SECTION 13500 - COMPUTER SYSTEM SOFTWARE

City of San Diego, CWP Guidelines

PART 1 - GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes engineering, programming, configuring, graphic generation, testing, calibrating, starting up, and training the OWNER'S personnel to use the Clean Water Operations Management Network (COMNET).

B. The Distributed Control System (DCS) and Supervisory Control and Data Acquisition (SCADA) hardware will be furnished by the OWNER. The [DCS] [,]PLC] [,]and] [SCADA] equipment is listed in Appendix 1. [The SCADA equipment is listed in Appendix 2.]

C. It is the intent of this Section that the COMNET software shall:

1. Manage communications between the DCS and the SCADA systems.

2. Implement real-time process control.

3. Transfer periodic analog and digital data from the DCS to the SCADA system.

4. Save periodic analog and digital data from the DCS in historical files.

5. Analyze historical trends in data.

6. Prepare reports.

7. Prepare graphic displays.

1.2 PREQUALIFICATION REQUIREMENTS

A. System Integration Contractors shall prequalify for bidding by submitting five copies of prequalification applications at least [21] days prior to the bid opening date. The list of prequalified System Integration Contractors will be limited to those which demonstrate competency to execute the WORK and furnish the services in this Specification by furnishing the following information:

1. Provide a list of at least two successfully completed projects in which the System Integration Contractor performed system engineering, programming, communication software implementation, documentation, field testing, calibration and startup, operator instruction and maintenance training. In addition, list the following information for each project:

a. Name of plant, owner, contact name, and telephone number
b. Name of manufacturer for the majority of instrumentation furnished
c. Type of transmitter, recorder, indicator equipment furnished
d. Manufacturer and model number of DCS system used
e. Approximate number of analog and digital input functions to the system
f. Approximate number of analog and digital output functions to the system
g. Contracted cost of the instrumentation including change orders

h. Date of completion or acceptance

2. Name of the individual who will be responsible for office engineering and management of this project, and the individual who will be responsible for field testing, calibration, startup and operator training for this project. Include references of recent projects of these individual persons.

3. Document that the System Integration Contractor's company has been actively involved in providing integration services under the same corporate name for a minimum of four years.

4. All prospective System Integration Contractors shall submit a financial prospectus indicative of the corporate financial state. The prospectus shall also include:

   a. A copy of a current Dunn and Bradstreet report
   b. A letter from a financial institution verifying the capability of securing a bond for this project

B. **Notification**: Each application will be examined, investigated and judged. Each applicant will be notified of his approval or disapproval for prequalification no less than 10 days prior to the bid opening data.

1.3 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 13400 Communications
2. Section 13600 COMNET Hardware Procurement
3. Section 16050 Basic Electrical Materials and Methods
4. Section 16170 Grounding System
5. Section 16400 Low Voltage Electrical Service and Distribution
6. Section 16611 Uninterruptible Power Systems

1.4 CODES

A. The WORK of this Section shall comply with the current editions of the following codes as adopted by the City of San Diego Municipal Code:

1. Uniform Fire Code
2. National Electrical Code

1.5 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1.	ISA RP55.1	Hardware Testing of Digital Process Computers
2.	ISA S5.4	Instrument Loop Diagrams
3.	ISA S51.1	Instrument Symbols and Identification

4.	NEMA ICS 1-101	Diagrams, Device Designations and Symbols
5.	NEMA ICS6	Enclosures for Industrial Controls and Systems
6.	MIL STDS 217	Reliability Prediction of Electronic Equipment
7.	MIL STDS 472	Maintainability Prediction
8.	MIL Q STDS 9858A	Quality Program Requirements
9.	IEEE 802.2	Logical Link Control
10.	SAMA PMC-32	Process Measurement and Control, Instrumentation Reliability Techniques
11.	SAMA PMC 32.1	Process Instrumentation Reliability Terminology

1.6 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in the order listed. The Software Design Submittal shall not be submitted until the Development Submittal is approved.

B. Development Submittal:

1. Software System Overview: A block diagram showing all major software functions and their interrelationships, including a general description of the block diagram and each major software function.

2. Software Implementation Standards: A description of all programming and configuration standards and procedures to be followed by all persons involved in the development, coding, configuring and testing of all software.

3. Software Features: A description of how the software will implement the following:

a. Communications: How the SCADA communicates with the DCS.

b. Diagnostics: The online and offline diagnostics, how they are used, and the execution options available for each.

c. System Expansion: How the computer system can be expanded to address additional disk drives, printers, tapes, CRTs and other terminals.

d. Data Base Generation: A detailed description of all commands and procedures available to the user.

e. Man-Machine Interface Operation: A general description of how the man-machine interface works, including a complete description of the keyboards involved, a discussion of the function selection scheme used, and a discussion of the protocol used to verify or confirm a function selection.

f. Message Formats: How operator actions and system alarms are shown on the system printer.

g. Alarm/Event Processing: The processing that occurs whenever an alarm or event occurs, including prompts, messages, affected displays, and audible alarms.

h. Operations Manual Data Entry: Operational procedures and display functions. A description of the data base access functions including all parameters available.

i. Data Storage and Retrieval: The data storage scheme employed including file name, file structure, and file location. How points are added to or deleted from the historical system and what limitations are posed by such modifications. The retrieval capabilities, procedures and syntax.

j. Report Generation: General description of usage, syntax, space requirements, and operator interface.

k. Historical and Real-Time Trends: Display functions and the operation of the trend, and data retrieval and displays.

4. Applications Software: An outline of all applications software to be developed. For each different type of application, describe the scope of the application and list the programming language(s) or configuration methods to be used.

5. CRT Display Formats: For each type of CRT display which is not shown in the Standard Software User's Manuals, present a minimum of two typical examples. Examples of typical process graphic display and historical trend plots used on previous projects will be accepted.

6. Report Formats: List the name of the program used to configure the report format, the name of the program to be used to print the report, give page number references to the user's manual(s) that describe these programs, and present examples of typical reports from other projects.

7. System Printer Format: Examples of system printer output formats to be used.

8. Disk and Memory Allocations: Single-page diagrams or tables that show how disk and computer memory will be partitioned. Only the relative percentages of memory required for each major function are necessary.

C. Software Design Submittal: The software design submittal shall describe the applications software. Software submittals shall include:

1. Color copies of the Process Graphic Displays.

2. Copies of the required reports. For reports that have multiple pages, submit examples of all pages of the report. For reports that can cover variable time periods, submit typical examples for daily, monthly and yearly time periods.

3. Data Base Configurations for the process data base, historical data base, I/O list, and any other process related data base.

4. Examples of typical trend displays covering terms less than 24 hours and longer than several weeks.

5. Changes and Additions to Standard Software. If any programming is required to augment the standard software, furnish detailed written descriptions, block diagrams, and macro level flow charts or pseudo code. Flow charts shall show I/O functions, general processing, subroutines, logical sequence, and decision points. Symbols and usage shall conform to ANSI X3.5-70. Pseudo code shall be in accordance with the software implementation standards of the development submittal.

6. A complete list of disk files showing name, usage, size and, if multiple disk drives are used, which drive contains what files.

7. Data Files: A complete description of all data files including name, usage, size, record format, and, if multiple disk drives are used, which drive contains the files.

8. A complete description of any other data structures used by the system.

9. Format and examples for recording computer operation related activities such as software problems, hardware problems, software changes, power and disk failures.

10. Recommended backup frequency, number of backup copies, and storage of backup copies.

D. The System Integration Contractor shall utilize the Instrument and Input/Output Summary (I&IOS) format in this Section to submit to the CONSTRUCTION MANAGER two copies of the "as-bid" I&IOS in a floppy disk format using DB3 structure within 90 days of Notice to Proceed. Subsequent data base submittals shall also be augmented with submission of a floppy disk. It is the CONSTRUCTION MANAGER's intent to utilize the floppy disk medium with IBM-AT hardware to facilitate the exchange of information and processing of submittals.

1.7 OPERATIONS MANUALS

A. **General**: The Systems Integration Contractor shall furnish thirty operation manuals, including information and drawings for the system, subsystems, and all components, and names, addresses and telephone numbers of equipment suppliers, representatives, and repair facilities.

B. **Hardware Documentation**: Hardware documentation shall include a complete description of the recommended operating procedures, maintenance procedures, and spare parts list for all equipment items and catalog data, diagrams, and drawings or cuts describing the equipment. Each manual shall include full size assembly and wiring diagrams.

C. **Software Documentation**: Software documentation shall include:

1. Initial values for all data base parameters.

2. An alphabetical listing of all error, warning, and alarm messages logged by the standard software. For each message, list the message, a description of the condition, a brief description of operator action required, and a reference to the specific manual that covers the logged condition.

3. Complete systems generation data.

4. Complete set of well commented source program listings and configuration data for all application software.

5. A complete set of system operating procedures including system generation, system loading, and startup.

6. A complete set of computer operations procedures including system restarts, power failure and recovery, generation of reports, disk backup and reload, manual data entry for reports, generation of plots, historical tape operations, and general troubleshooting.

7. A complete set of operating procedures for all functions of the CRTs, printers, and system terminal.

8. For all application software, one copy of fully commented source programs and configuration data on disk and two copies of the same on tape.

1.8 RECORD DRAWINGS

A. The following shall be included in the Project Record Drawings in compliance with Section 01300:

1. Loop and schematic diagrams showing all field and panel wiring.

2. Point to point diagrams with cable, wire, tube, and termination numbers.

3. Drawings of piping and tubing routing, mounting details.

PART 2 - PRODUCTS -- Not Used

PART 3 - EXECUTION

3.1 SOFTWARE REQUIREMENTS

A. **General**:

1. The DCS/SCADA system software shall be capable of controlling system level activities and allow the operator to monitor and control the process through an interactive human interface. The software shall allow concurrent execution of more than one program in a background, foreground or multi-tasking mode.

2. The operator interface for all process control activities shall be through the use of fully interactive software modules. Such modules shall be target oriented using easily recognized icons or custom symbols or they shall be entirely menu driven using pulldown menus. Selection choices shall be through the use of a cursor-positioning mouse and shall not require the use of an alphanumeric keyboard. The use of typed commands to move from module to module or from display to display is not acceptable.

3. Through the execution of all software modules, the operator shall be presented with all of the command or operation choices available at that point in the program using words or symbols to make the choices self-explanatory and unambiguous. Question and

answer or fill-in-the-blank format shall only be accepted where file names, tag names, or other unique text or numerical information is required.

4. System software shall include a real time operating system, a calendar and time program, a file management program and a system of diagnostic routines in addition to any compilers, editors, loaders, or assemblers required to support the process control software language.

5. Changes to the system database, report formats, and display formats shall be made from the engineering or operator workstation by interactive modules and shall not require direct modification at the source code level.

6. All programs shall be self-configuring, such that they obtain the size and configuration of the system from parameters contained in the various files created during system generation. No parameters related to the hardware configuration shall be hard coded into any of the software.

B. **System Software:** System software shall include a complete and unmodified operating system furnished by the System Supplier that enables the indicated system functions. Operating system software shall function fully automatically without operator intervention, except as required to establish file names and similar information.

1. Operating System Software: The operating system software shall be the standard uncorrupted product of the central computer manufacturer and shall support the following functions:

   a. Response to a program request or an operator demand.

   b. Dynamic allocation of main memory usage, computation time, peripheral usage, and I/O channel usage in the system.

   c. Allotment of system resources on the basis of task priority levels such that a logical allocation of resources and suitable response times are assured.

   d. Queuing of requests in order of priority if one or more requested resources are unavailable.

   e. Resolution of contending requests for the same resource based on priority.

   f. Servicing requests for execution of one program by another.

   g. Transferring data between programs as requested.

   h. Management of all information transfers to and from peripheral devices.

   i. Control and recovery from all program fault conditions.

   j. Diagnosing and reporting real-time hardware device errors.

2. Software Execution: Program execution shall be based on a multilevel priority interrupt structure. A program interrupted by a higher priority program shall be entered into a list of pending programs and its execution shall be resumed once it becomes the

currently highest priority program. Initiation of programs shall be activated by all of the following:

a. In response to external interrupts.

b. At a scheduled time of the day.

c. On an elapsed time interval basis.

d. On request by another program.

e. On request from the operator interface.

The system shall allow periodic programs to be scheduled. The allocation of resources to a time scheduled program shall be based on its relative priority and the availability of computer system resources.

3. System Startup and Restart:

a. Software shall initialize and bring a computer or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.

b. Initialization shall include determining computer system status prior to initializing operating system software and initializing application software. Initialization shall also include the loading of all memory resident software, initializing timers, counters, and queues, and initializing all dynamic database values.

c. No less frequently than every 15 minutes the system shall save on disk a complete copy of all main memory resident data base and system parameters required to completely characterize the current status of the computer system hardware and software. In the event that a system restart is required, a special Restart program shall be activated to read these data and initialize the main memory resident parameters. The Restart program shall use a battery operated real-time clock to automatically set the time and date. The Restart program shall also perform any other "housekeeping" functions required to restore the system to normal operation.

4. System Shutdown: The software shall initiate orderly shutdowns for equipment failure, including computer processor failure, primary power failure, or a manually entered shutdown command. When a loss of primary power is sensed, a high- priority hardware interrupt shall initiate software for an immediate, orderly shutdown. When a shutdown occurs in response to a command or malfunction, the software shall bring the affected hardware quickly and automatically to a secure state.

5. System Failover: The software system shall support fully automatic failover to redundant hardware for all indicated systems.

During normal operation, two hardware units shall be in an operational state with one unit in the primary mode performing all on-line and real-time functions and the other unit operating in a backup mode. The backup unit may be performing parallel off-line functions. Periodic checkpointing or other methods shall be utilized to ensure that files used by the backup processor are current. When a malfunction of the primary unit is detected, an orderly transfer of function shall take place from the failed unit to the

backup unit. Operator intervention shall not be required. Neither unit shall be favored as primary.

After restoration of the failed processor, retransfer to the restored unit shall not be required.

6. Diagnostics: The software shall contain diagnostic programs to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures. The system manufacturer's standard diagnostic routines shall be used as much as possible. Diagnostic software and test programs shall be included for each indicated component in the system.

   Diagnostic routines shall test for power supply, central processing unit, memory, and I/O bus failures

7. Alarm Handling:

   a. Diagnostic alarms shall result from hardware and software errors detected by online diagnostics which might affect operation of the software.

   b. The alarm handling sequence shall be:

   When an alarm condition has been detected, log an alarm message on the system printer, display the alarm message on the alarm window of each operator display screen and actuate an audible alarm at the operator display screen.

   Continue the audible alarm until the alarm condition is acknowledged by an entry from the operator display screen.

   When an alarm is acknowledged log an Alarm Acknowledge message on the system printer.

   When an alarm condition clears, log a Clear message on the system printer.

8. Message Logging:

   a. All alarms, status change, parameter change and event messages directed to the system printer shall begin with the time of day in hours, minutes, and seconds using 24-hour clock notation. Every hour or once per page log a "date" message indicating the day, month, and year. Buffer messages if they are generated faster than the printer can print them.

   b. Messages shall include the following:

      Time of day of occurrence (HH:MM:SS).
      Message type.
      Tag or device number.
      Description of device or parameter.
      Description of condition.

9. Calendar/Time Program: The calendar/time program shall update the second, minute, hour, day, month, and year in the operating system and make accurate time and date information available to all system level and application software. Variations in the

number of days in each month and in leap years shall be handled automatically. The operator shall be able to set the time and date from any terminal after giving his unique security code.

10. Operator Interface:

    a. System software shall create and modify alphanumeric and graphic displays, compress display information for storage, and link dynamic field to database variables. The system shall be capable of storing up to [200] different displays at each operator workstation.

    b. Each display screen shall be able to be made up of any or all of the following components at the option of the operator:

       Static and dynamic alphanumeric information.
       Static and dynamic graphic symbols.
       Dynamic bar graph displays.
       Dynamic analog trending displays.

    c. Additionally, all display screens shall include a dedicated area that shall display the current time and date, and system messages.

    d. All configurable information shall be able to be displayed flashing or non-flashing in any of 16 colors. Dynamic fields shall change color or change from flashing to non-flashing or back in response to a change in value, state, or alarm condition of its linked variable. Dynamic displays linked to discrete process inputs and outputs shall be capable of displaying at least three states corresponding to active, inactive, and alarm.

    e. In addition to user-configurable displays, the software shall be provided with standard displays as indicated. The software shall be capable of storing and utilizing a total of at least 75 user-configurable display formats.

    f. All user-configurable displays shall be able to be viewed on any operator workstation:

       (1) Alphanumeric: Static and dynamic alphanumeric information shall be able to be displayed in any of 16 colors and in at least four different font and character size combinations. Dynamic alphanumeric displays linked to discrete signals shall change color or flash in response to the status or alarm condition of its variable.

       (2) Graphic Symbols: Graphic symbol display software shall include a standard library of symbols indicated and allow generation of at least 32 user- defined custom symbols for inclusion in the library. All custom and library symbols shall be capable of being positioned in at least 8 different positions in 45-degree increments at the time of creation.

           Standard graphic symbols shall consist of representatives of process equipment such as pumps, valves, flowmeters, motors, and other equipment in accordance with ISA Standard S5.3.

All graphic symbols shall be easily placed anywhere in the display to a resolution of one pixel at the time of creation and shall be able to be defined as dynamic and linked with a process variable.

(3) Display Editor: An interactive on-line display editor software module shall create, inspect, and modify all displays from any engineering or operator workstation.

Display generation software shall be pixel-based. The use of character-based graphics software, where geometric shapes and figures consist of combinations of fixed graphic character, is not acceptable. The display editor software shall include a menu-driven module for creation of user displays providing the following features:

Creation and storage of closed geometric shapes including circles, ovals, rectangles, and polygons. Shapes shall be able to be created in variable dimensions to pixel resolution.

Creation and storage of open geometric shapes.

No fewer than 100 standard shapes, not counting rotations, shall be in storage at final acceptance.

Creation of single and multiple segment lines in at least three line widths and three line styles.

The ability to fill closed shapes with any available color.

The ability to overlap shapes and symbols and to define which object appears in front or back.

Addition of text to the display in any location in horizontal and vertical formats.

The ability to group, copy, relocate, and resize shapes and groups of shapes. Shapes and symbols shall be able to be moved in any direction a distance as small as one pixel.

The ability to change border and fill colors of shapes and color displayed text.

Recall and insertion of predefined shapes or symbols from a symbol library.

The ability to use different background colors, selected from the table of available colors, for each display.

Displays shall be able to be stored at any time during creation for later completion.

New displays shall be able to be created starting from a blank screen or by recalling existing displays, editing, and storing the display under a new title.

Copying of existing displays shall not require the user to copy files directly using operating system commands.

All displays shall be able to be stored in the system in a logical order, with all displays dealing with a particular area or process grouped together in submenus or subdirectories. Displays shall be selected by the operator from menus or submenus listing all available displays or by paging forward or backward from a current display. Each display menu shall list display titles for each display of sufficient length to allow intuitive identification of the display contents.

Whenever a new display is created, the user shall be prompted for its desired menu references, which shall be automatically added to the menu or submenu upon completion of the display.

(4) Bar Graph Displays: Bar graph displays shall be dynamic representations of analog process variables. Bar graph displays shall be able to be placed anywhere in any graphic display and configurable in variable height and width units. Bar graphs shall indicate process variable value by varying the height of a solid bar in proportion to the variable. Bar graphs shall indicate the range of the variable as defined in the database and shall change color, flash, or otherwise indicate when the variable exceeds its alarm limits.

(5) Trending

Dynamic trend displays shall plot at least four user selectable analog process variables in a time line format. Each variable shall be plotted in a unique color. At least three sets of trend axes shall be able to be displayed on a single display screen.

Current trend displays shall plot real-time data and historical trend displays shall plot data retrieved from historical files. The range of time to be plotted shall be selectable at the time the display is generated. The user shall only be required to set beginning and end time and dates for historical trends and the system shall automatically retrieve the proper data from historical files.

Both the time and process variable axes shall be clearly labeled. Process variable axes shall indicate engineering units for the variables as defined in the database. Trending software shall have the ability to place and move a pointer at any time position and display the actual numeric values for all plotted variables at the pointer.

Trend lines shall be one pixel in width. Full screen trends shall have a resolution of at least 0.75 percent of full scale or better. Trends that use graphic characters to simulate the trend line will not be acceptable.

(6) Standard Displays: The following standard, non-configurable displays shall be included:

Current Alarm Summary.

System Overview, to Display the current status of major system hardware components including the input/output hardware.

Menu Displays, to indicate the various display and application level choices available to the operator.

Point Displays, to indicate all parameters associated with any point in the system. Each entry in the display shall be labeled in engineering units.

(7) Windows: The system software shall be capable of displaying up to four different pages on the operator or engineer monitors simultaneously.

(8) Short Term Historical Trends: Displays shall graphically present the relationship of up to four analog variables on the Y-axis versus time. Alphanumeric information shall be displayed on the same screen to identify points, scales, current values and related information. X versus Y plots shall also be available.

Each operator station shall maintain a one hour history of up to 20 user selected process variables. Both standard and custom graphic displays shall automatically retrieve the full history of a plotted variable if it is one of the 20 active points. Each operator station shall be capable of assigning its own set of 20 process variables for collection. Both ten second and one minute display intervals shall be available.

(9) Variable Term Historical Trends: Any user shall be able to trend any variable stored in the historical data base, including analog, calculated, and digital values. Capabilities shall include:

Trending of up to four variables simultaneously at time intervals ranging from one minute to 24 hours.

Compression and expansion of trends between predefined scales.

Scrolling back and forth in time in full page and half page increments.

Copying any trend in color to a printer with one keystroke.

Predefining sets of historical trend screens accessible from the keyboard or custom graphic displays.

(10) Alphanumeric Group Displays: Groups of up to [96] points shall be displayed with current values. The groups shall be both predefined and operator assignable. The minimum information displayed shall include process variable name, description, value, units, and current status. All points in a group may be displayed through paging keys.

(11) Operator Guides: Operation information guides shall be static messages and may also contain current equipment status information.

Guides shall be accessible by direct function button, by menu, by paging between "adjacent" displays, or by placing the CRT cursor on a currently displayed picture element or alarm line and pushing a"select diagram" button. Paging shall be linked in four directions,i.e., left, right, up and down.

The system shall support split screen displays so that plant information or alarms may be displayed continuously on the main screen while detailed information or operator entry fields are displayed concurrently on a subscreen of the same CRT.

The engineer's workstation shall be able to create new displays and modify existing displays.

C. **Control System Database Software**:

1. Application-level software shall include a comprehensive interactive database system for creating, sorting, editing, and monitoring all process inputs and outputs and internally used variables. The system shall request, receive, process, and store all real-time data according to the information contained in the database. Database points shall be enabled or disabled individually at any time via the engineering workstation by persons with predefined security codes. All creating, sorting, and editing of the database shall be via the engineering and operator workstations.

2. An interactive database editor shall create, inspect, and modify database entries. Modification, addition, or deletion of database information shall not require direct changes to the program source code. Changes made to the database contents shall automatically update all affected locations where the information is stored or used and all applicable displays and formats.

3. Database entries for each type of input/output signal shall consist of the following information in addition to any information required by the system for addressing or internal use.

   a. Discrete Inputs and Outputs (DIO):

      A tag name for internal reference to the point.

      A description of sufficient length to allow a unique name for each point with a minimum of abbreviations or acronyms.

      An enable/disable status flag.

      An alarm monitoring attribute stating if the point is to be alarmed on change of state.

      An alphanumeric description of the inactive state of the point plus an attribute indicating if the field contact is normally open or normally closed.

      A field to accumulate the number of transitions of the point.

   b. Analog Inputs and Outputs (AI and AO):

      A tag name for internal reference to the point.

      A description of sufficient length to allow a unique name for each point with a minimum of abbreviations or acronyms.

      An enable/disable status flag.

Zero, offset, and range constraints.

Engineering units.

An integration and totalization factor as a power of 10.

Engineering units for the totalized value.

At least four separate alarm points.

An alarm priority attribute.

Rate-of-change alarm values for percent change and time.

Active/inactive status flags for absolute and rate-of-change alarms.

c. Database points shall also be definable for manually entered data not received by the system from process interface hardware. Database entries for manually entered data shall be identical to those required above.

4. Database software shall support the algorithms for the determination of control actions and special calculations involving analog and discrete data. Algorithms shall be capable of outputting positional or incremental control outputs and providing the product of calculations to the database for storage. The algorithms shall include alarm checks where appropriate.

   a. As a minimum, the following algorithms shall be provided:

      A calculator algorithm which performs functions such as summing several variables, raising to a power, taking roots, dividing, multiplying, and subtracting.

      A switch algorithm which reads the current value from its input address and stores it as the value of its output address. Two types of switches shall be accommodated, two outputs with one input and one output with two inputs.

      A three-mode Proportional-Integral- Derivative (PID) controller algorithm, with each of the three modes independently adjustable. The algorithm shall support both direct and reverse acting modes.

      Algorithms for lead, lag, dead time, and ratio compensators.

      Algorithms to perform integration and totalization of analog process variables.

   b. Algorithms that drive the setpoint of a controller shall implement bumpless transfers using bias values.

   c. Algorithms shall be modifiable at any time through interactive software modules in a manner consistent with other interactive modules and shall not require any direct source code changes.

5. Alarm Processing:

a. Alarm processing software shall recognize and report alarm events and conditions to the operator in an organized, unambiguous, clear, and convenient manner. Alarms shall be classified into two priority levels and at least two independent classes.

b. Alarm processing software shall generate alarms for the following conditions:

Discrete input or output change of state if defined as an alarm in the database.

Analog value exceeding alarm limits defined in the database.

Analog rate of change exceeding limits defined in the database.

Failure of the workstation processor, mass memory device, printer, process input/output hardware, or other major hardware component.

c. Alarms shall be generated at the time of occurrence and at the time the condition returns to normal.

d. Alarm displays and alarm log entries shall indicate the date and time that the alarm was detected, the tag name and description of the alarmed point, and an entry describing the nature of the alarm.

e. Alarms shall be logged on alarm and event printers as they occur and added to a dedicated standard display containing all current alarms. A portion of all operator workstation display screens shall be dedicated to display up to three recent alarms or other methods shall be used to alert the operator that a new alarm has occurred and provide a means to inspect the alarm display that requires only a single keystroke or menu pick. An alarm summary display shall list at least 100 of the most recent alarms in all classes with the most recent alarm listed first. An additional, separate display shall be available for each individual alarm class. Each alarm class display shall list at least 50 of the most recent alarms in that class with the most recent alarm listed first. Alarms shall appear as flashing or in a unique color until they are acknowledged by the operator. Alarms of different priority shall be easily distinguished on all alarm displays through the use of unique colors or other similar methods.

f. An audible alarm shall sound at the operator's console at each occurrence of a new alarm. The audible alarm shall be silenced when the operator acknowledges the alarm.

g. Alarms originating from database entries such as discrete change or state or analog limit violations shall be able to be enabled or disabled on a point- by-point basis.

h. Acknowledged alarms shall be automatically removed from all displays after returning to a normal condition.

6. Operator Control:

a. All operator commands related to changing system configuration or controlling field devices shall be performed only through an engineer's workstation and shall require more than one keystroke to protect against inadvertent operations.

b. System configuration commands shall require operator confirmation of a requested action before any change is made. This shall apply to changes in the database, report or display formats, algorithms, control sequences, and similar configuration related actions, as well as file copy and file delete commands.

c. Operator control of field devices shall utilize at least a two-step procedure. To control a system output, the operator shall first select the point to be operated. The system shall then respond by confirming that the point has been selected either graphically or by a displayed message and shall present a menu of the valid control actions that can be executed for the point. The operator shall then be required to pick one of the valid control actions and verify his selection before the command is transmitted to the field I/O device.

d. In any sequence requiring operator confirmation, the operator shall be able to cancel the operation at any point prior to executing the command.

7. Historical Data Storage:

a. System software shall include historical data gathering, data reduction, and reporting. Real-time analog signal values shall be collected and stored in the historical database at user selected intervals of every second to every minute. Data reduction capabilities shall be provided to allow the 1 second collection frequency database a minimum of [512] points, 10 second collection frequency database a minimum of [1,280] points, and 60 second collection frequency database a minimum of [3,400] points. Records shall be averaged and reduced to hourly records, and the hourly records shall be averaged and reduced to daily records. Entries for all hourly and daily averaged records shall include minima and maxima. Data shall be stored with a flag to identify it as good, bad, or missing data.

b. Historical records shall be maintained in on-line files before being transferred to removable storage media. System software shall automatically store and summarize on-line files without requiring operator intervention, and shall also prompt the operator to enable the transfer of historical data to removable media. The archiving of historical data to removable media files shall be accomplished through the use of interactive operator software modules and shall not require direct use of operating system commands.

c. Data transferred to removable media shall be able to be easily retrieved for use in reports and on- screen trending or display.

d. A historical data editor shall allow the operator to edit, replace bad values, or insert new values in historical records. Altered values in the historical database shall be tagged for reference purposes.

e. The system shall store on-line data for the following periods:

1 sec. to 1 min. records:	At least 72 hours
Hourly records:	At least 72 hours

Daily records:	At least 180 days
Monthly records:	At least 24 months

f. Historical data retrieval software shall allow access to on-line and off-line data files. Operator requests for off-line files shall be followed by a prompt to the user to mount the appropriate file media. Retrieval software shall allow the data to be used for trending functions, user-written programs, and predefined displays or logs.

8. Logging and Reports: System software shall support two modes of printing for system data. Event and alarm printers shall print entries describing alarms or operator actions at the time they take place. Report printers shall print user defined tabular reports summarizing process data on demand or at previously scheduled times.

a. Event and Alarm Log: Event and alarm logs shall provide a hard- copy record of all alarms and significant operator actions. In addition to the indicated alarms, the following operator actions shall be logged:

Operator acknowledgement of alarms, indicating time and date.

Operator control actions and system database modifications indicating date, time and action taken.

Loss or recovery of communications with input/output hardware.

Event and alarm logging software shall provide page breaks to prevent the printing of log entries over perforations in continuous forms. Each page shall include a header identifying the print-out as an alarm log, and shall include the current date.

b. Reports: Report logs shall provide a hard-copy summary of user-selected process data. At least [30] report formats shall be able to be defined in the system for each log. Report-printing software shall include a user-interactive, on- line report editor to allow the operator to select the following parameters for each log:

Measured variables, calculated variables, or manually entered data.

Start and end time of data to be included in the report.

Print format for each variable.

Titles and subtitles to appear on each page of the report, including the assigned report name, current time, and date.

Paper width from 8 to 14 inches.

Print pitch from 5 to 16.5 characters per inch.

Number of lines per page and number of pages per report.

All points in the system, including all input/output points, manually entered points, and calculated points, shall be available for use in logs. Points shall be referenced in report formats by their assigned identification tag name.

The linking of tag names to the appropriate database entry shall be automatic and transparent to the user.

All reports shall be able to be printed on a user-selected time schedule or on demand.

Reports shall include "no data" and "bad data" entries to distinguish those conditions form zero values and shall distinguish manually entered values from values collected automatically by the system.

Reports shall be capable of printing average, minimum, and maximum values for analog variables and the time occurrence for minima and maxima. Information that shall be printable for discrete variables shall include run time, state, and transition count.

Demand reports shall be selected by the operator for printing from a menu of all available reports. Whenever new report formats are created, the user shall be prompted for the report name, which shall automatically be added to the menu upon completion of the format.

Creation and modification of report formats or content shall not require direct modifications to system source code and shall only be accomplished from the engineering workstations.

3.2 TRAINING

A. **General**:

1. The training program shall be tailored to the requirements of the OWNER'S personnel and shall include general overview and detailed training classes for engineers, programmers, operators, and maintenance personnel.

2. An "instructor week" shall consist of 40 hours of actual instruction time. Instruction shall be scheduled to accommodate the OWNER'S personnel schedules. The training schedule shall be coordinated with the CONSTRUCTION MANAGER.

B. **Training at Training Center**: The following training shall be conducted at the equipment manufacturer's factory or training center prior to delivery of equipment to the jobsite. Training center training shall include a minimum of [eight] instructor weeks of manufacturer's software training on the system for [five] of the OWNER'S personnel.

1. Conduct training for students having had a one-semester class in Fortran, Basic, or Pascal, but no professional programming experience such that students shall be able to:

a. Operate the computer system on a day-to-day basis.

b. Make configuration changes.

c. Make simple program changes to the applications software.

2. Cover at least the following subjects:

a. System overview, covering basic system design, configuration, functions, maintenance, and operation.

b. System hardware.

c. Operating system.

d. Overall design and philosophy of the application programs.

e. Complete system backup and reload procedures.

f. Operational details of the text editor, compilers, debugging aids, file management utilities, and system generator.

g. Diagnostic software capabilities, usage, and interpretation of results.

3. Training in the maintenance of the computer system software shall include:

a. Training on the system design features, components, and functions of the computer system software and hardware.

b. Training for standard software.

c. Training for application software.

C. TRAINING AT THE SITE

1. A minimum of [16] instructor weeks of software and hardware training shall be conducted.

2. The software training shall provide instruction and hands on experience such that students with limited programming or configuration experience shall be capable of day-to-day programming and configuring with no guidance and with only minimal supervision on unusually complex problems.

3. Site training shall cover the following subject, as a minimum:

a. System overview including basic system design, configuration, and purpose.

b. System hardware including specific hardware elements and configurations.

c. Programmer equipment orientation in which the student becomes familiar with the operation maintenance procedures.

d. Application programs, covering the design and philosophy of all applications. The intent is to make each student fully knowledgeable in all aspects of the system, along with methods for making additions, modifications, and deletions to systems.

3.3 SYSTEM PRECOMMISSIONING

A. Precommissioning shall commence after acceptance of all wire, calibrating and loop tests, and all inspections have been conducted. Precommissioning shall demonstrate proper operation of all systems under this contract with process equipment operating over full operating ranges under actual operating conditions. All precommissioning and test activities shall follow procedures developed under Section 13300.

B. Proper operation of all final control elements, control panels and instrumentation shall be verified by tests conducted in accordance with these requirements. Where feasible, system pre-commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges and environmental conditions.

Final control elements, control panels, and ancillary equipment shall be tested under startup and steady-state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. All hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady-state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory operation. The transient stability of final control elements operating under the control of field mounted, and software based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any) and making necessary controller adjustments, as required, to eliminate excessive oscillatory amplitudes and decay rates.

C. All electronic control stations incorporating proportional, integral and differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset and rate setting(s) as required to achieve a proper response. Measured final control element variable position or speed setpoint settings shall be compared to measured final control element position or speed values at 10 percent, 50 percent and 90 percent of span and the results checked against specified accuracy tolerances. Specified accuracy tolerances are defined as the root-mean-square- summation of individual component accuracy requirements. Individual component accuracy requirements shall be as specified by published manufacturer accuracy specifications whenever accuracy requirements are not specified.

D. The Systems Integration Contractor shall submit an instrumentation and control system precommissioning completion report which shall state that all contract requirements have been met and which shall include a listing of all instrumentation and control system maintenance and repair activities conducted during the precommissioning testing. Acceptance of the instrumentation and control system precommissioning testing must be in writing by the CONSTRUCTION MANAGER before the seven day operational testing shall begin.

3.4 STARTUP

A. **Startup and Instruction:** The Systems Integration Contractor shall furnish start-up support to include the Instrumentation Subcontractor's personnel, electrical personnel, and any

instrument manufacturers representatives as required during the testing period to achieve a fully operating system.

3.5 INSTRUMENT AND I/O SUMMARY

A. **General**: The Instrument and I/O Summary (I&IOS) contained herein itemizes the I/O associated with the hardware provided under this Contract.

B. Each column on the I&IOS is defined as follows:

1. Tag Number: The identifier assigned to a device which performs a function in the control system. The System Integration Contractor shall use the identifier in tagging devices in the field.

2. Loop Title: The name of the control loop in which the device functions.

3. Description: A process-oriented functional assignment made to a device which puts the device in the context of the loop in which it functions.

4. P&ID Dwg: The Process and Instrumentation drawing upon which the device appears.

5. Spec. No.: The number of the Specification Section which describes the device.

6. I/O Type: The itemization of input or output by type.

7. Control Panel No.: The designation of the control panel with which the device is associated.

8. Panel Face Dwg. No.: The instrumentation drawing upon which the control panel face is indicated.

9. CSI No.: The designation of the Computer System Interface Cabinet associated with the control panel.

10. Install. Detail: The designation of the detail indicating how the device shall be installed.

11. Mech. Dwg.: The mechanical drawing upon which the device appears.

12. Elect. Dwg.: The electrical drawing upon which the device appears.

13. Remarks: A "scratch pad" area which may contain information relating to the device.

C. [ ] pages of I&IOS follow this Section

** END OF SECTION **

INSTRUMENT AND I/O SUMMARY

Tag No.	Loop Title	Description	P&ID Dwg.	Spec. No.	I/O Type	Control Panel No.	Panel Face Dwg. No.	CSI No.	Install. Detail	Mech. Dwg.	Elect. Dwg.	Remarks
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

I/O Total: DI = [ ] DO = [ ] AI = [ ] AO = [ ]