicated pressure traceable to National Institute of Standards and Technology (NIST).
3. Construction: Steel or aluminum carrying case, compact design unit with weights and pump fitting within one carrying case, weights replaceable without replacing remainder of apparatus.
4. Accessories: Gauge pointer puller, 6 mm (1/4 inch) and 15 mm (1/2 inch NPT) pressure gauge connectors, sufficient hydraulic fluid to fill tester three times, all tools recommended by manufacturer.
5. Delivery: Deliver to COR for use by VA personnel only. Deliver prior to boiler tests. Include NIST traceable certificate with kit.

B. Portable Digital-Type Pressure Gauge Tester:

1. Type: Portable digital pressure calibrator with a minimum range of //48 to 1380 kPa// //7 to 200 psig//.
2. Accuracy: Within plus or minus 0.04 percent of indicated pressure traceable to National Institute of Standards and Technology (NIST).
3. Construction: Steel or aluminum carrying case, compact design unit with hand pump, fittings for connecting to pressure gauges and pump, test leads.
4. Accessories: Gauge pointer puller, 6 mm (1/4 inch) and 15 mm (1/2 inch NPT) pressure gauge connectors, all tools recommended by manufacturer for testing pressure gauges.
5. Delivery: Deliver to COR for use by VA personnel only. Deliver prior to boiler tests. Include NIST traceable certificate with kit.

C. Portable Pneumatic Deadweight-Type Pressure Gauge Tester:

1. Type: Portable pneumatic deadweight-tester with minimum range of //48 to 2070 kPa// //4 to 300 inches of water//. Operable with either shop air or nitrogen.

2. Accuracy: Testable to within 1 inch of water with accuracy of 0.05 percent of reading. Traceable to National Institute of Standards and Technology (NIST).
 3. Construction: Steel or aluminum carrying case, compact design unit with weights and tester within one carrying case, weights replaceable without replacing remainder of apparatus.
 4. Accessories: Gauge pointer puller, 6 mm (1/4 inch) and 15 mm ½ inch NPT) pressure gauge connectors, all tools recommended by manufacturer.
 5. Delivery: Deliver to COR for use by VA personnel only. Deliver prior to boiler tests. Include NIST traceable certificate with kit.
- D. 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 (26.4 gallons) of gas, approx. 75 x 355 mm (3 x 14 inch) cylinder.
 3. Delivery: Deliver to COR prior to initial calibration of instrumentation. Contractor personnel shall use gases. Provide new full cylinders, to replace gases used during start-up and testing after boiler plant testing is complete.
- E. 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 COR.

PART 3 - EXECUTION

3.1 GENERAL

- A. If in the substantiated evaluation of the COR, the installation fails to meet the requirements of the construction documents with respect to function and maintainability, an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.
- B. //Provide specified 0 to 300 PSIG deadweight tester// //and// //4 to 300 inches of water pneumatic deadweight tester// //each// in individual cases.//

3.2 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 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
2. Electrical Work and Safety Requirements: Comply with NFPA 70 and referenced electrical sections of these specifications.
3. Electrical Wiring: Comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS; Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS; Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES; 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 VHA Boiler Plant Safety Devices 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 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 gauge 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 shall 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.
 10. Flexible conduit of any type is limited to 900 mm (3 feet) in length unless longer runs are required for access to equipment such as opening the front door of a boiler.
 11. Conduit smaller than 50 mm (1/2 inch) is prohibited.
 12. All electrical conductors shall be installed in conduit.
(Including SO Cord).
- 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. An adequate water seal shall be always maintained to protect sensors or controllers on steam or water services 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 4.6 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 gauges 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 in the contract documents. All wiring and piping shall be provided in accordance with NFPA 70 and ASME B31.1.

F. Combustion Control Linkage Systems: After completion of burner adjustments, counter sink all lever set screws into shafts or pin levers to shafts to prevent levers from slipping on the shafts.

G. Boiler Stack Opacity Monitors (if provided): Locate downstream from oxygen sensing systems so that opacity monitor air purge does not affect flue gas oxygen reading. Locate sensor within 4.6 m (15 feet) of floor or accessible from platform without use of portable ladder. Locate air purge blower unit within 2400 mm (8 feet) of floor or accessible from platform without use of portable ladder.

H. Compressed Air Filters: Pipe drain to nearest floor drain.

3.3 INSTALLATION, NATURAL GAS FLOW METERS

A. 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.

3.4 INSTALLATION, PRESSURE GAUGES

A. Orient gauges so that dials are upright and visible from the nearest walkway or access platform. Install gauges with gauge cocks. Provide

pig-tail syphons on steam service. Provide compound gauges on all pump suction lines and on feedwater deaerator; provide pressure gauges elsewhere. Install liquid-filled or equivalent (as specified) gauges 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 gauges are used, provide pulsation dampeners instead of liquid filling.

3.5 INSTALLATION, THERMOMETERS

- A. Arrange thermometers so that scales are upright and visible from nearest walkway or access platform. Provide adjustable angle thermometers on applications greater 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.

3.6 INSTALLATION, WATER AND OIL FLOW METERS

- A. 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.

3.7 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 COR. 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 shall be completed prior to the testing.
- B. Burner Management (Safety Control) Systems: All tests shall be based on the VHA Boiler Plant Safety Devices Testing Manual, also Refer to //Section 23 52 39, FIRE-TUBE BOILERS// //Section 23 52 33, WATER-TUBE BOILERS//.
- C. Steam Flow Measuring: Demonstrate proper calibration of each flow rate signal and indication and each totalizer signal and indication to COR or their representative prior to the start of the final boiler testing.
- D. 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.

- E. Document all tests with detailed report of test results. Explain in detail the nature of each failure and corrective action taken.
- F. 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, and retest. Provide written report to COR.
- G. Demonstrate all safety and operating interlocks.
- H. 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.
- I. Furnish to COR 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.
- J. 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.
- K. 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.

3.8 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

- C. //The CxA shall observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.//

3.9 //COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification shall be tested as part of a larger system.//

3.10 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for //16//
// // hour//s// to instruct each VA personnel responsible in operation and maintenance of the system.
- B. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

- - - E N D - - -