

SECTION 23 09 11  
INSTRUMENTATION AND CONTROL FOR BOILER PLANT

**PART 1 - GENERAL:**

**1.1 DESCRIPTION:**

Automatic controls, instruments, monitoring and data management systems and accessories for boiler plant mechanical equipment. The specification classifies the systems into data management and instrumentation systems.

**1.2 RELATED WORK:**

- A. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
- B. Air compressors and accessories for pneumatic control: Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
- C. Automatic controls for water level in the feedwater deaerator storage tank and the condensate storage tank: Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
- D. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

**1.3 QUALITY ASSURANCE:**

- A. The 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.
- C. Code Approval:
  - 1. 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.
  - 2. All electrical wiring shall be in accordance with NFPA 70.
- D. 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

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employed by the equipment supplier. Personnel must have three years minimum experience with industrial and institutional boiler plant controls and instruments similar to those being furnished for this project.

**1.4 SUBMITTALS:**

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Certificates of compliance with Article, QUALITY ASSURANCE.
- C. Submit information sufficient to verify compliance with all contract requirements as specified and shown on project drawings.
- D. Boiler Plant Instrumentation:
  - 1. Catalog cuts and specification sheets providing description and performance data on instruments and accessories.
  - 2. Installation and troubleshooting instructions for all equipment in bound sets shipped with equipment.
  - 3. List of ranges of recorder displays or charts. For paper chart recorders, submit ranges for charts that will be furnished.
  - 4. Flow meter primary element design, size, performance, and sizing calculation. Steam flow performance data for flow meters verifying project performance requirements.
  - 5. Complete wiring and piping diagrams for all equipment and systems.
  - 6. Wiring and piping materials.
- E. 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.
- F. 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.
- G. As-built Logic and Wiring Diagrams: One set of reproducible prints and CAD disks delivered to the Contracting Officer Technical Representative

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(COTR) prior to turning systems over to VA for operation. Supply revised drawings if changes are made during the startup and commissioning process.

**H. 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).

**I. Pressure Gages and Thermometers:**

1. Catalog cuts showing design, construction, dimensions of gages and accessories.
2. Accuracy.
3. Pressure and temperature limitations of gages and accessories.
4. List of scale ranges to be provided.

**1.5 APPLICABLE PUBLICATIONS:**

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute (ANSI):  
INCITS 154-1988(R1999)..Office Machines and Supplies - Alphanumeric  
Machines - Keyboard Arrangements
- C. American Society of Mechanical Engineers (ASME):  
B16.36-1996.....Orifice Flanges  
B31.1-2004.....Code for Pressure Piping, Power Piping, with  
Addenda  
B40.100-2005.....Pressure Gauges and Gauge Attachments
- D. National Fire Protection Association (NFPA):  
70-2007.....National Electrical Code
- E. National Electrical Manufacturers Association (NEMA):  
ICS 6-93(R2001, R2006)..Industrial Control and Systems Enclosures  
WC 63.2-1996(R2003).....Performance Standard for Coaxial Premise Data  
Communications Cables
- F. Underwriters Laboratories Inc. (UL):  
508-99.....Industrial Control Equipment

1449-96.....Transient Voltage Surge Suppressors, Second  
Edition

1998-98.....Software in Programmable Components

## **PART 2 - PRODUCTS:**

### **2.1 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 XP Professional-based desktop computer workstation with keyboard, mouse, two speakers, color graphic monitor, alarm printer, logging printer, uninterrupted power supply. Equip with latest version Microsoft Windows XP Professional operating system compatible with SCADA software furnished. The system shall be designed so that additional workstations and peripheral equipment can be added in the future. Provide all devices necessary for complete access to all features of the programs applied.
2. Desktop Computer: Comply with requirements published by SCADA software supplier for optimum performance of software furnished. System must include hardware as recommended by Microsoft for installation of Windows XP Professional Business operating system. Minimum requirements are Intel Core 2 Duo processor, 4 MB L2 cache, 2.4 GHz, 1066 FSB; 4 GB 600 MHz DDR2 SDRAM memory ECC(2 DIMMS); dual hard drives each 400 GB SATA, nVIDIA QUADROFX4400 512 MB graphics, DVD+/-RW optical drive, integrated gigabit Ethernet, 250 MB Iomega Zip internal drive, sound card, high density 1.44 megabyte 88 mm (3.5 inch) drive floppy disk, audible alarm and a battery-backed clock

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- which counts seconds, minutes, hours, days and years. Provide two parallel ports and two serial ports, minimum.
3. Digital Flat Panel Color Monitor: TFT, 475 mm (19 inch) diagonal (nominal) screen with capability of 1600 by 1280 pixels resolution, non-interlaced, dot pitch 0.31 maximum. Minimum of True 16bit colors supported. Energy-Star compliant.
  4. Keyboard: ASCII standard, QWERTY-style, enhanced 101-key consisting of at least 32 dedicated function keys and a 12-key numeric data entry section. Keys shall have tactile feedback and be permanently and clearly labeled. In addition, a set of arrow keys shall be provided for moving from the current screen of data to "next screen". Function keys shall have custom legends for each key to allow report generation, graphic display selection, alarm silencing, and data retrieval with single keystrokes. Provide removable continuous Mylar faceplate to exclude dust and spills.
  5. Mouse: The operator interface shall minimize the use of the typewriter style keyboard through the use of a mouse and "point and click" approach to menu selection. Users shall be able to access features of the program from graphical displays through the use of the mouse.
  6. Alarm Printer: Impact printer, 9-pin dot-matrix type. The printer shall have a minimum 96 character ASCII character set based on ANSI INCITS 154. The printer shall have tractor feed with adjustable sprockets for paper width up to 380 mm (15 inches), print at least 132 columns per line and have a draft quality speed of 680 characters per second. Character spacing shall be selectable at 10, 12 or 17 characters per 25 mm (one inch) at front panel. The printer shall utilize sprocket-fed fanfold paper. The printer shall have programmable control of top-of-form. The sound level of the unit shall not exceed 55 dBA at 1500 mm (5 feet). Provide one box of 2000 sheets of printer paper.
  7. Logging Printer: Black/color inkjet type, 20 ppm black and white - 15 ppm color - draft quality, minimum 8 scalable fonts, 4800 x 1210 dpi color, 16 mb RAM, capability of letter and legal paper size.
  8. Speakers: Two Altec Lansing ACS295 or equal.
  9. Uninterrupted Power Supply: Provide complete protected power conditioner. Line interactive, UL 1449 rated, interactive digital display. Power supply shall protect computers, controls, instruments

and accessories from damage due to ground leakage, spikes, surges, sags, transients and overloads in the incoming power supply. Smooth sine wave output. Hot swappable batteries. Audible and visual alarm to signal failure of UPS.

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

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

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

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

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



styles for pens, minimum of three prebuilt line makers and a customizable line marker.

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

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

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

12. Alarms and Message Handling:

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

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

- g. Provide an alarm summary display as a dynamic link within the graphics package. This must show a list of the pending alarms in the system. As new alarms are detected, entries are made to the display list. Placement of alarm information and color codes shall be configurable. Alarms can be acknowledged from the summary display either individually or for all alarms in the queue.

13. Archiving and Reporting:

- a. Provide facility for automatically collecting, storing and recalling data. Recalled data shall be made available to a trend display program, a report generation program and to user-written programs.
- b. Store data in Windows-compatible files in compressed format. Entries containing time, name, value and status will be made in the file whenever the real-time value exceeds the previously stored value by a user-supplied deadband limit. A deadband value of zero will cause an entry in the file each time the real-time value is examined. Files shall be organized according to time and will contain values for multiple, named variables. The files can be placed on the hard disk or floppy disk. Provide a mechanism for on-line maintenance and automatic purging of files.
- c. The data to be collected by the archiving program will be identified through an interactive, menu-based configuration. The user will enter the tag name, collection rate, and data compression deadband value. Collection rates shall be selectable:

- 1 second, 2 seconds, 10 seconds, 20 seconds, 30 seconds, 1 minute, 2 minutes, 10 minutes.
- d. The operator shall be able to recall archived data from the disk to be displayed in graphic format along with real-time data. The display of archived data shall be user-configurable. It shall be possible to configure objects in graphic displays that, when selected, fetch pre-defined historical trend data from disk and display it to the operator. Attributes of pens shall be editable during run-time.
- e. The historical trend display shall be made up of the following components:
- 1) Pen Group: Configuration shall be used to define the particular tag names to be displayed. Along with tag names, pen color, marker style and engineering units may be defined.
  - 2) Time Group: Configuration shall be used to define the time period over which the archived data is to be displayed.
  - 3) Legend Group: Configuration shall be used to define the legend parameters for a historical display. Both a primary and alternate legend may be displayed.
- f. The display shall support unlimited variables to be displayed on the same time/value axis simultaneously. For each entry in the display list, the operator will be able to assign a given tag name and marker to a particular line color selected from palettes of unlimited colors. The operator may also enter display engineering units ranges to cause scaling of the display. Support shall be provided for multiple, different y-axis engineering units to be displayed as appropriate.
- g. The display shall have two fields of view. The top portion of the screen shall be the graphic field and will display the values of the variables (y-axis) against time (x-axis). It will also contain labels for the axes and graphs. The bottom portion of the screen shall be user-configurable to display information, such as node-names, tag names, and descriptors, pertaining to the tags in the trend display.
- h. The trend object shall allow for bi-directional trending and scrolling. A movable, vertical line will act as a time cursor on the display. The date, time and values of the trends corresponding to that time will be displayed in the bottom portion of the

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

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

14. Event Scheduling:

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

15. Security Management:

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

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

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

16. Services:

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

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17. Acceptable Programs: GE Fanuc "Cimplicity" and "iFIX; Iconics  
"Genesis32"; Wonderware "FactorySuite"; or equal.
18. Remote Operation of Controllers
  - a. Provide capability to operate controllers locally at the control  
and indicating stations and, except for burner management (flame  
safety) controls, remotely at the computer workstation. For  
safety, it shall be possible to defeat the remote control from the  
front panel of each individual controller, preventing any status  
changes from being initiated at the computer workstation. The  
controllers include: master steam pressure, boiler/burner sub-  
master, burner fuel/combustion air, boiler draft, burner oxygen  
trim, boiler feedwater level, deaerator water level, condensate  
storage tank water level.
  - b. The operating personnel, when controllers are so enabled, shall  
have remote control of the following functions from the computer  
work station:
    - 1) Select manual/automatic mode.
    - 2) Set point (requiring use of high-level password).
    - 3) Controller output when in manual mode.
    - 4) Proportional/integral/derivative tuning parameters (requiring  
use of high-level password).
    - 5) Controller analog output values.
    - 6) Controller discrete output values.
  - c. The monitor display shall provide a facsimile of the controller  
front plates with clearly labeled English language and engineering  
unit display of the control parameters.
  - d. No special programming skills shall be required for any routine  
operating sequence.
19. Graphics: As a minimum, the following pictorial "screens" shall be  
available for observation:
  - a. Individual boilers with economizers (if provided) showing:
    - 1) Main flame proven and approximate firing rate as shown by flame  
size depiction.
    - 2) Steam output instantaneous flow rate (pressure compensated),  
lb/hr.
    - 3) Steam output flow totalization (pressure compensated), lb. This  
is total production starting from time, day, month and year as  
set by operating personnel. Calculation shall be accomplished



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

- 4) Steam header pressure, psi.
- 5) Boiler flue gas outlet temperature, °F.
- 6) Boiler flue gas oxygen percent. Set point of oxygen trim system (if trim provided).
- 7) Boiler stack opacity (if opacity monitors are provided).
- 8) Boiler flue gas outlet draft (if outlet draft control system is provided), inches WC.
- 9) Economizer flue gas outlet temperature, °F.
- 10) Economizer feedwater inlet temperature, °F.
- 11) Boiler feedwater inlet (economizer outlet) temperature, °F.
- 12) Signal to feedwater control valve.
- 13) Water level in boiler plus or minus inches from normal level.
- 14) Boiler plus economizer "Heat Loss" combustion efficiency not including radiation and unaccounted losses.
- 15) Fuel flow rate and totalization if individual boiler fuel meters are provided standard scfh; gpm / mscf; gal.  
Totalization calculations shall be accomplished at the meters, not in the SCADA software.
- 16) Feedwater flow rate and totalization if boiler feedwater flow meters are provided gpm; gallons. Totalization calculations shall be accomplished at the meters, not in the SCADA software.
- 17) Trends of all flow, pressure and temperature data as listed above.

b. Boiler Plant:

- 1) Feedwater deaerator storage tank water level, inches of water.
- 2) Condensate storage tank water level, inches of water.
- 3) Oil tanks oil level, gallons of oil.
- 4) Pumps in operation.
- 5) Chemical feeders in operation.
- 6) Steam header pressure, psi.
- 7) Feedwater deaerator steam pressure, psi.
- 8) Emergency gas valve status (open or closed).
- 9) Natural gas header pressure, psi.
- 10) Fuel oil header pressure, psi.
- 11) Fuel oil header temperature (if heated oil), °F.

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- 12) Boiler feed header pressure - each header, psi.
  - 13) LP igniter gas header pressure psi.
  - 14) Instrument air pressure psi.
  - 15) Fuel oil tank and piping leak detection in operation.
20. Specific Requirements - Historical Trending:
- a. Display No. 1 (one display per boiler): Individual boiler pressure-compensated steam flow rate, lb/hr; flue gas oxygen, percent; boiler stack temperature, F; economizer flue gas outlet temperature, deg.F; percent opacity (if opacity monitor is provided); fuel flow rate (if fuel meters are provided on the boilers), standard cubic meters/sec, scfh, gpm, feedwater flow rate (if feedwater meters are provided on the boilers)gpm.
  - b. Display No. 2: Pressure-compensated steam flow rate for: total of all boilers; in-plant steam line; and each distribution steam line, lb/hr; total plant fuel flow, scfh, gpm.
  - c. Display No. 3: Outside air temperature, deg.F; feedwater temperature, deg.F; steam header pressure, psi.
21. 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.

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

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- d. Totalization of steam used in boiler plant, lb.
  - e. Separate totalization of steam exported into each distribution system, lb.
  - f. Totalization of oil consumed, gallons.
  - g. Totalization of natural gas consumed, mscf.
  - h. Totalization of feedwater consumed, each boiler, gallons.
  - i. Overall boiler efficiency, fuel vs. steam (combination of all boilers).
  - j. Electricity used, kWh.
  - k. Make-up water used, gallons.
  - l. Make-up water as a percent of total steam production of all boilers combined.
  - m. Number of heating degree-days.
  - n. Hours of operation of each boiler.
23. 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.
24. Monitor Screen Printout: Any display on the screen shall be able to be printed as required to provide hard-copy record.
- D. Sensors and Transmitters: Provide as necessary to satisfy programming requirements. Refer to Articles, PRESSURE SENSORS AND TRANSMITTERS, and TEMPERATURE SENSORS AND TRANSMITTERS.
- E. Transmitters shall be provided for:
- 1. Main Steam Header Pressure
  - 2. Steam Distribution Flow
  - 3. D/A Level
  - 4. Natural Gas Header Pressure
  - 5. Condensate Tank Make-Up Water Flow
  - 6. Condensate Tank Make-Up Water Pressure
  - 7. Compressed Air Pressure
  - 8. Fuel Oil Pressure
  - 9. Fuel Oil Flow
  - 10. Condensate Tank Level

**WATER STORAGE TANK LEVEL2.2 FLOW METERS:**

**A. Vortex Flow Meters with Transmitters:**

1. Provide vortex-shedding flow meters designed for accurate measurement of flow rate ranges shown at required pressures. Minimum turndown capability shall be as scheduled. Meters shall have digital readout of pressure-compensated flow rate and totalization located at transmitter and transmit flow rate and totalization digital signals to computer workstation. As an option, pressure compensation and the compensated flow rate may be performed and displayed by a boiler plant controller receiving signals from the flow meter and from a pressure transmitter. Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.
2. Programmable microprocessor electronics with on-board programming. Output signals immune to ambient temperature swings. Continuous self-diagnostic routines that identify electronics problems and provide a warning. Electronics replaceable in the field without affecting metering accuracy. Provide power supply as recommended by meter manufacturer. Mount electronics separate from meter body in position accessible from platform or floor without the use of a portable ladder.
3. All welded wafer-type or flanged stainless steel meter body with no seals. No sensor parts exposed to the flow stream. Provide alignment rings with wafer-type meters to assure proper centering in the pipeline. Trapezoidal shedder bar, sensing by detecting stresses in the shedder bar caused by vortices, dual piezoelectric crystals located outside the process flow sense the shed vortices, dual crystal alignment cancels effects of noise and vibration. Designed for Schedule 40 piping.
4. Transmitted signal accuracy plus or minus 1.5% of flow rate. Repeatability 0.2% of actual flow rate. Meter designed to minimize vibration effect and to provide elimination of this effect.

**B. Water Flow Meters:**

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

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shown. Minimum accuracy plus or minus 0.5% of flowrate over 4/1 turndown.

4. Meter Construction:

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

C. Fuel Oil Meters:

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

D. Turbine-Type Natural Gas Flow Meters:

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

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

- b. Indication Devices on Meter: Electronic type which provides a totalized continuous volume flow digital indication in cubic feet automatically continuously corrected to the local contract base temperature and pressure from actual varying line temperatures and pressures. Unit shall also display a totalized uncorrected volume flow indication. The display shall show actual line temperature and pressure at the meter and pressure-temperature correction factor. Smallest corrected flow indication shall be one thousand cubic feet, and indicator shall have at least six digits. Unit shall be watertight where drawings show an outdoor location.
- 4. Calibration: Factory calibrated. Furnish three-point curve spanning required flow range on actual meter furnished.
- 5. Manufacturers: American Meter, Sensus Metering Systems (formerly Equimeter and Rockwell), or equal.
- 6. Accessories:
  - a. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.
  - b. Filter: Shall have replaceable glass-fiber or cellulose cartridge with ten micron or smaller particle retention. Filter enclosure shall be the pipe size of the meter or larger as required by pressure drop considerations. Static pressure capability shall be at least twice lockup pressure of service supply regulators. Maximum pressure loss 1.25 kPa (5 inches WC) at maximum design flow rate of meter. Plug all drains or instrumentation outlets. Provide vent with cock for relieving pressure in filter.  
Manufacturer: American Meter, Dollinger or equivalent.

### **2.3 PRESSURE SENSORS AND TRANSMITTERS:**

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

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

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

#### **2.4 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 computer workstation.
- C. Minimum accuracy one percent of actual temperature.
- D. Boiler and economizer flue gas temperature sensors shall be averaging type and shall extend across width of stack or breeching.
- E. Provide stainless steel weather hood on outside air temperature sensor, which shields the sensor from direct sunlight.

#### **2.5 GAGES, PRESSURE AND COMPOUND, PIPE OR TANK-MOUNTED:**

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



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- to provide pulsation dampening. As an option to liquid filling, provide dry gages that have built-in fluid clutch dampeners that are not vulnerable to plugging due to foreign material, such as Ashcroft "Duragage Plus" or equal.
- B. Accuracy: ASME B40.100, Grade 2A, ½ percent, on all gages; except Grade A, one percent permitted on diaphragm actuated gages, liquid filled gages, and compound gages.
- C. Accessories:
1. Red set hands on gages located at automatic pressure regulator valve outlets.
  2. Needle valve or gage cock rated for the service.
  3. Syphon on all steam gages.
  4. Pulsation snubbers on diaphragm-type gages located adjacent to gas burners.
- D. Scale Ranges: Provide English scales:
1. Low pressure steam to 15 psi: 0 to 30 psi.
  2. Medium pressure steam to 59 psi: 0 to 100 psi.
  3. High pressure steam above 59 psi: 0 to 200 psi.
  4. Natural and LP gas: 0 to 30 psi.
  5. LP gas at tanks: 0 to 300 psi.
  6. Gas burner, 125 percent of full load pressure, inches WC.
  7. Oil pump suction: 30 inches Hg vacuum to 15 psi.
  8. Oil pump discharge: 0 to 200 psi.
  9. Oil burner, 125 percent of full load pressure, psi.
  10. Compressed air, 345 kPa & higher (50 psi & higher): 0 to 160 psi.
  11. Feedwater pump discharge: 0 to 300 psi.
  12. Feedwater pump suction: 30 inches Hg vacuum to 30 psi.
  13. Pumped condensate: 0 to 60 psi.
  14. Condensate transfer pump discharge: 0 to 60 psi.
  15. Condensate transfer pump suction: 30 inches Hg vacuum to 15 psi.
  16. Feedwater deaerator: 30 inches Hg vacuum to 30 psi.
  17. Other services, 200 percent of maximum operating pressure.
- E. Panel-mounted Gages: Refer to Article, MAIN INSTRUMENTATION AND CONTROL PANEL.

**2.6 THERMOMETERS, PIPE OR TANK-MOUNTED:**

- A. General: Thermometer locations are shown on the drawings.
- B. Construction:
1. Industrial type, separable well and socket, union connected.

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

**PART 3 - EXECUTION**

**3.1 INSTALLATION, BOILER PLANT INSTRUMENTATION, COMPUTER WORK STATION:**

**A. General:**

1. Electrical Work and Safety Requirements: Comply with NFPA 70 and referenced electrical sections of these specifications.
2. 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.
3. Except for short apparatus connections, run conduit and pneumatic tubing parallel to or at right angles to the building structure.
4. Run tubing and wire connecting devices in control cabinets parallel with the sides of the cabinets neatly racked to permit tracing. Rack wiring bridging a cabinet door along the hinge side and protect from damage. Provide grommets, sleeves or vinyl tape to protect plastic tubing or wires from sharp edges of panels, conduit, and other items. Fit all equipment contained in cabinets or panels with service loops; each loop shall be at least 300 mm (12 inches) long. Equipment for fiber optic systems shall be self-supporting, code gage steel enclosure.
5. Permanently mark terminal blocks for identification. Label or code each wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
6. Cables:

- a. Keep cable runs as short as possible. Allow extra length for connecting to the terminal board.
  - b. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
  - c. Cables shall be supported for minimum sag.
  - d. Splices in shielded and coaxial cables shall consist of terminations and shielded cable couplers. Terminations shall be in accessible location. Cables shall be harnessed with cable ties.
- B. Pressure, Temperature, Level and Flow Transmitters: Mount in locations accessible from floor or platform without use of portable ladders. Provide separate conduit for each transmitter signal if recommended by manufacturer. Protect sensor or controller on steam or water service by an adequate water seal at all times and provide blowdown facilities to permit blowdown of sensing lines. Install temperature sensors with entire temperature sensing surface immersed in media being measured. Locate outside air temperature sensor on north side of building away from heat sources. Provide isolation valves on all transmitters connected to fluid systems. Locate isolation valves so that transmitter can be isolated while main sensing line is being blown down. Provide equalizing valves on all differential pressure transmitters. Provide valved drains on all fluid lines. Valves shall be rated for minimum of 150 percent of system pressure and temperature.
- C. Steam Flow Meter Primary Elements (In-Line Flow Sensors) including Vortex-Shedding Type: Provide straight runs of piping upstream and downstream as recommended by manufacturer to achieve maximum accuracy and rangeability. Verify that stresses in piping system do not exceed allowable stress of flow meter body. Locate meter electronics including read-out devices accessible from floor or platform without the use of portable ladders.
- D. Wiring and Piping: Is generally not shown on the drawings. All wiring and piping must be provided in accordance with NFPA 70 and ASME B31.1.
- E. Compressed Air Filters: Pipe drain to nearest floor drain.

### **3.2 INSTALLATION, PRESSURE GAGES:**

Orient gages so that dials are upright and visible from the nearest walkway or access platform. Install gages with gage cocks. Provide pig-tail syphons on steam service. Provide compound gages on all pump suction lines and on feedwater deaerator; provide pressure gages elsewhere. Install liquid-filled or equivalent (as specified) gages at

inlet and outlet of all pumps, on compressed air systems, and on fuel and atomizing media lines at locations closest to burners. If diaphragm-type gages are used, provide pulsation dampeners instead of liquid-filling.

### **3.3 INSTALLATION, THERMOMETERS:**

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

### **3.4 INSTALLATION-WATER AND OIL FLOWMETERS:**

Provide strainer upstream with 80-mesh screen liner. Position register for upright viewing from nearest walkway.

### **3.5 TESTING, BOILER PLANT INSTRUMENTATION, COMPUTER WORKSTATION:**

- A. Representatives of the designer of the system shall demonstrate proper operation and calibration of all components, computer programs, and entire systems to the COTR. If the project includes boiler/burner testing, the demonstration involving boiler/burner data shall be conducted during the boiler/burner tests. Furnish personnel, instrumentation, and equipment necessary to perform calibration and testing. All calibration work must be completed prior to the testing.
- B. Steam Flow Measuring: Demonstrate proper calibration of each flow rate signal and indication and each totalizer signal and indication to the COTR or their representative prior to the start of the final boiler testing.
- C. Pressure test all pneumatic control tubing at one and one-half times the normal operating pressure.
- 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. Provide written report to the COTR.
- G. Demonstrate safety and operating interlocks.

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- 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 the COTR 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.

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