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SECTION 16799

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

****

(NOTE:) This specification covers the requirements for supervisory control and data acquisition systems. This specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.

****

PART 1 - GENERAL

****

(NOTE:) This section will be used in conjunction with Section 16415 ELECTRICAL WORK, INTERIOR; Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL; Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; Section 16768 FIBER OPTIC DATA TRANSMISSION SYSTEM; Section 16792 WIRELINE DATA TRANSMISSION SYSTEM; Section 16760 INTERCOMMUNICATION SYSTEM; and any other guide specification sections required by this design.

****

1.1 SUMMARY (Not Applicable)

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI X3.64	(1979) Additional Controls for Use with American National Standard Code for Information Interchange
ANSI C57.13	(1978) Requirements for Instrument Transformers.
ANSI C62.16	(1993) American National Standard Guide for Gas Tube Surge Arresters on Wire Line Telephone Circuits
ANSI C63.16	(1993) American National Standard Guide for Electrostatic Discharge Test Methodologies and Criteria for electronic Equipment

DEPARTMENT OF COMMERCE

FIPS 127-2	(1993) Database Language SQL
FIPS 151-2	(1993) POSIX: Portable Operating System Interface for Computer Environments (IEEE 1003.1-1988)

CODE OF FEDERAL REGULATIONS (CFR)

CFR 47 Part 15	(July. 1986) Radio Frequency Devices

DNP USER'S GROUP

DNP V3.00	(1992) DNP V3.00 Data Object Library

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA 232-E	(1991) Interface Between Data Terminal Equipment and Data Circuit-Interchange
EIA 485	(1983) Standard for electrical characteristics of Generators and Receivers for use in Balanced Digital Multipoint systems
EIA 568A	(1995) Commercial Building Telecommunication Cabling Standard

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std C37.1	(1994) IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control
IEEE C37.90.1	(1989) Surge Withstand Testing (SWC)
IEEE C62.41	(1991) Surge Voltages in Low-Voltage AC Power Circuits
IEEE C62.45	(1992) Guide of Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
IEEE No. 100-92	(1993)IEEE Standard Dictionary of Electrical and Electronic Terms
IEEE No. 383	(1974) Type Test of Class 1E Electrical Cables, Field Splices, and Connections
IEEE 610	(1990) IEEE Standard Computer Dictionary
IEEE 693	(1997) Recommended Practice for Seismic Design of Substations
IEEE 802.3	(1992) Carrier Sense Multiple Access/Collision Detection (CSMA/CD)

INSTRUMENT SOCIETY OF AMERICA (ISA)

ISA S5.1	(1992) Instrumentation, Symbols and Identification - ANSI/ISA
ISA S5.5	(1985) Graphic Symbols for Process Displays - ANSI/ISA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(1993) General Standards for Industrial Controls and Systems
NEMA WC 3	(1989; including Revision 6) Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81)
NEMA 250	(1985; Incl. Rev. 1 and 2; ICS-6) Enclosures for Electrical Equipment

STANDARD PERFORMANCE EVALUATION CORPORATION

OSG	(1996) Open Systems Group SPEC marks, including SPECfp95 and SPECint95.
XPC	(1997) X Performance Characterization Project, including Xmark 93.

1.3 SYSTEM DESCRIPTION

****

(NOTE:) Designer will add location and site specific requirements.

****

1.3.1 System Requirements

The supervisory control and data acquisition (SCADA) system will be used by [...] to monitor and control the operation of [...] at [...]. The SCADA system master station will be located at [...] and remote access workstations will be located at ...].

1.3.2 System Reliability

a. The system, including all components and appurtenances, shall be configured and installed to yield a mean time between failure (MTBF) of at least 10,000 hours as defined in PARAGRAPH RELIABILITY CALCULATION, and shall be calculated based on the configuration specified in paragraph "DELIVERY OF TECHNICAL DATA AND COMPUTER SOFTWARE" for system overall reliability calculations. Each component MTBF shall be determined based on the specific equipment to be provided for this project.

b. With the exception of a fiber-optic cable cut or other similar cable destruction, the Mean-Time-To-Repair for the system shall not exceed 12 hours based on an electronic technician, trained as specified, having the recommended set of spare parts, a test set, and with repair beginning within 15 minutes of the failure. A failure is defined as anytime the system is unable to perform specified requirements.

1.3.3 System Activity States

a. The normal activity state is defined as the condition where 10% of the digital inputs have changed state, and 10% of the analog input have changed by an amount exceeding the exception reporting limits in the past 30 seconds. In addition, four new display and one control command have been requested in the past 60 seconds, and one hourly scheduled log of two pages content with associated alarm logging has occurred.

b. The high activity state is defined as the condition where 50% of the digital inputs and 50% of the analog inputs have changed state in the past 30 seconds. In addition, sixteen new displays have been requested in the last 30 seconds and four control commands have been issued in the last 60 seconds. Also, one global "FREEZE" and read as specified, and one hourly scheduled log of two pages content with associated alarm logging has occurred in the last 30 seconds.

1.3.4 System Scan Times

System scan times shall be adjustable. The scan rates for integrity scans, pulse accumulator, and exception scans shall be adjustable separately. The time limit that the master station will wait for a response shall be operator selectable for each RTU or communication channel. It shall be possible to set each type of scan to use any communication channel independently of the settings for any other channel.

1.3.4.1 Integrity Scans

An integrity scan shall gather the exact value of all digital and analog inputs to the system from each point, regardless of previous values and exception deadbands. It shall be possible for the operator to perform integrity scans on demand or on a settable time schedule for any point or RTU. A system-wide integrity scan for every point shall be performed on a time schedule adjustable between 5 minutes and 24 hours. The system-wide integrity scan period shall be initially set to 60 minutes.

1.3.4.2 Exception Scans

Exception scans shall obtain digital data from digital points which have changed from the previously reported value, and shall obtain analog data from analog points which have varied by more then a pre-determined limit from a previously reported value. Notification to the Master station of the availability of SOE data shall be part of the exception scan. The exception scan rate shall be adjustable from 1 to 15 seconds, and shall initially be set to 3 seconds. The analog exception limits shall be operator selectable between 1% and 100% of full scale for individual points, and shall initially be set to 3% of full scale for all analog inputs.

1.3.4.3 Pulse Accumulator Scans

At adjustable intervals, from 5 to 60 minutes, the master station shall broadcast a freeze command to all RTUs to ensure that pulse accumulator data is taken at the same time. Intervals shall be selectable based on time, or as the result of an external command. Accumulator scans shall be initially set to 15 minutes, synchronized with the beginning of the hour.

1.3.5 System Response Times

Every operator request shall generate a response within 1 second which indicates the request has either been completed, is being processed, or cannot be performed. The system update times shall not exceed the following requirements.

a. Any new display shall begin to update the monitor within 2 seconds after being requested by the dispatcher command under a normal activity state. Preformatted displays shall be completely presented within 5 seconds after the request.

b. All calculated points with real-time variables shall be updated from the database, when displayed at the operator's workstations, at least every 5 seconds.

c. All digital input changes which are the result of a commanded control operation shall be updated on the monitors within 3 seconds of the change occurrence at the RTU.

d. During periods of normal activity state, the following performance criteria shall be met. Any change in a digital input point shall be updated, when displayed at the operator's workstations, in less than 3 seconds after the change occurs in the RTU. Analog exception changes (values which vary by an amount greater than the reporting deadband) shall be updated within 3 seconds after the analog value changes in the RTU.

1.3.6 Display Accuracy

****

(NOTE:) Designer will add requirements for additional site specific measurements, including range and accuracy, for any special application not listed.

****

The system shall maintain a 0.5 percent total end-to-end accuracy from transmitter signal output to workstation monitor for the applications specified and shall display the value as specified.

a. Current: with a range for the specific application ± 1.0% of reading; display and print to nearest ampere.

b. Voltage: with a range for the specific application ± 1.0% of reading; display and print to nearest volt.

c. Power Factor: 1.0% of reading; display and print to nearest hundredth.

d. kWh: with a range for the specific application ± 1.0% of reading; display and print to nearest kWh.

e. Temperature: with a range for the specific application ± 2.0 °F; display and print to nearest 1.0 °F.

f. Pressure: with a range for the specific application ± 2.0% of range; display and print to nearest psi.

g. Flow: with a range for the specific application ± 3.0% of range; display and print to nearest unit.

[h. Special application(s) added by the designer.]

1.3.7 Environmental Requirements

****

(NOTE:) Designer will include sufficient air conditioning to maintain the Master Station temperature at 23 degrees C (75 degrees F), including allowance for Master Station Equipment and personnel cooling loads.

****

1.3.7.1 Temperature and Humidity:

a. All SCADA system Master Station and associated equipment shall operate without damage or degradation under the following ambient conditions, unless otherwise noted.

Operating Temperature: 60 degrees F to 85 degrees F (16 degrees C to 29 degrees C)

Operating Humidity: 20 % to 80 %, noncondensing

b. All SCADA system field equipment shall operate without damage or degradation under the following ambient conditions, unless otherwise noted.

Operating Temperature: -17 degrees F to 140 degrees F (-25 degrees C to 60 degrees C)

Operating Humidity: 10 % to 90 %, noncondensing

1.3.7.2 Vibration and Shock

All SCADA system equipment shall withstand vibration and shock in accordance with IEEE Standard C37.1. Master Station equipment shall operate as specified when subject to vibrations of severity V.S.1. Field equipment shall operate as specified when subject to vibrations of severity V.S.3. Portable equipment shall continue to operate as specified when subjected to shock associated with a height of fall equal to 1000 millimeters.

****

(NOTE:) The designer will determine the need for seismic qualification and establish the seismic qualification level for the project, using the guidelines of IEEE 693.

****

[1.3.7.3 Seismic Qualification

RTUs, intelligent transducerless RTUs and intelligent electronic devices shall be qualified according to the requirements of IEEE 693, [high] [moderate] [low] seismic qualification level.]

1.3.8 Electrical Transients and Electromagnetic Interference

1.3.8.1 General

All equipment shall comply with IEEE C62.41. All RTUs shall also comply with IEEE C37.90.1, including all input and output interfaces as defined in IEEE C37.1.

1.3.8.2 Power Line Surge Protection

All equipment connected to ac circuits shall be protected from power line surges and meet the requirements of IEEE C62.41 location category B3, while equipment is operating. In addition, all RTUs shall be protected to meet the requirements of IEEE C37.90.1. Fuses shall not be used for surge protection.

1.3.8.3 Sensor and Control Wiring Surge Protection

All digital and analog inputs and outputs shall be protected against surges induced on control and sensor wiring. and meet the requirements of IEEE C37.90.1 while equipment is operating. Fuses shall not be used for surge protection.

1.3.8.4 Communications Links Surge Protection

All communications equipment shall be protected against surges induced on any communications link and meet the requirements of IEEE C37.90.1 while equipment is operating. Fuses shall not be used for surge protection. All cables and conductors, except fiber optics and LAN circuits run inside buildings, which serve as communications links shall have surge protection circuits installed at each end. Protection shall be furnished at equipment and additional triple electrode gas surge protectors rated for the application on each wireline circuit shall be installed within three feet of the building cable entrance. Surge protectors shall meet the requirements of ANS1 C62.61.

1.3.9 Master Station Equipment Power Source.

Master Station equipment shall be powered from an UPS as shown, and described in SECTION 16611, UNINTERRUPTIBLE POWER SYSTEM (UPS) up to 5 KVA.

1.3.10 Communications

****

(NOTE:) The designer will select the minimum number of communication channels required for the project, based on site layout, point counts and required communication protocols. The designer will not exceed 1,000 points per communication channel and will provide a separate communication channel for every required communication protocol.

****

****

(NOTE:) The designer will utilize fiber optic communication channels where feasible. Other communication options, such as spread spectrum radio, are available for sites which are not served by physical communication links, but may result in degraded time clock synchronization. Radio communication will not be used for RTUs requiring coordinated time-tagging of SOE inputs which are divided among multiple RTUs.

****

****

(NOTE:) The designer will coordinate with the installation communication office, when using RF, to obtain radio equipment approval and frequency assignments.

****

The Master Station shall be configured to accept a minimum of [64] [32] [16] [8] data communications channels. Each communication channel shall meet the performance requirements as specified. Each SCADA system communication channel shall be set to 9600 bps. Each of the channels shall support independent transmission rates and any single protocol as specified.

1.3.11 Expansion Requirements

****

(NOTE:) The designer will select the Master Station I/O point capacity based on project specific requirements.

****

The Contractor shall provide sufficient I/O capacity in each RTU to accommodate all I/O points shown and specified, including specified spare capacity. In addition, the contractor shall provide at the Master Station for a total of [64,000] [32,000] [16,000] [8,000] points (50% digital and 50% analog) that will be a combination of points shown, existing or new programmable logic controllers and intelligent electronic devices, and future requirements. Based on these requirements, the Contractor shall determine actual processor memory and speed

requirements, RTU data storage capacity, communication polling capacity at an RTU, number of I/O card racks, power supply capacity, battery capacity, and enclosure dimensions.

1.3.12 Protocols

****

(NOTE:) The designer will verify the communication protocols of any existing RTUs, programmable logic controllers, or intelligent electronic devices to be integrated into the SCADA system, and include the required additional protocols in the list below. In addition, the designer will review with the installation the need to specify MODBUS and DNP, which are industry standard protocols which will provide flexibility in system expansion. The designer will require multiple data communication channels between the Master Station and any site requiring multiple protocols.

****

The Master Station shall include software allowing it to communicate and fully utilize all functionality of any RTU using any of the following protocols. Each of these protocols shall be independently supported on all communication channels. In addition, RTUs shall include software allowing them to communicate and fully utilize all functionality of any intelligent electronic device using any of the following protocols. Where interfaced to existing RTUs, operation shall be transparent to the user.

a. Contractor's Supplied Protocol.

[b. MODBUS RTU/ASCII.]

[c. Distributed Network Protocol (DNP) 3.0.]

[d. Protocols added by designer.]

1.4 DELIVERY OF TECHNICAL DATA AND COMPUTER SOFTWARE

1.4.1 General

All items of software and technical data (including technical data which relates to computer software), which is specifically identified in this specification shall be delivered strictly in accordance with the CONTRACT CLAUSES and the Contract Data Requirements List, DD Form 1423. All data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All drawings submitted shall be in latest version of Microstation or latest version of AutoCAD as required. Five sets of CD-ROMs shall be provided after final drawings are approved. Manuals provided shall contain the minimum content specified, although varied packaging and formats are acceptable. The Contractor may submit standard manuals with additions as necessary to conform to the requirements listed below.

1.4.2 Technical Data Package

The data package shall include:

1.4.2.1 System Drawings

a. SCADA system block diagram.

b. Master Station equipment installation, block diagrams, and wiring diagrams.

c. RTU installation, block diagrams, and wiring diagrams.

d. RTU physical layout and schematics.

e. LAN equipment installation, block diagrams, and wiring diagrams.

f. Sensor and controls wiring and installation drawings.

g. Details of connections to power sources, including grounding.

h. Details of surge protection device installations.

i. Instrumentation and control diagrams, based on ISA S5.1.

j. Annotated logic diagrams, based on ISA S5.2.

k. Spare parts lists.

l. Test equipment requirements lists.

1.4.2.2 Equipment Data

A complete data package shall be delivered for all materials and equipment as specified.

1.4.2.3 System Descriptions and Analyses

The data package shall include complete system descriptions, analyses, and calculations used in sizing equipment required by these specifications. Descriptions and calculations shall show how the equipment shall operate as a system to meet the performance of this specification. The data package shall include:

a. Master Station Computer memory size, including specified expansion requirements.

b. Data transfer rates and protocol descriptions for all communications, including LAN, Master to RTU and RTU to intelligent electronic device.

c. Hard disk drive descriptions and sizes, including specified expansion requirements.

d. RTU memory size.

e. Channel loading calculations for each Master Station to RTU communication channel.

f. Alarm response time calculations for analog and digital alarms.

g. Command response time calculations.

h. Automatic start up description.

i. Database update procedure and response time calculations.

j. Historical database description and time calculations for retrieval and display of historical data.

k. Expansion and method of implementation, including specified expansion requirements.

l. RTU operation, all modes specified.

m. Sample copy of each report specified.

n. Color printouts or photographs representative of typical graphics, for all distinct types of displays.

o. Library of graphics symbols.

1.4.2.4 Software Data

The data package shall consist of descriptions of the operation of system, command, and applications software as specified. The software data shall be organized as follows:

a. Normal mode operation (primary and backup master station computer on-line).

b. Degraded mode operation (primary master station computer off-line, backup master station computer on-line).

c. RTU communicating modes.

d. RTU noncommunicating (stand alone) mode.

1.4.2.5 System Overall Reliability Calculations

The data package shall include all manufacturers' reliability data and calculations required to show compliance with the specified reliability. The calculations shall be prepared using the information provided in PARAGRAPH RELIABILITY CALCULATION as a guide. The calculations shall be based on the following configuration:

a. All Master Station system equipment.

b. Data transmission equipment associated with one communication channel circuit, for each type of data transmission required.

c. A single RTU with total I/O functions as specified in paragraph "FIELD EQUIPMENT" for RTU test set.

d. Sensors shall not be included in the calculations.

1.4.2.6 Certifications

****

(NOTE:) The designer will include IEEE 693 if seismic requirements are included in the project specification.

****

The Contractor shall provide written certifications that system components meet the requirements specified including:

a. CFR 47 Part 15

b. IEEE C37.90.1

c. IEEE C62.41.

[d. IEEE 693.]

1.4.3 Existing Conditions Report

The existing conditions report as specified in Paragraph Existing Controls, and associated documentation as specified.

****

(NOTE:) The designer will consult with the installation and select a factory test or a factory demonstration. A factory test will be more costly.

****

1.4.4 Factory Demonstration Data

a. Factory Demonstration Outline

The Contractor shall submit an outline of the demonstration in accordance with Paragraph Factory Demonstration. The factory demonstration shall demonstrate the capacity of the system to accomplish control and monitoring. The Contractor shall submit the factory demonstration outline to the Government for approval.

b. A copy of the standard operation and maintenance manuals, including a draft of required changes/additions shall be delivered to the Government prior to beginning the factory demonstration.

c. Factory Demonstration Data

The Contractor shall submit the factory demonstration data to the Government after successful completion.

1.4.5 Performance Verification Testing and Endurance Testing Data

1.4.5.1 Performance Verification Testing and Endurance Testing Procedures

The Contractor shall submit test procedures for the Performance Verification Test (PVT) and endurance test. The test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification. The Contractor shall submit the PVT and endurance test procedures for approval.

1.4.5.2 Performance Verification Testing Data

The Contractor shall submit the performance verification test data to the Government after successful completion of the performance verification test.

1.4.5.3 Endurance Test Data (Phase II)

The Contractor shall submit the endurance test data (Phase II) to the Government after completion of phase I of the endurance test.

1.4.5.4 Endurance Test Data (Phase IV)

The Contractor shall submit the endurance test data (Phase IV) to the Government after completion of phase III of the endurance test.

1.4.6 Training Data

Lesson plans and training manuals for the training phases, including type of training to be provided and with a list of reference material shall be submitted for approval as specified.

1.4.7 Operation and Maintenance Manuals

****

(NOTE:) The designer will consult with the installation to determine the quantity of each type of manual required.

****

1.4.7.1 General

The operation and maintenance manuals shall consist of the manufacturer's standard manuals. Final copies of the manuals shall be delivered to the Government within 30 days after completing the endurance test. Each manual's contents shall be identified on the cover. The manuals shall have a table of contents. The final copies delivered after completion of the endurance test shall include all modifications made during installation, checkout, and acceptance. Manuals provided shall contain the minimum content specified, although varied packaging and formats are acceptable, with addenda/appendices as necessary to conform to the requirements listed below.

a. Functional Design Manual: [2] [...] copies.

b. Hardware Manual: [2] [...] copies.

c. Software Manual: [2] [...] copies.

d. Operator's Manual: [6] [...] copies.

e. Maintenance Manual: [2] [...] copies.

f. Test Equipment Manuals: [2] [...] copies for each type of equipment.

1.4.7.2 Functional Design Manual

The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functionality. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes. The manual shall describe complete details of the processing of data, data communications, including data types and formats, data processing and disposition, data link integrity for all system components and peripherals required for each system's functional and operational modes.

1.4.7.3 Hardware Manual

The hardware manual shall describe all equipment furnished, including:

a. General description and specifications.

b. Installation and checkout requirements.

c. Equipment electrical schematics and layout drawings.

d. Interface definitions.

e. Expansion, including installation of new RTUs.

1.4.7.4 Software Manual

The software manual shall describe the functions of the operating system and all applications software, and shall include all other information necessary to enable proper loading, testing, operation and expansion.

a. The manual shall have a separate section for Master Station Equipment, LAN equipment, peripherals and Workstation software including:

1. Definitions of terms and functions.
2. Procedures for system startup.
3. Database format, data entry tables/listings.
4. Description of the applications programs.
5. Operator commands.
6. Report generator data format, output format, and content.
7. Directory of all disk files.
8. Alarm messages and formats.
9. System access requirements.
10. Description of all communications protocols, including data formats, command characters, and a sample of each type of data transfer.
11. Description of procedures for adding new RTUs to the system.
12. Methods of expansion and modification.

b. The manual shall have a section for RTU software, including:

1. Definitions of terms and functions.
2. Descriptions of applications programs.
3. Description of database format and data entry requirements.
4. System access requirements.
5. Description of all communications protocols, including data formats, command characters, and a sample of each type of data transfer.

c. The manual shall have a section for all custom application software provided. The section shall include:

1. Definitions of terms and functions.
2. Description of the applications programs.

1.4.7.5 Operator's Manual

The operator's manual shall explain all procedures and provide all instructions for operation of the system, including:

a. Computers, peripherals, LAN and Workstations.
b. System startup and shutdown procedures.
c. Commands.
d. Alarm presentation.
e. Graphics.
f. Reports generations.
g. Failover and restart procedures.
h. Application programs as specified.

1.4.7.6 Maintenance Manual

The maintenance manual shall include descriptions of maintenance for all equipment, including;.

a. Condensed description of how the equipment operates.
b. Block diagrams indicating major assemblies.
c. Troubleshooting information.
d. Software and hardware test and diagnostic routines.

e. Adjustments necessary for periodic maintenance.

f. Schematic diagrams of electrical/electronic circuits down to a module replacement or field repair level.

g. Parts location illustrations.

h. Repair parts lists indicating sources of supply.

i. Recommended test equipment indicating sources of supply.

1.5 TESTING

1.5.1 General

The Contractor shall perform testing of all Master Station and associated equipment, data transmission equipment and circuits, instrumentation, and field equipment, at the site, including adjustments of the completed SCADA system as specified. The Contractor is responsible for providing all personnel, test equipment, instrumentation, and supplies necessary to perform all testing. Written notification of any planned testing shall be given to the Government at least 21 days prior to any test, and in no case shall notice be given until after the Contractor has received written Government approval of the specific testing procedures.

1.5.2 Test Procedures and Reports

The procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. The test reports shall be used to document results of the tests. Reports shall be delivered to the Government within 7 days after completion of each test.

1.6 MAINTENANCE AND SERVICE

1.6.1 General Requirements

The Contractor shall provide all maintenance services required and equipment necessary to maintain the entire SCADA system operational as specified for a period of 2 years after successful completion of the Endurance Test. Maintenance shall include preventive maintenance in addition to repairs, replacements, and adjustments and software updates. Written permission shall be obtained from the Government prior to performing any service work or adjustments which have any impact on facility operations.

1.6.2 Description of Work

The adjustment and repair of the SCADA system includes all Master Station equipment, Workstation equipment, LAN equipment, software updates, data transmission equipment, and RTUs. Contractor shall perform each manufacturer's required adjustments and all other work necessary for proper operation as specified.

1.6.3 Service Calls

The Government will initiate service calls when the SCADA system is not functioning properly. The Government shall be furnished with a telephone number where the service supervisor can be reached at all times. Service personnel shall be at the site within 24 hours after receiving a request for service. The SCADA system shall be restored to proper operating condition within 72 hours after receiving a request for service.

1.6.4 Records and Logs

The Contractor shall keep records and logs of each maintenance and service task, and shall organize cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices on a site-by-site basis. The log shall contain all initial analog span and zero calibration values and testing of all digital points. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the SCADA system. The Contractor shall provide the government with a summary report of the maintenance and service performed during each previous month.

1.6.5 System Modifications

The Contractor shall make any recommendations for system modification as part of maintenance and service in writing to the Government. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the system documentation including drawings and manuals.

1.6.6 Software

The Contractor shall provide notices of all software updates and verify operation in the system, if the Government chooses to incorporate the update. These updates shall be accomplished in a timely manner, fully coordinated with SCADA system operators, and shall be incorporated into the manuals and software documentation. There shall be at least one scheduled update per year of the warranty period, at which time the Contractor shall install and validate the latest released version of the Contractor's software, upon receiving written approval by the Government.

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(NOTE:) The designer will consult with the installation to determine if telephone consultation is to be required.

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[1.6.7 Telephone Consultation

The Contractor shall provide up to 80 hours per year of telephone consultation to Government personnel. The Contractor shall keep a log by month, identifying caller, date and length of call, and results of call.]

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, with model and serial number in a conspicuous place. All materials and equipment shall be currently in production at time of delivery to the Government.

2.1.2 Factory Burn-In

a. All RTUs shall be tested for a minimum of 72 hours under power prior to shipment from the factory. The second 24-hour period shall be run with an elevated ambient temperature of 122 degrees F (50 degrees C). The equipment shall be interconnected with devices which shall cause it to perform all operations with loads on the various components equivalent to those which will be experienced in actual service. Units shall be in continuous scan during the burn-in.

b. In the event that a component fails, system testing following component replacement shall resume at the beginning of the test.

c. Results of the testing shall be submitted to the Government prior to shipment.

2.1.3 Nameplates

Laminated plastic nameplates shall be provided for each equipment enclosure and device furnished. Laminated plastic shall be 1/8-inch (0.3 cm) thick, white with black center core. Nameplates shall be a minimum of 1-inch by 3-inches (2.5 cm by 7.5 cm), with minimum 1/4-inch (0.6 cm) high engraved block lettering. Nameplates for devices smaller than 1-inch by 3-inches (2.5 cm by 7.5 cm) shall be attached by a non-ferrous metal chain. All other nameplates shall be attached to the device. The nameplate for each equipment enclosure or device shall include the designator or number as shown, and the site name. Site names shall be provided after order placement. Nameplates shall be attached to the equipment with stainless steel panhead screws.

2.1.4 Field Wiring, Cabling, and Terminal Blocks

a. Internal wiring in factory pre-wired enclosures shall be installed according to the Contractor's standard as to wire size, insulation, and method of termination on internal equipment. Interconnecting cables between devices shall meet the flame test requirements of IEEE Standard 383 (ANSI N41.10) using a gas burner flame source. The individual conductors of the interconnecting cables shall meet the flame resisting test requirements of NEMA WC 3. Each individual conductor in individual enclosures shall be uniquely identified in accordance with ICS-1. Splices shall not be permitted.

b. Rail mounted compression clamp terminal blocks shall be provided for conductors requiring connection to circuits external to the specified equipment, and shall be suitable for up to 12 AWG wire. Terminal blocks for analog circuits shall be knife switch disconnecting type. Terminal blocks shall be grouped for easy accessibility unrestricted by interference from structural members and internal devices. Sufficient space shall be

provided on each side of each terminal block to allow an orderly arrangement of all leads to be terminated on the block. Plastic wiring duct or other factory mounted cable support devices shall be provided to support cables for external circuit wiring.

c. Terminal blocks, interposing relays, switches, or similar devices shall be readily accessible. The equipment shall be located in compartments, enclosures, or junction boxes in such arrangement that maintenance personnel shall have direct access to the equipment without removal of barriers, cover plates, or wiring. Grouped terminal blocks for all external connections shall be provided. All wiring leaving an enclosure shall leave from terminal blocks or prefabricated connectors and not from other devices in the enclosure. Terminal blocks and jumpers shall be permanently and uniquely marked in conformance with ICS-1.

2.1.5 Power Supplies

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(NOTE:) The designer will verify existing power source characteristics and circuit availability. Sources of power will be shown including transformers if required. 125 Vdc or 48 Vdc power will be used for project applications where adequate station battery power is available.

****

Power supplies shall accept 120 Vac, 125 Vdc or 48 Vdc nominal as shown and shall have dc outputs to power all RTU components. Power supplies shall be factory-mounted inside of the equipment enclosures.

2.1.6 Enclosures

2.1.6.1 General

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(NOTE:) The designer will coordinate number of keys with the installation.

****

Enclosures shall conform to the requirements of NEMA 250 for the types specified. Damaged surfaces shall be repaired and refinished using original type finish. Enclosures installed outdoors shall be type 4X stainless steel, unless otherwise shown. Enclosures shall have removable hinged, key-locked front doors. All RTU enclosure locks shall be keyed alike. A total of [5] [...] keys shall be turned over to the Government.

2.1.6.2 Size Limitations

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(NOTE:) The designer will define space limitations at each project location and verify space at installation location.

****

a. Free-standing RTU enclosure locations are shown based on a maximum size of [90-inches high by 36-inches wide by 30-inches deep] [...]. Wall-mounted RTU enclosure locations are shown based on a maximum size of [36-inches high by 30-inches wide by 16-inches deep] [...].

b. Certain RTUs shall be located inside existing electrical substation compartments, as shown on the drawings. Depending on equipment furnished, these RTUs may not fit in the locations shown, but may need to be mounted at an alternate location outside the substation in an enclosure. The Contractor shall be responsible, in those instances where the specified mounting area is inadequate, for providing all necessary hardware, accessories, and wiring required for an alternate mounting location at no extra charge to the Government.

2.1.6.3 Enclosure Finish

All enclosures, including sun shields, shall have a corrosion resistant finish, gloss white in color.

2.1.6.4 Sun Shields

All RTU equipment enclosures that are located outdoors shall be factory-equipped with a sun shield to minimize heat buildup inside the enclosure. Sun shields shall be made of either stainless steel or fiberglass. Sun shield size shall be based on enclosure size, with tilt angle and orientation adjusted to provide maximum shading. Sun shields shall be fastened to the enclosure such that they can be swung out to facilitate enclosure access.

[2.1.6.5 Salt Environment

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(NOTE:) This paragraph shall be used for all projects located at ocean-side installations or otherwise subjected to a salt environment.

****

All enclosures indicated as requiring a type 4X stainless steel rating shall be protected from degradation due to a salt-laden, corrosive environment. All metallic surfaces shall be protected by suitable coatings applied in the manufacturer's facility. Coatings shall provide a service life of 20 years with manufacturer's recommended field touch-up or renewal. Surfaces inaccessible after assembly shall be protected by coatings with a service life of 20 years without field touch-up or renewal.]

2.1.7 EMI/RFI Compliance

Equipment shall be designed to minimize the generation of electromagnetic and radio frequency interference. Master station and workstation equipment shall be in compliance with 47 CFR 15, for Class B computing devices.

2.2 FIELD EQUIPMENT

2.2.1 General

2.2.1.1 Controls

****

(NOTE:) Switchgear cabinets with "43" local/remote switches may use the existing "43" switch to provide this output disable function. The designer shall show the switch location and availability of spare contacts.

****

Each RTU with control outputs shall be equipped with a switch to positively inhibit each digital output point without shutting off the RTU or otherwise affecting its operation. An auxiliary contact on the disable switch shall be wired to one of the RTU digital input points to provide remote indication of the switch status.

2.2.1.2 Grounding

The Contractor shall provide instrumentation grounding in accordance with manufacturer's recommendations.

2.2.1.3 Spare Capacity

Each RTU shall have a minimum of 15% of its I/O functions, as spare capacity. The types of spares shall be in the same proportion as the implemented I/O functions in the RTU, but in no case shall there be less than two spare points of each implemented I/O type. The RTU I/O functions shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function. Implementation of spare points (by others) shall necessitate only providing the additional field sensor or control, field wiring including connection to the system, and point definition assignment by the operator.

2.2.1.4 RTU Battery Backup

Each RTU powered by 120 Vac shall be equipped with an internal sealed battery and battery charger. Each battery shall be sized to supply continuous full power to the fully loaded and operational RTU, including the modem, for a minimum of 4 hours, during which there are eight control operations. The battery charger shall be able to fully recharge a completely discharged battery in 8 hours.

2.2.2 RTU

****

(NOTE:) Current transducer leads (from the current transformer to a current transducer or to an intelligent transducerless RTU) shall never be brought outside the switchgear enclosure.

****

2.2.2.1 General

The Contractor shall furnish, fully operational, microprocessor-based RTUs. The RTUs shall not require the use of PROM or EPROM burners to make revisions to point parameters. The RTU shall operate autonomously in the event of a communications failure with the Master Station, collecting data from its I/O points utilizing a real-time clock function.

2.2.2.2 Processor and Memory

The processor and memory shall provide operation and performance as specified.

2.2.2.3 Communications

a. RTU to Master Station: Communications interfaces shall be provided for each RTU to the data transmission system for data transfer between RTU and Master Station.

b. RTU to intelligent electronic device: Communication interfaces, at least two per RTU, shall be provided for each RTU shown for data transfer between RTU and intelligent electronic devices.

c. Each RTU shall have ports and modems to perform the specified functions with an additional dedicated port for connection to a portable tester.

2.2.2.4 Power Fail Automatic Restart

The RTU shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected data collection functions, but without control functions. An RTU restart program based on detection of power failure at the RTU shall be included in the RTU software. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the RTU, if the database and application software are no longer resident or if the clock cannot be read, the RTU shall not restart until the necessary repairs are made. If the database and application programs are resident, the RTU shall resume data collection operation.

2.2.3 Intelligent Transducerless RTU

2.2.3.1 General

The intelligent transducerless RTU shall meet the requirements of the RTU specified above and shall also accept AC analog inputs directly configurable for current and voltage. Input ranges of 0 to 5 amperes and 0 to 120 Volts shall be accommodated. Accuracy's shall be 0.25% of full scale. Intelligent transducerless RTUs shall be provided where shown, or intelligent electronic devices providing the specified functions shall be provided and shall communicate with RTUs. The device shall measure and calculate the following quantities and shall perform additional functions as shown and specified:

a. Phase voltage, phase current, and neutral current.

b. Fault current up to 20 times full scale.

c. KW, kVAR (bi-directional), kWH (bi-directional), and kVARH (both total and for each phase).

d. Power factor.

e. Harmonics (2nd through 5th).

f. Voltage quality data (sag and swell).

2.2.3.2 I/O

I/O provided shall include all functions in paragraph I/O Card Functions below and the following transducerless analog input (TAI). The TAI function shall monitor each AC analog input, perform A-to-D

conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 12 bits including sign. Signal conditioning shall be provided for each transducerless analog input. Contractor shall individually calibrate all analog inputs for zero and span, in hardware or in software. The TAI shall incorporate common mode noise rejection of 90 dB from 0 to 60 Hz. Input ranges shall be 0 to 5 amperes and 0 to 120 volts.

2.2.4 I/O Card Functions

2.2.4.1 Analog Inputs (AI)

The AI function shall monitor each differential analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 12 bits including sign. Signal conditioning shall be provided for each analog input. Contractor shall individually calibrate all analog inputs for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 90 dB from 0 to 60 Hz for differential inputs, and normal mode noise rejection of 60 dB at 60 Hz from a source impedance of 10,000 ohms. Input ranges shall be within the range of 0-1 mAdc, nominal impedance of 10,000 ohms, or 4 to 20 mAdc, nominal impedance of 300 ohms.

2.2.4.2 Analog Outputs (AO)

The AO function shall accept digital data, perform D-to-A conversion, and output a signal within the range of 4 to 20 mAdc. D-to-A conversion shall have a minimum resolution of 12 bits including sign. Contractor shall individually calibrate all analog outputs for zero and span. Open circuit protection on current outputs shall be provided.

2.2.4.3 Digital Inputs (DI)

The DI function shall accept on-off, open-close, or other change of state (two state data) indications from dry contacts. All status changes shall be reported regardless of whether they were the result of commanded or uncommanded operations. All field contacts shall be opto-isolated from RTUs internal power. The field contact input to the RTU shall be either a Form "A" or a Form "B" contact. The input circuitry shall be accept either a Form "A" or Form "B" contact as a normal condition. Sensing voltage for devices supplying digital inputs shall be powered by the RTUs, by a power supply which is isolated from RTU electronics power supply. Input signals shall be filtered to minimize noise and contact bounce, with an adjustable filter time constant of 1 to 20 milliseconds.

2.2.4.4 Sequence of Events (SOE)

All RTUs shall be able to perform SOE functions as specified. RTUs indicated by the I/O Lists to have SOE points shall contain all necessary equipment to determine and time tag the order of occurrence of changes of the external contacts. Time tagging shall be accurate to plus or minus 1 millisecond at the SOE card. If the Contractor's equipment requires separate SOE and DI points, DI points shall be furnished in the specified quantity plus a quantity equal to that specified for SOE points.

2.2.4.5 Digital Outputs (DO)

The DO function shall provide contact closures for momentary and maintained operation of devices. Upon command, each output relay shall close for a definite but adjustable period of time. The time of momentary closure shall be between 0.1 second and 60 seconds and the timing shall be accomplished by software on a point by point basis. The time of momentary closure shall be set initially to 3 seconds. These relays shall be de-energized in the event of RTU malfunction. Each momentary Raise or Open/Lower or Close control point and each Open/Close control point shall consist of a Raise (or Open) output and a separate Lower (or Close) output. Separate relays shall be provided for each RAISE (or OPEN) and each LOWER (or CLOSE) function. Contacts shall be rated for the application. Relays shall be rated for a minimum life of 1 million operations. For select-before-operate control, dual interposing relays shall be utilized.

2.2.4.6 Pulse Accumulator Inputs (PI)

The PI function shall have the same characteristics as the DI, except that a buffer shall be provided to totalize pulses and allow for interrogation by the system. The pulse accumulator shall accept rates up to 10 pulses per second. The accumulator points shall totalize pulses received from dry contacts. A sensing voltage shall be supplied from the RTUs. Accumulator points shall accept Form C contacts (both the "Y" and "Z" contacts on the KYZ shall be monitored) from all Kilowatt-hour meters, and Forms "A" or "B" contact inputs from all flowmeter processors. Each pulse accumulator shall totalize a count of up to 65,536, and shall be able to be read at any time without loss of input data. When each pulse accumulator reaches its maximum value, it shall automatically reset to zero, and begin counting pulses again.

2.2.5 Support Equipment

2.2.5.1 Portable Tester

A portable, self-contained, laptop computer shall be furnished to diagnose malfunctions. The tester shall be furnished with cable and connectors for communication with RTUs. The tester shall connect to the Master Station via a compatible network adapter and an EIA 232 port for loading a particular RTU database and operational data which later can be loaded into that RTU. In addition, the tester shall connect to an RTU, receive data stored in the RTU, and run diagnostics on the RTU. When connected to an RTU, the tester shall be able to call up any I/O point associated with the RTU it is connected to. The tester shall also support the following operating modes.

a. Master Station mode.

The tester shall emulate a Master Station by transmitting commands to an RTU based on operator commands. RTU responses shall be stored in memory or displayed on the portable tester, based on the tester operator's selection via keyboard.

b. Monitor mode.

The monitor mode shall allow the tester to operate in parallel with an operating Master Station or RTU and shall display and store on disk (but not respond to) data being transmitted and received.

c. Self Test mode.

The self test mode shall permit the operator to verify proper operation of the portable tester.

2.2.5.2 RTU Test Set

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(NOTE:) Many SCADA functions are standard pre-programmed applications not requiring simulation on a test set. Coordinate with the installation to determine if an RTU test set is to be required.

****

A test set consisting of an RTU and an I/O simulator test panel shall be provided for use at the Master Station, connected as shown. The I/O test panel shall manually generate values or status for I/O functions. The test panel shall receive, display, and send different types of signals. All cables, connectors, test jacks, controls, indicators, and equipment required to simulate field sensors and control devices and display operations of the RTU shall be included. The I/O function mix shall be 4 analog inputs, 2 transducerless analog inputs (1 current and one voltage), 8 digital inputs, 2 analog outputs, 8 digital outputs, 2 pulse accumulator inputs, and 2 SOE inputs.

2.3 INSTRUMENTATION AND CONTROLS

2.3.1 General

All instrumentation shall conform to NEMA and IEEE standards for SCADA system applications.

2.3.2 Potential Transformers

Potential transformers shall be compatible with the kilowatt-hour meters, power factor transducers, and voltage transducers specified. Transformer shall conform to NEMA and ANSI standards. The Contractor shall be responsible for determining the actual voltage ratio of each transformer. Potential transformers shall conform to the following requirements.

Type: indoor, dry type, of two-winding construction

Frequency: Nominal 60Hz

Accuracy: plus or minus 1% at 60Hz

2.3.3 Multi-Ratio Current Transformers

****

(NOTE:) The designer will select ANSI metering class 0.3% accuracy for billing applications. If the system will not be used for billing, 1.2% accuracy will be selected.

****

Current transformers shall be compatible with the kilowatt-hour meters, power factor transducers, and current transducers specified. Transformer shall conform to NEMA and ANSI standards. Current transformers shall conform to ANSI C57.13 and the following requirements.

Insulation Class: BIL rating shall be equal or greater than the equipment being connected to.

Frequency: Nominal 60Hz

Accuracy: plus or minus [0.3%] [1.2%] at 60Hz and rated burden

Burden: Burden class shall be selected for the load

2.3.4 Kilowatt-hour Meters

****

(NOTE:) The designer will use digital multi-meters where new meters are required, unless the user specifically requests that electro-mechanical kilowatt-hour meters be used instead of digital multi-meters or where the use of digital multi-meters is not feasible for some other reason.

****

2.3.4.1 General

a. Kilowatt-hour meters shall be semi-flush, secondary type, drawout switchboard type, or socket type depending on the installation requirements. All electronic modules shall be physically identical and interchangeable. Meter covers shall be polycarbonate resin.

b. Meters shall be 2-stator, 120Vac, for use on a 3-wire delta, 3-phase system, unless otherwise shown and specified.

c. Meter Multiplier shall be shown on the face plate, and shall be the product of the indicated current transformer and potential transformer ratio.

d. Meters shall have a draw-out arrangement for removal whereby the current transformer circuits shall be automatically short-circuited. Metering wiring systems shall include shorting terminal blocks and drawout fuse blocks (30A rating, type J fuses).

e. Each meter shall be complete with a 5-dial mechanical kilowatt-hour register.

f. A frictionless optical assembly, mounted directly to the meter frame, generating pulses per meter disc revolution for input to the electronic register, shall be provided.

g. Meters shall have a pulse initiator with a programmable ratio selection.

h. All meters shall output a KYZ signal.

i. Meters shall have a detent to prevent negative registration by restricting the backward rotation of the disk.

2.3.4.2 Electronic Demand Register

a. All meters shall be furnished and installed with an electronic demand register module. The register module shall be used to indicate maximum kilowatt demand as well as cumulative or continuously cumulative demand. Demand shall be measured on a block-interval basis. The meter shall have provisions to be programmed to calculate demand on a rolling interval basis. All program variables shall be contained in the register.

b. The register shall have a liquid crystal display, 9 digits, blinking icons confirm register operation.

c. Display operations, programmable sequence with display identifiers. Display identifiers shall be selectable for each item.

d. The normal billing data scroll shall be fully programmable. The following items shall be displayed in the data scroll.

1. Kilowatt-hours
2. Maximum demand
3. Cumulative or continuously cumulative
4. Number of demand resets
5. New maximum demand indication
6. End-of-internal indication
7. New maximum demand indication

e. The register shall incorporate a built-in test mode that allows it to be tested without the need for any special tools or other accessories and saves data and constants prior to start of test. The following quantities shall be available for display in the test mode.

1. Time remaining in demand interval
2. Preset interval's accumulating method
3. Maximum demand
4. Number of impulses being received by the register.

f. The electronic demand register shall be of modular design, and be easily removable from the mechanical register for programming, maintenance, and trouble-shooting. Meters shall have a battery with battery port for quick changes.

2.3.5 Digital Multi-Meters

Digital multi-meters shall be microprocessor based intelligent electronic devices providing multiple measurements for 60 Hz single phase or three phase electric systems as shown. All inputs and outputs shall be certified to pass IEEE C37.90.1 surge withstand tests. Digital multimeters shall have LCD panel indicators and shall utilize a communication protocol compatible with RTUs in accordance with Paragraph: Protocols for display and transmission of the following parameters as specified plus other parameters as shown:

Voltage line-to-neutral:	plus or minus 0.5%
Voltage line-to-line:	plus or minus 1%
Frequency:	plus or minus 0.1%
Current:	plus or minus 0.5%
kVA:	plus or minus 1%
kVAR:	plus or minus 1.5%
kVAh:	plus or minus 1% of reading
kVARh:	plus or minus 1.5% of reading
Power factor:	plus or minus 1%
kW:	plus or minus 1.5%
kWh:	plus or minus 1.5% of reading

2.3.6 Single Phase Power Factor Transducers

****

(NOTE:) The designer will select single phase power factor transducers for each phase of unbalanced feeders. For balanced feeders, three phase power factor transducers are more cost effective and will be selected.

****

Single phase power factor transducers shall be single phase - two wire, 2-element, 4-20 mAdc signal output devices. Transducer output shall be bipolar and linearly proportional to the cosine of the phase angle difference between the voltage and current on the AC power system bus. Contractor shall be responsible for determining transducer input current range and input voltage range for proper operation. Transducers shall be externally-powered from a 115 Vac power source. The Contractor shall be responsible for determining a suitable power source and for all associated wiring. Power factor transducers shall meet the following requirements:

Frequency:	60Hz nominal
Current Overload:	2 times full-scale rating (continuous) 6 times full-scale rating (10 sec.)
Voltage Overload:	full-scale rating
Dielectric Test:	1500V (input/output/case)
Surge Withstand:	ANSI/IEEE C37.90.1 SWC Test
Output Signal:	4-20 mAdc; 12mAdc at unity 4 mAdc at lag 20 mAdc at lead
Output Loading:	0-1500 ohms
Output Ripple:	less than 1.0% full-scale
Phase Angle Range:	0 to 60 degrees
Accuracy:	plus or minus 0.01 PF at 25C plus or minus 0.02 PF from -20C to +60C
Temperature Effect:	1.0 % of reading (-20C to 60C)
Calibration:	field adjustable 10 %

2.3.7 Three Phase Power Factor Transducers

Three phase power factor transducers shall be three phase - three wire, 2-element, 4-20 mAdc signal output devices. Transducer output shall be bipolar and linearly proportional to the cosine of the phase angle difference between the voltage and current on the AC power system bus. Contractor shall be responsible for determining transducer input current range and input voltage range for proper operation. Transducers shall be externally-powered from a 115 Vac power source. The Contractor shall be responsible for determining a suitable power source and for all associated wiring. Power factor transducers shall meet the following requirements:

Frequency:	60Hz nominal
Current Overload:	2 times full-scale rating (continuous)
Voltage Overload:	full-scale rating
Dielectric Test:	1500V (input/output/case)
Surge Withstand:	ANSI/IEEE C37.90.1 SWC Test
Output Signal:	4-12-20 mAdc; 4 mAdc at lag 12mAdc at unity 20 mAdc at lead
Output Loading:	0-500 ohms
Output Ripple:	less than 1.0% full-scale
Phase Angle Range:	0 to 60 degrees (bipolar; lead and lag)
Accuracy:	plus or minus 0.01 PF at 25C plus or minus 0.02 PF from -20C to +60C
Temperature Effect:	1.0 % of reading (-20C to 60C)
Calibration:	field adjustable 10 %

2.3.8 Current Transducers

a. Current transducers shall be single-phase AC, 4-20 mAdc signal output devices. Transducer output shall be derived from the average absolute value of the input calibrated in terms of the RMS value of the sine wave input. The transducer nominal input current range shall be 0-5 amperes. Transducers shall be externally-powered from a 120 Vac power source. The Contractor shall be responsible for determining a suitable power source and for all associated wiring.

b. Current transducers shall meet the following requirements:

Frequency:	60Hz nominal
Current Overload:	2 times full-scale rating (continuous) 50 times full-scale rating (1 sec. transient)
Dielectric Test:	1500V (input/output/case)
Output Signal:	4-20 mAdc
Output Loading:	0-1500 ohms
Output Ripple:	less than 1.0% full-scale
Accuracy:	plus or minus 0.5 % full-scale
Temperature Effect:	1.0 % of reading (-20C to 60C)
Calibration:	field adjustable plus or minus 10 %

2.3.9 Voltage Transducers

a. Voltage transducers shall be single-phase AC, 4-20 mAdc signal output devices. Voltage transducers shall measure phase-to-ground voltage. Transducer output shall be derived from the average absolute value of the input calibrated in terms of the RMS value of the sine wave input. The transducer nominal input voltage range shall be 0 to 180 volts. Transducers shall be externally-powered from a 120 Vac power source. The Contractor shall be responsible for determining a suitable power source and for all associated wiring.

b. Voltage transducers shall meet the following requirements:

Frequency:	60Hz nominal
Overload:	180 Vac
Dielectric Test:	1500V (input/output/case)
Output Signal:	4-20 mAdc
Output Loading:	0-1500 ohms
Output Ripple:	less than 1.0% full-scale
Accuracy:	plus or minus 0.5 % full-scale
Temperature Effect:	plus or minus 1.0 % of reading (-20C to 60C)
Calibration:	field adjustable plus or minus 10 %

2.3.10 Breaker Overcurrent (O/C) Trip Relay Kits

Breaker overcurrent trip relay kits shall be provided where shown for existing drawout-type circuit breakers which lack this function. Relay kits shall incorporate the drawout feature and shall allow for easy removal of circuit breakers with finger disconnects. All relay kits shall be purchased from their respective original breaker manufacturers, and shall include all mechanical linkages, electrical devices, accessories, and wiring to provide a dry contact output for wiring into the system.

2.3.11 Instantaneous/Time Overcurrent Relays

Instantaneous/time overcurrent (50/51) relays shall be semi-flush, drawout switchboard type, and shall be all from the same manufacturer. Relays shall have a draw-out arrangement for removal whereby the current transformer circuits shall be automatically short-circuited. Relay wiring systems shall include shorting terminal blocks and drawout fuse blocks (30A rating, type J fuses). Relay covers shall be polycarbonate resin. Relays shall include auxiliary contacts for interface to the system.

2.3.12 Interposing Relays

Interposing relays (momentary and latching types) shall be provided for remote circuit control of remote equipment, or to provide device status input for those devices which do not have an auxiliary relay contact output available. Relay contacts shall be enclosed in a dust proof enclosure. Relays shall be rated for a minimum of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Interposing relays shall meet the following requirements.

Rating:	150Vac/ 150Vdc coil, 10 Amperes contacts
Working Voltage:	120Vac/ 48Vdc to 150Vdc, nominal
Contact Arrangement:	DPDT (2 Form "C"; 1-N.O., 1-N.C.)
Base:	Plug-in socket, suitable for panel mounting

2.3.13 VAR Transducer

VAR transducers shall measure the reactive volt amperes of a three phase system, and produce a proportional 4-20 mAdc output signal. An integral power supply shall be provided if required for the analog output signal. The transducer shall have an accuracy of plus or minus 0.25 percent of full scale, and shall include offset and span adjustments.

2.3.14 Phase Angle Transducer

Phase angle transducers shall have an accuracy of plus or minus 1 percent at 25 degrees C and shall measure the phase angle between two voltage inputs or between one voltage input and one current input. The full scale range shall be capable of ranges from + 45 degrees to + 180 degrees, 60 Hz. The output shall be 4 to 20 mA linear with the calculated full scale phase angle range. Voltage inputs shall be 95 to 135 Vac, 60 Hz, and current shall be 0.5 to 5 Amperes, 60 Hz.

2.3.15 Watthour Transducers

Watthour transducers shall have an accuracy of plus or minus 0.25 percent of full scale for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

2.3.16 AC Voltmeters

Transformer rated, 250 volt, 60 Hz input, for measuring 480V, three phase, wye service with 120 volt potential transformers. Provide external dropping resistor if required. Voltmeter shall provide plus or minus 1 percent accuracy at full scale. Scale shall span 250 degrees. Mounting shall be flush type.

2.3.17 AC Voltmeters

Transformer rated, 150 volt 60 Hz input, for measuring 480V, three phase, delta service with 120 volt potential transformers. Provide external dropping resistor if required. Voltmeter shall provide plus or minus 1 percent accuracy at full scale. Scale shall span 250 degrees. Mounting shall be flush type.

2.3.18 AC Voltmeter Switch

Voltmeter switch shall be designed specifically for the purpose and shall have seven positions, one position for each phase to neutral and one position for each phase to phase and "off." Contacts shall be rated for 20 amperes, 600 volts AC. Switch shall have a 7 position escutcheon plate indicating each position including "off." Switch shall have metal shaft and removable handle.

2.3.19 AC Ammeters

Transformer rated, 5 ampere, 60 Hz input, for use with current transformers. Ammeter shall provide plus or minus 1 percent accuracy at full scale. Scale shall span 250 degrees. Mounting shall be flush type.

2.3.20 AC Ammeter Switch

Ammeter switch shall be design specifically for the purpose and shall short circuit all current circuits except the one being read. Contacts shall be rated for 20 amperes, 600 volts AC. Switch shall have 4-position escutcheon plate indicating each position and "off." Switch shall have metal shaft and removable handle.

2.3.21 Pressure Transducer

The pressure transducer shall withstand up to 300 percent of rated pressure, with an accuracy of plus or minus 1 percent of full scale. Transducer shall be selected so as to put the expected range of the measured variable in the middle third of the transducer's range. The sensing element shall be either capsule, diaphragm, bellows, bourdon tube, or solid state as applicable for the installation. A transmitter located at the transducer shall be provided to convert the sensing element output to a linear 4 to 20 mAdc output corresponding to the required pressure span. The output error shall not exceed 0.1 percent of calibrated span. The transmitter shall include non-interacting zero and span adjustments.

2.3.22 Resistance Temperature Detector (RTD)

RTDs shall be platinum, with an accuracy of +/- 0.1% at 32 F. RTDs shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper . RTDs shall have a range of plus 30 to plus 400 degrees F +/- 1.0 degree F (display and print to nearest 0.1 degree F). RTD shall be furnished with an RTD transmitter mounted integrally. The RTD transmitter shall be selected to match the resistance range of the RTD. The transmitter shall be a 2 wire device, producing a linear 4 to 20 mAdc output corresponding to the required temperature span. The output error shall not exceed 0.1% of calibrated span. The transmitter shall include noninteracting offset and span adjustments.

2.4 MASTER STATION EQUIPMENT

2.4.1 General

2.4.1.1 Description

The SCADA system Master Station shall be furnished as shown on the drawings. Two identical Master Station computer systems shall be configured in a hot-standby mode with mirrored data bases to fully back up each other. All required cables and connectors shall be provided for equipment supplied.

2.4.1.2 Noise Level

The equivalent "A" weighted sound level for all Master Station equipment shall not exceed 58 dBA at a distance of one meter.

2.4.2 Master Station Computers

2.4.2.1 General

The Master Station computers shall function as the overall system coordinator, perform automated SCADA functions, control peripheral devices, and perform calculations associated with operator interactions, alarm reporting, and logging of events. Each Master Station computer shall be a single manufacturer's standard unmodified digital computer of modular design. The Master Station computers shall not include any hardware precluding the purchase of a standard maintenance and service contract from the computer manufacturer. Each Master Station computer shall meet the following as a minimum:

a. Automatic failover between Master Station computers.

b. SPEC int 95:4.0

c. SPEC fp 95:6.0

2.4.2.2 Network Interface Card

Each Master Station computer shall be supplied with an internal network interface card for connection to IEEE 802.3 100 BASE-T twisted pair Ethernet LANs. Interface cards shall be supplied with an on-board transceiver for direct connection to the LAN, and with an AUI port for performing diagnostics. Interface cards shall also have an on-board buffer memory to prevent loss of data packets.

2.4.2.3 Processing Capacity

Each Master Station computer shall have the ability to support all SCADA system software without utilizing more than an average of 50 percent of its processing capacity during any 5-minute interval.

2.4.2.4 Memory

Each Master Station computer shall be provided with 512 megabytes RAM as a minimum, expandable to 2 gigabytes.

2.4.2.5 Hard Disk Drive Data Storage

Each hard disk drive system shall be a RAID 3 controller with associated drives for each Master Station computer system. Formatted individual drive capacity shall be not less than 4 gigabytes, and average access time shall not be greater than 10 milliseconds.

2.4.2.6 System Terminal

Each Master Station computer shall include a monitor for the system terminal function, which will provide for interface to the computer's operating system for diagnostics, setup and other similar operating system functions.

2.4.2.7 Internal Processor-to-Processor Link

A high speed hardware interface shall be provided between the two Master Station computers to keep each Master Station computer's database current for facilitating bumpless transfer.

2.4.2.8 CD-ROM Drive

A CD-ROM drive having a nominal storage capacity of 650 megabytes shall be provided for each Master Station Computer. The CD-ROM drive shall have the following characteristics, as a minimum:

a.	Data transfer rate:	1.2 Mbps.
b.	Average access time:	150 milliseconds.
c.	Cache memory:	256 kilobytes.
d.	Interface	SCSI II.

2.4.2.9 Master Station Computer Four mm Magnetic Tape Drive

Each Master Station Computer shall have a 4 mm Magnetic Tape Drive with a formatted uncompressed storage capacity of 4 gigabytes and formatted compressed storage of 8 gigabytes.

2.4.3 Communications

Communications channels for the RTUs shall be provided as shown. The Master Station shall include communication channels as shown, expandable as specified with additional cards. Data transfer shall be set at 9600 bps per channel.

2.4.4 Failover Control

When failover occurs during operation, no configuration or database data shall be lost.

a. Automatic failover shall be provided between the Master Station computers. The system shall provide an alarm to the operator that a failover has occurred. A means for the operator to perform a manual failover separately from automatic failover shall be provided.

b. Acknowledged alarms on the primary Master Station computer shall not generate alarms on the backup Master Station computer when failover occurs. The transfer shall be transparent to the operator, and there shall be no loss of data, settings or programs when the failover occurs.

2.4.5 Satellite-Synchronized Clock

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(NOTE:) The designer will show the location of the roof-mounted antenna.

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The Master Station shall include a 19-inch rack-mountable satellite clock, using the NAVSTAR Global Positioning System satellites for system timing. The satellite clock shall provide a 1 pulse per second timing signal with an accuracy of at least plus or minus 100 nanoseconds, traceable to UTC-NIST. The clock shall include an external roof-mounted antenna specifically designed to receive the satellite signal. Input sensitivity shall be at least 0.2 microvolts per meter with the satellite viewing angle at least 3 degrees above the horizon. The manufacturer's recommended cable of proper length to connect the antenna shall be supplied. The satellite clock shall be interfaced

to the SCADA system master clock. The master clock shall be synchronized to the satellite clock within plus or minus 0.5 millisecond at least once per day.

2.4.6 Workstations

2.4.6.1 General

Workstations shall be configured for high-performance computing, high resolution graphics, and multi-tasking applications in a networked environment. Each workstation shall be equipped with controllers and I/O ports for a laser printer, mouse, color monitor, network interfaces, 2 serial ports, and a parallel port. All device controllers and drivers shall be included. Each workstation shall be able to withstand an 8 KV contact static discharge and a 15 KV air static discharge in accordance with ANSI C63.16 with no misoperation or data loss. Workstations shall meet X mark 93:16.0 as a minimum.

2.4.6.2 Memory

A minimum of 512 megabytes RAM shall be provided, expandable to at least 2 gigabytes.

2.4.6.4 Data Storage

A hard drive and controller shall be included with a minimum formatted capacity of 2.0 gigabytes. Average access time shall be no more than 10 milliseconds. A 3.5 inch, 1.44 megabyte floppy drive and controller shall be furnished. A CD-ROM drive and controller with minimum data transfer rate of 1.2 Mbps shall be furnished with each workstation.

2.4.6.5 Network Interface Card

Each workstation shall be supplied with an internal network interface card for connection to IEEE 802.3 100 BASE-T twisted pair Ethernet LANs. Interface cards shall be supplied with an on-board transceiver for direct connection to the LAN, and with an AUI port for performing diagnostics. Interface cards shall also have an on-board buffer memory to prevent loss of data packets.

2.4.6.6 Workstation Color Monitors

a. Workstations shall include a color monitor with a tilt/swivel base and local controls for contrast, brightness, focus, vertical size, horizontal size, vertical position, and horizontal position.

b. A graphics adapter shall be furnished, with two megabyte (minimum) of video memory, supporting all video modes and resolutions specified.

c. The color monitors shall meet the following minimum requirements:

1.	Monitor Size:	40 inch nominal, or 27 inch nominal, or 20 inch nominal, as shown.
2.	Color Palette:	256 or more colors at 1280 X 1024 resolution
3.	Resolution:	1280 X 1024 pixels
4.	Scan Method:	Raster scan, roll free, or 72 hertz refresh rate minimum
5.	Dot Pitch:	0.24 mm maximum (20 inch), 0.75 mm maximum (27 inch), 0.95 mm maximum (40 inch).

2.4.6.7 Keyboard

All keyboards provided with the system shall comply with the ANSI X3.64 standard and shall include a typewriter arrangement of alphanumeric symbols, vertical and horizontal tab keys, a standard numeric pad, cursor direction controls with a home key, and 10 user assignable push-button keys.

2.4.6.8 Mouse

The Contractor shall provide a standard mouse with each workstation. Mouse speed and resolution shall be adjustable.

2.4.6.9 Laser Printer

Resolution shall be a minimum of 600 dots per inch and there shall be a minimum of 2 megabytes RAM. Printing speed shall be a minimum of eight pages per minute, with a 100-sheet minimum paper cassette and with manual feed. A parallel interface shall be provided for connection to the workstation computer.

2.4.6.10 Audible Alarm

Each workstation shall include an audible alarm, actuated by the on-line Master Station computer.

2.4.7 Network Alarm Printer

Network alarm printer shall have a minimum 96 character standard ASCII character set based on ANSI X3.64 and ANSI X 3.154 and with graphic capability. Each unit shall have adjustable sprockets for paper width up to 15 inches and shall print at least 132 columns per line. The printers shall have a minimum speed of 240 characters per second. The minimum character spacing shall be 12 characters per inch and 3 to 8 lines per inch. The printers shall utilize standard form size, sprocket-fed fanfold paper, and have multiple copy capability. The units shall have programmable control top-of-form and variable line skip capability.

2.4.8 Network Color Laser Jet Printer

Network Color printer shall provide a hard copy snapshot of any workstation monitor. The printer shall meet the following requirements:

a.	Resolution:	600 by 600 dots per inch
b.	Paper Printing Time:	12 pages per minute color
c.	Data Buffer Size:	32 Megabytes
d.	Media Type:	Paper and transparency film
e.	Media Size:	8.5" X 11"
f.	Interfaces:	LAN interface
g.	Paper Cassette (8.5"x11"):	250 sheet capacity

2.4.9 Network Laser Printer

Network laser printer shall be provided with LAN interface as shown. Resolution shall be a minimum of 1200 by 1200 dots per inch and there shall be a minimum of 32 Megabytes RAM, a minimum printing speed of 16 pages per minute, a minimum 500-sheet paper cassette and manual feed.

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(NOTE:) The designer will coordinate with the installation on requirements for additional telephone modems for remote access.

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2.4.10 Security Callback Controller

The security callback controller shall be equipped with [one] [...] full duplex telephone modem[s], individually selectable as to parity, word length, and data rate. Data rate shall be 28.8 kbps. The unit shall provide individual password protection with automatic callback verification.

2.4.11 Portable Workstation

Each portable workstation shall consist of a portable computer with a nominal 12 inch active color matrix liquid crystal display, capable of displaying up to 256 colors at a minimum resolution of 640 X 480 pixels, minimum 32 bit microprocessor operating at a minimum of 150 MHz. The portable workstation shall have, as a minimum, a 2 gigabyte hard drive, 32 megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, V.34 modem, PCMCIA type 3 slot, rechargeable battery, battery charger and 120 Vac power supply. It shall include carrying case, extra battery, charger and a compatible network adapter.

2.5 LAN EQUIPMENT

2.5.1 General

All LAN equipment shall comply fully with IEEE 802.3 10 BASE-T for twisted pair Ethernet networks. The LAN shall interconnect and service system local and remote components.

2.5.2 Cables

The network transmission media shall be Category 5 twisted pair cable as defined by EIA568A. All cabling, patch panels, patch cables, and accessories shall be provided as required to implement a complete wiring system for the LANs. Connector type shall be Category 5 rated. A minimum of one AUI port shall be provided per twisted pair module.

2.6 SYSTEM SOFTWARE

2.6.1 General

The Master Station computer system software shall provide a real time multi-tasking, multi-user environment. The standard system software supplied by the computer system manufacturer shall not be modified in any way that would preclude purchase of a standard maintenance and service contract from the computer manufacturer.

2.6.2 Bootstrap Program

The software shall include a bootstrap and loader adequate to initiate SCADA system operation using only procedures specified by the computer manufacturer, including loading both Master Station computer and communication processor memory from the hard drive system.

2.6.3 Real-Time Operating System

A currently available and supported real-time disk operating system, compliant with FIPS PUB 151-2 (POSIX) shall be utilized, including:

a. Operation and management of all peripheral devices.

b. Scheduling of tasks executing according to assigned priorities.

c. Task assignable to any priority level.

d. On-line error detection and recovery.

e. System generation to include all peripheral devices required.

f. File management functions for disk I/O, including creation and deletion of files, copying of files, a directory of all files including size and location of each, sequential and random ordered records, and illegal user access protection.

g. I/O queuing, suspension, transfer initiation, and spooling.

h. Task builder and scheduler, including memory allocation, contention resolution, and overlay building.

2.6.4 Assembler

An assembler shall be provided for each assembly language used in the system.

2.6.5 Relocatable Linking Loader

A general purpose loader shall be provided to load all object code programs from an input device or file. The loader must be able to link and load a set of object code programs.

2.6.6 Editor

An editor shall be provided for accomplishing input, modification, display, listing, and storage onto disk files of source languages.

2.6.7 Compiler

A compiler, with file management, real-time extensions, and library routines shall be provided for each high level language used.

2.6.8 Debugger

A debugger shall be provided for diagnostic software development with any assembly and high level language used.

2.6.9 Copy Routine

Software shall be provided to transfer information between appropriate I/O devices.

2.6.10 Program Development

2.6.10.1 General

A program development facility shall be provided with the Master Station computers. The program development facility shall allow the development and debugging of control programs while the running SCADA system programs are executing in the on-line mode. Programs written in the high level language shall have access to the system database, programs, and to I/O device handlers. Program development activities shall take place at the system terminal. The program development facility shall allow the following.

2.6.10.2 Enter Program

Source programs shall be entered into the Master Station computer by utilizing the editor specified. The source program shall be saved in a disk file defined by the programmer.

2.6.10.3 Compile Program

The compiler shall be used to compile the source code into object code while the SCADA system programs are running. A hard copy listing shall be provided with embedded diagnostic messages or codes for language errors.

2.6.10.4 Debug Program

The debugger specified shall be used to identify and locate errors in compiled programs.

2.6.10.5 Install Program

The relocatable linking loader specified shall be used to load the compiled programs.

2.6.11 Disk Compress Routine.

Utility software shall be provided to defragment the hard disk.

2.6.12 Mathematics Package

A mathematics package shall be provided to support all functions of the high level language delivered.

2.6.13 Calendar/Time Program

The system shall have a calendar program updated by the satellite clock as specified, which updates the millisecond, second, minute, hour, day, month, and 4 digit year. Variations in the number of days in each month, and in the leap year, shall be handled automatically. In addition, there shall be a means to automatically initiate dispatcher entered daylight savings time (DST) start and end date/time with a DST adjusted notation on all dated/timed displays and printouts. The dispatcher shall be able to correct or set time and date of the system from within the SCADA system application.

2.6.14 Diagnostic Programs

Diagnostic programs to report all failures of the Master Station computers and peripherals shall be provided.

2.6.15 User Access

Controls shall be implemented to prevent unauthorized access to system software, by means of user ID and passwords.

2.6.16 Startup, Failover, and Shutdown

2.6.16.1 Startup and Restart

a. The system shall automatically perform a cold start (both Master Station computers and communications processors off-line, all RTUs off-line) upon application of power, and shall be in full operation as specified within 10 minutes. The system shall automatically perform a warm start (both Master Station computers and communications Master Station off-line, all RTUs on-line) upon application of power, and shall be in full operation as specified within 5 minutes. The Master Station computer shall review and enable all programs that are running at that time, including the restart of any automatic control programs resident at the Master Station computer. The following operating states shall be supported.

1. Primary: The primary Master Station computer is performing all real-time functions.

2. Off-line: The Master Station computer is not communicating with the RTUs or peripheral devices, shall not automatically assume control (primary mode) without operator intervention, but can perform functions such as editing, programming, and testing.

3. Backup: The backup Master Station computer is communicating with the primary Master Station computer, is ready to assume control via failover and can perform stand-alone processes which do not interfere with the primary Master Station computer.

b. Initialization shall include the determination of Master Station system status as a prerequisite to startup, initializing operating system software, and initializing application software. Initialization shall also include the loading of all memory resident software, initialization of timers, counters and queues, and initialization of all real-time database values.

c. The database values shall be initially determined by performing an integrity scan of all RTUs in the system. Manually entered data and manually set configuration data shall be stored and restored from disk resident files.

d. Systems which require operator intervention to accomplish a startup are not acceptable.

2.6.16.2 Shutdown

Upon loss of power, the Master station shall initiate an immediate, orderly shutdown.

2.6.16.3 Failover

Failover software shall be provided for each Master Station computer. Software shall detect system failures and shall automatically initiate failover actions to recover from the detected failure. If the computer which fails is operating in the primary mode, the failover system shall automatically initiate a bumpless failover, and make the backup computer the primary computer. After a failover, all workstations, printers, and other similar devices shall continue the same mode of operation they were assigned prior to the failover, without loss of data.

2.6.16.4 Redundant Data Base Update

Under normal operation, the Master Station primary computer shall keep the corresponding backup Master Station computer system database mirrored in order to facilitate bumpless failover. Dispatcher entries, alarms, alarm acknowledgments, and changes in the active database status shall be transmitted continuously to the backup computer as they occur. In the event of a system failover, no data, alarms, or configuration (setup) information shall be lost. This includes pulse accumulator data, device attributes, and alarm acknowledgments, all of which may not be recoverable via forced scan. These data elements shall be passed to the backup system immediately upon receipt at the Master Station.

2.7 COMMAND SOFTWARE

2.7.1 General

The command software shall request, receive, and process all real-time data acquired from periodic data scans of RTUs and manual data and command entries from operator workstations. The SCADA system software shall effectively coordinate the RTU scanning and database updating with the workstation interface, report and event software, alarm processing software, and other related calculation and data processing software.

2.7.2 Database Management

2.7.2.1 Real-Time Database

a. A real-time database shall be provided to store and manage the most current manually entered, calculated, and scanned data and status information.

b. Data and status processing shall be performed for implemented points only.

c. Commands shall be provided to deactivate points in the database (status or analog data). Upon reactivation, the data from the field units shall resume being processed and used as current data.

d. Data validity flags shall be provided for each point in the database. As a minimum, flags shall be provided for scan validity (point out of scan, RTU out of scan, or integrity scan failure) and manually entered data. Alarm, reasonability limit, tagging, and area of responsibility flags shall also be included to provide features required in other sections of these specifications.

e. The real-time database shall be designed to handle a total number of I/O points, 50% digital and 50% analog, specified in PARAGRAPH Expansion Requirements.

2.7.2.2 Database Editor

a. The database editor shall enable the operator to add, modify, and delete system RTU's data via interactive procedures. The editing software shall dynamically resize tables and files as points at RTUs are added or deleted. The system shall provide "fill-in-the-blank" displays for editing. The following is illustrative of editable items in the database.

1. Limits
2. Scaling factors
3. Point and RTU names and descriptions
4. Status normality definition
5. Normal and abnormal state descriptions
6. RTU channel assignment and address
7. Tables and files (as used by application programs in table driven software)
8. Historical database
9. Equipment data

b. The operator shall be able to perform the following actions while the system is on-line.

1. Update or revise a system database.
2. Create and remove a copy of database information on removable media.
3. Transmit a copy of the database to the backup system.
4. The SCADA system shall automatically store partially completed editing without permanently updating the system database. This feature shall permit the operator to acknowledge alarms or otherwise operate the system and then return to editing procedures.

2.7.2.3 Calculated Point

This value shall be created by calculating it from any combination of digital and analog points, and other data. The results of the calculation will be an analog or digital point having all the properties of real points, including alarms, without the associated hardware. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be available for use in any program. Constants used in calculations shall be changeable on-line by the operator.

2.7.3 Scan Modes

a. The software shall provide the message exchange sequence for all scan modes, generate necessary commands to retrieve data and status information, and perform all required error checking to ensure validity of received data, and/or proper completion of the scan sequence. All system malfunctions, including no response from RTU, incomplete data, or invalid data, shall be reported as an alarm.

b. The Master Station shall communicate with RTUs on a sequential continuous scan basis except when interrupted for control functions. The Master Station shall be able to disable scanning at any RTU, or of any Point.

c. Inclusion or exclusion of any RTU or point from the scanning sequence shall be accomplished from any Workstation using an appropriate high-level password.

2.7.4 Error Detection and Retransmission

A Bose-Chadhuri cyclic code error detection algorithm shall be used for data between RTU and Master Station which shall detect all single and double bit errors, all burst errors of eight bits or less, and at least 99% of all multi-bit and burst error conditions. A message shall be in error if one bit is received incorrectly. The system shall retransmit all messages with detected errors. A 2-digit decimal number shall be dispatcher assignable to each communications link representing the number of retransmission attempts. When the number of consecutive retransmission attempts equals the assigned quantity, The Master Station shall close down transmission to that particular device, and print an alarm message. The dispatcher shall manually reopen any communications line after automatic closedown, subject to the same error checking and automatic closedown procedures in effect before the first automatic closedown. The system shall monitor the frequency of data transmission errors for display and logging.

2.7.5 Supervisory Control

2.7.5.1 General

The SCADA system shall accomplish transmission of control commands to the RTUs and the subsequent verification of control operations. Control commands shall have priority over the periodic scans and shall be initiated as soon as current activity on each communication channel is completed. The control sequence shall be handled in a manner that assures the minimum possible interruption to the normal scanning sequence.

2.7.5.2 Select-Before-Operate Breaker Control

a. The communication sequence of control commands between the Master Station and RTUs shall be initiated when the operator requests that it be executed and shall use select-before-operate methodology.

b. Once a point is selected, the transmitted communication messages shall follow the sequence below to assure a secure control scheme between the Master Station and RTUs.

1. The system shall transmit the appropriate point select message.

2. The RTU shall ensure that the point has been selected.

3. Upon receipt of verification that the proper point has been selected, the operator shall be prompted to send the appropriate execute command.

c. If the response received from the RTU indicates that an incorrect point has been selected, the system shall automatically reset the selected point, generate a control error indication, and initiate a printout.

d. When the control command verification is successfully completed, a selectable timer shall be initiated to check for the completion of requested device operation (by checking the status of the controlled device) within a pre-specified time interval. A time interval for each control point individually is required. The time interval may be set for each individual control point. These time intervals shall have a range of 2 to 30 seconds. An appropriate message (different than the one used for SCADA system or communication malfunction) shall be displayed and logged for control completion or failure. There shall be no automatic retry if a controlled device fails to operate. A change in status within the allotted time due to an operator command shall be logged as an event, but shall not be processed as an alarm.

2.7.5.3 Tap Changer Raise/Lower Control

The system shall provide for multiple execution or "jogging" of the control output to tap changers (only) without re-selecting the point. The selected control points shall not automatically cancel after execution of the operate command. However, selection of control points shall automatically cancel if more than 60 seconds elapse between the select and operate steps of the control sequence or if more than 60 seconds elapse between operate commands.

2.7.6 Digital Input Scan Processing

a. Each status and alarm indication scan shall be analyzed to determine the current status of the monitored devices and to determine if a change in state has taken place. Information relating to any changes shall be processed as required for display, alarming, and logging of the changes. All uncommanded changes of state, including return-to-normal, shall be alarmed, displayed, and logged. The system shall ensure that changes of status, including multiple operations, are not lost under any circumstances.

b. To provide detection between scan cycles, momentary change detection shall be provided for all DI points. Between scans, each RTU equipped with DI points shall detect and report at least two contact transitions for any contact input or a total of at least 64 transitions. Positive retrieval of this data shall be accomplished by the Master Station before the data is reset. After the data has been successfully retrieved by the Master Station, a reset command shall be automatically generated by the Master Station to reset the appropriate buffer in the RTU memory.

2.7.7 SOE Input Scan Processing

a. Master Station software shall be furnished for processing SOE data received from RTUs. SOE data retrieval scans shall be separate from the status cycles. The Master Station shall scan the RTUs during the normal status scans to determine if SOE data are available. When a status change occurs, the event shall be identified with a point identification number, type of event, and time of occurrence in hours, minutes, seconds, and milliseconds. If data are available, the Master Station software shall initiate an SOE data block transmit request.

b. The system-wide resolution for SOE data shall be within ±10 milliseconds at any RTU.

2.7.8 Analog Input Scan Processing

a. The system shall measure, transmit, and display all analog values including calculated analog points. An analog change in value is defined as a change exceeding an operator selectable preset differential value. All displays and reports shall express analog values in proper engineering units with sign. One hundred-twenty eight different sets of engineering units conversion shall be provided. Each engineering conversion unit shall include range, span, and conversion equation. Data conversion shall use an Ax + B scheme, where A is a conversion factor and B is an offset value.

b. Limit checking shall be performed after each scan for all calculated and telemetered analog values. High, low and reasonableness limits shall be operator enterable and adjustable for all analog signals. The system shall perform high and low limit checks for flows in the "in" or "out" direction (plus or minus). Alarm limits shall be selectable by the operator.

c. In order to minimize excessive alarming, a threshold (dead-band) for clearing the alarm shall be individually assigned to each analog point. These threshold values shall be operator-settable.

2.7.9 Scan Processing

a. The Master Station shall collect pulse accumulator data stored at each RTU every 5 to 60 minutes, operator selectable, initially set to a 15 minute period. The software shall provide for transmission of a "FREEZE" command to specific RTUs and as a global command to all RTUs. The FREEZE command shall cause the contents of the accumulator count registers in the RTUs to be copied to separate holding registers (FREEZE registers) for later transmission to the Master Station. The accumulator scan shall transfer the contents of the FREEZE registers to the Master Station without altering the FREEZE register contents. A time tag shall be assigned to accumulator data by the RTU; the time shall be the time when the data was "FROZEN."

b. If communications between an RTU and the Master Station are lost, the RTU shall continue to perform data collection on the same time schedule. All accumulator readings shall be uploaded to the Master Station from RTUs after restoration of Master Station-to-RTU communications upon request by the Master Station. Master Station data collection shall be automatically initiated, including resynchronizing of all system clocks, and completed as soon as possible without loss of data following restoration of communications.

c. The scan system shall permit the FREEZE commands and the accumulator scans to be scheduled on a periodic basis synchronized to time of day.

d. The scan scheduler shall permit multiple schedules (global FREEZE and scan on the hour, and FREEZE and scan all RTUs in 5 to 60 minute intervals).

2.7.10 Prediction Software

Prediction software shall be provided having the following characteristics:

a. The prediction software shall perform an extrapolation into the future based on a time series using a minimum of six analog values equally spaced on the time axis, or

b. The prediction software shall perform a least squares or parabolic curve fit to obtain an extrapolation into the future.

2.7.11 Workstation Software

2.7.11.1 Operating System

Each workstation shall be provided with an operating system supporting multi-tasking applications.

2.7.11.2 Windowing System

Each workstation shall be provided with a windowing system software package, with communication protocol, programming library, and tool kit. The windowing system shall also include a client application window management program which shall manage the display screen, define window policy (geometry, movement, interaction), and client arbitration (resource allocation)).

2.7.11.3 Graphical User Interface

Each workstation shall be provided with a portable, object-oriented graphical user interface. The graphical user interface shall implement a windows system tool kit, and provide a set of desktop utilities as listed below.

a. File management

b. Shell tool

c. Calculator

d. Text editor

e. Calendar management

f. Snapshot tool

g. Clock

h. Icon editor

2.7.11.4 Graphics Applications Software

Each workstation shall meet the following minimum graphics requirements.

a. 16 levels of decluttering and detailing. Decluttering is the removal of unnecessary information from the graphics displays. This feature shall be activated when the user is zooming out in a display such that the most pertinent information can be viewed. Detailing is the reverse of decluttering; additional detail is added to layers as the user zooms in.

b. Pan and zoom capabilities. Pan and zoom shall be independent of each other such that the user shall be able to pan at any zoom level with the exception of maximum zoom out. Panning shall be accomplished by positioning the mouse cursor anywhere in the graphics window, pressing the mouse button, and while holding the button down, dragging the screen to the new position. Zooming shall be accomplished by positioning the mouse cursor where the new window is to be centered, and pressing the button to zoom in or out a predetermined amount.

c. 16 colors, assignable to dynamic data, charts, and trends.

d. 4 active windows per display.

e. Dynamic trending.

f. Object-oriented hierarchical displays.

g. Bar charts.

h. Dial/meter presentations of data.

j. 8 text fonts.

2.7.12 User Interface Software

2.7.12.1 Monitor Display System

All monitor displays shall be self-contained and labeled. All displays shall be identified by English language descriptive titles. All displays shall include time and date. Displays shall contain any combination of graphic and tabular information.

2.7.12.2 Types of Display Information

Each monitor display shall clearly distinguish the following types of information.

a. Real-time updated data

b. User-entered data

c. Bad or out-of-scan data

d. Tagged devices (control inhibited)

e. Devices in alarm (unacknowledged)

f. Disabled alarm points

g. Out-of-limits data

2.7.12.3 Display Fields

Certain display areas on the monitor shall be designated for display fields. All screens shall be write protected, such that keyboard entries shall not overwrite the content of the current display, with the exception of areas designated on a display as fields where user input can be typed. Display fields shall include:

a. Cursor home position

b. User input fields

c. Hot button

d. Computer message output field

e. Display title and page number

f. Time and date

g. Main data field

h. Indication of Master Station computer mode (primary or backup)

i. Operator initials or name

2.7.12.4 Display Editor

The display editor shall enable an operator with proper password to create, modify, and delete displays. The primary use shall be for adding and modifying one-line diagrams, station status displays, system summaries, and system directories, as RTUs or new data are added.

a. The basic functions shall include:

1. Creation, modification, and deletion of a new display (graphical/tabular)

2. Pan, Zoom, Layering, Decluttering, and Detailing

3. Cut, Copy, and Paste

4. Bring to Front and Send to Back

5. Selection of multiple objects by holding the <Control> or <Shift> keys or rubberbanding

6. Grouping and ungrouping of objects

7. Undo last action

8. Automatic timed backup (with a user selectable interval)

9. Importing, sizing, placing, and moving graphical files such as TIFF, GIF, and PCX, JPEG and DXF

10. Importing, sizing, placing, and moving text files

b. The basic tools shall include:

1. A tool palette containing the following objects to be placed on a display:

Line
Arc
Circle (outline or filled)
Box (outline or filled)
Polygon (outline or filled)

Text (with multiple fonts)
Foreground/Background color selector

2. A background grid with the following modifiable attributes to assist the drawing process:

Visible/Not visible
Grid spacing
Snap to grid
Grid color

3. Contractor's standard symbol library plus any additional symbols necessary to implement displays as specified. Symbol library shall support addition, deletion or modification of symbols by the operator.

c. The operator shall be able to link status values to pairs of symbols such that a different symbol will be displayed for each state of the status point. The user shall also be able to link any drawn object to a status point which will subsequently change color and other attributes(in the real time environment) based on the state of the status point.

d. Analog values shall be displayed in a user selectable format (i.e. Display all analog values to 3 digits, except for power factor rounded off to 2 digits) on a per point basis. This shall be independent of the format of the value in the database.

e. The operator shall be able to make any object a hot button such that selection of that hot button in the real time environment will be able to call up any other display or run any program (defined with the display editor).

2.7.12.5 Hard-Copy Screen Request

Each workstation shall be able to obtain a hard-copy of the monitor display being viewed. This shall be an exact "snapshot" of the data and device symbols shown on the selected monitor. The hard-copy output shall be directable to the network color printer, or the local workstation laser printer. Completion of printing each image requested shall not exceed two minutes.

2.7.12.6 Displays

The contractor shall provide uniform operating procedures for all displays. Operator prompts from the system shall use industry-standard methods to focus the operator's attention on options after an operator has made a selection. The contractor shall use a consistent method of background and foreground colors to allow operators to easily distinguish between systems and bases with standard background and foreground colors. As an example: 69 KV electrical buses colored blue, 12 KV electrical buses colored orange, 480 V buses colored black, closed breakers colored red, open breakers colored green, and alarms flashing. Values associated with the various devices shall be the same color as the devices. Group values, such as phase A, B, and C voltages, shall be clearly delineated from each other. The contractor shall provide methods for an operator to easily and rapidly select the various displays. Methods include: direct keyboard entry, selection from display menu, dedicated function keys, page chaining using NEXT PAGE, PREVIOUS PAGE keys, and poke points. An operator, with an appropriate password, shall be able to turn equipment on or off from the graphical display, by selecting the point and being prompted by the system with control options. The contractor shall provide the following data entry method and standard displays:

a. Data Entry

Provide a consistent method of data entry to identify fields in which the operator may enter data such as: color, character delimiters, or inverse video. This method shall apply to all displays in the SCADA system. Provide easy and fast positioning of the cursor on the data entry fields. The operator shall be able to make multiple data modifications prior to entering the data. Upon entry the system shall check data entries for validity (such as: syntax and limits). Good data shall be accepted and bad data flagged for subsequent operator correction.

1. An operator, with an appropriate password, shall be able to manually enter replacement data into the appropriate data field when existing data needs manual revision or when scanned data are suspect. The new data values shall be entered into the appropriate data fields and shall replace the existing values when entered into the computer.

2. An operator, with an appropriate password, shall be able to manually enter replacement data into the appropriate data field when existing scanned data is suspect. Scanned data shall be prevented from overwriting a display field when manual entry is in process (automatic freeze operation). Substitute data shall block the entry of scanned data into the data base. Substitute data shall be distinguishable on all displays by the use of uniquely different display colors and data quality tagging. Provide the operator an easy method of releasing the data point back to automatic operation. Provide precautions so that entry of a substitute value does not destroy the

value in the data base until after the entry has been successfully executed. Prior to executing, the original or scanned value shall be reinstated to the display by canceling the operation.

3. An operator scratch pad function shall be provided that will allow operators to enter data and associate that data to displays or specific system points. Data shall also be able to be associated with alarms or with any other event. A note created by an operator shall be automatically called up when any other workstation calls up the associated point, alarm, or alarm summary. The operator scratch pad function shall also support free form entry of data which can be used by any workstation operator as general reminders or instructions. Typical uses of the operator scratch pad are to provide the operator with written instructions associated with controlling a device, energizing a line, restoring power service or operating the system. The contents of the displays will be supplied by the Government. The operator scratch pad function shall support multi-page instructions.

b. Graphic and Tabular Displays

The contractor shall provide the following graphic and tabular displays:

1. System Menu (menu of all tabular, reports, graphical displays, active trends, and other displays provided on the system). Hot buttons shall be provided to allow an operator with an appropriate password, to select and go to any display from this index.

2. Station Index (a list of all RTUs). Hot buttons shall be provided to allow an operator with an appropriate password, to select and go to the RTU graphic displays and tabular displays for the selected RTU.

3. Site index (a list of SCADA sites such as substations or switching stations). Hot button shall be provided to allow an operator with an appropriate password, to select and go to the graphic displays and tabular displays for the selected site.

4. Alarm Summary (list of all uncleared alarms)

5. Abnormal Summary (list of all devices not in normal state; keeps track of alarm conditions which have been cleared)

6. Communication Channel Polling Summary (listing of availability for each communication channel, by statistically processing the number of transmission errors, outages, and other abnormal conditions for each channel)

7. Inhibit Summary (all points which are alarm inhibited)

8. Lockout/Tagout Summary (all points which are locked out or tagged with the reason and operator)

9. Graphic displays based on the information shown

2.7.13 Workstation Software Requirements

2.7.13.1 General

a. All operator control commands shall use the select-before-operate concept. The operator will first be required by the system to select the icon for the device to be controlled. The system shall then respond by distinctively identifying the device which has been selected and request operator verification. After verification of the selected device, the system shall present a menu of all available actions. Available actions shall be displayed in customary terminology for the device to be controlled; for example, breaker control actions shall be "trip/close" and tap changers shall be "raise/lower". The dispatcher will then be required by the system to select the desired control command, and the system shall respond with a message indicating the command which has been selected, requesting verification of the command. The system shall perform the selected command only when the operator provides an affirmative response to all verifications.

b. When the operator has requested execution of the selected command, message exchanges between the Master Station and RTUs or between RTUs shall begin.

c. The operator shall be able to cancel any selected operation prior to entering an execute command.

d. All responses to the operator shall be clear and complete. Every operator request shall generate a response which indicates that the request has either been completed, is being processed, or cannot be performed. Every request must generate a response even if it is negative. If the operator, for example, requests a display of all points in alarm at a time when there are no points in alarm, the system shall notify the operator that no points are in alarm.

e. The software shall accept each operator command, decode it, and check its validity and correctness. Attempts to select a point which has already been selected by another workstation shall be rejected by the software. Point selection with an invalid cursor position shall result in an "Invalid Cursor Position" (or similar) message on the monitor.

f. All invalid requests shall be rejected before any transmission is made to the RTU for control. Whenever the "checks" are not passed, the software shall respond to the last operator command with a "Function Cancel" (or similar) message indicating why it is unable to proceed. When a Function Cancel is signaled, the software shall clear all pending sequences and not initiate any system control commands.

g. The operator shall be able to cancel demand logs or displays during their operation. The cancel function shall be implemented as either a dedicated function key or as a poke point.

h. The system shall automatically cancel selections if the execute command has not been requested within an adjustable timeout interval, initially set to 10 seconds, if another selection is requested, or if the system has successfully performed the associated operation.

i. An alarm shall be generated if a field device that has been given a control command fails to change state after a previously selected time interval.

j. The system shall provide help to the operator upon request during operation of the system.

k. The system shall provide for the operator to input procedural help (script) files to be used in guiding the operator through sequences and for obtaining precautionary information about selected operations.

2.7.13.2 Operator Control Command Functions

The operator shall be able to execute the following control commands using cursor or function keys. Every operator command requiring the select-before-operate shall be logged to.

a. Silence the audible alarm until the system receives a new unacknowledged alarm.

b. Disable the audible alarm until it is enabled again by dispatcher request.

c. Selectively acknowledge either a single alarm or all of the alarms on an alarm summary display page.

d. Operate multi-state devices at RTU locations (open, close).

e. Tag or untag any control output (digital or analog).

f. Manually enter a status or analog value in the database.

g. Auto-acknowledge.

2.7.13.3 Tagging

The system shall not permit control commands to devices which are tagged. As a minimum, a clearance tag classification shall be provided. A clearance tag indicates that all supervisory control of a device is disabled. The operator shall be able to enter a short description of why the device is being tagged. Tagging or untagging a device shall require the operator to select the device to be tagged/untagged and then to verify the selection prior to emplacing/removing the tag.

2.7.14 System Access Control

a. A minimum of 32 passwords shall be usable with the system software. The system shall include software security provisions to prevent inadvertent or unauthorized change of the password. The system shall display the operator’s name or initials in the operator’s display. The system shall print the operator's name or initials, action, date, and time on the disk file at log-on and log-off. The password shall not be displayed or printed. Each password shall be definable and assignable for the following:

1. Commands usable.
2. Access to operating system software.
3. Access to command and applications software.
4. Individual points which are to be accessed.
5. Access for tagging/untagging.
6. Workstations (by name).

7. Each dial-up PC.

b. The operator workstations shall have full system access, including circuit breaker and tap changer control, at all times.

2.7.15 Trending

2.7.15.1 General

a. The trending software shall maintain data files for a minimum of 64 data trends. Any monitored or calculated value, including output data from any algorithm, shall be trendable. Each data trend file shall retain a minimum of 500 data samples. The time rate of sampling shall be selectable on an individual trend basis. The data files shall be maintained with new data "pushed" in and the oldest data overwritten.

b. The monitor shall display at least four trend values per window with separately selectable amplitude scales and time scales for each window. The time line programming shall allow for time scale references to be presented in a visual format that is representative of the application. As each new data line is written on the display, all previous entries shall be advanced to the next sequential element position. Time lines shall automatically move with each data point such that the time reference is always correct.

c. An operator shall be able to enter upper and lower limits for each trend.

d. The system shall provide for dynamic line and bar graphs, illustrating an analog value through a horizontal or vertical bar. The color of the bar graph shall be user-specified and may change based on the point crossing alarm boundaries.

e. The trending software shall allow at least eight colors to be used for different trends.

f. The trending system shall include indication of alarm conditions. Shading, color change, and blink are acceptable methods for indicating values in alarm.

g. As a minimum, the system shall support the presentation of data with time on the X-axis (horizontal) and amplitude on the Y-axis (vertical). A minimum of 24 1-hour divisions and 31 1-day divisions shall be displayed on the X-axis. The start and end date/time shall be operator definable. Systems that provide only strip chart type vertical scrolling displays shall not be acceptable.

2.7.15.2 Trend Description Fields

Each trend display shall include the following trend user-definable description fields.

a. Variable name

b. Amplitude scale

c. Amplitude designation (engineering units)

d. Time units per division

2.7.15.3 Trend Functions

The trending system software shall support the following trend functions.

a. Trend data from history file without active update.

b. Trend data with active update and trend history from time of request to present (no prior history).

c. Trend data with active update and with prior history from a trend history file.

2.7.15.4 Storage of Trend Files

A user shall be able to select any combination of trend files for storage on hard disk or optical disk. The files shall be automatically saved after a user-selectable number of trend values.

2.7.16 Report Generator

2.7.16.1 General

Software shall be provided with commands to generate and format both tabular and graphical reports (including bar charts, pie charts and curve plots) for displaying, printing, and storing on hard disk and optical disks. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the user.

Reports shall use database dynamic values and parameters, values calculated using the database, and reports stored on disk or tape. Reports shall be spooled allowing the printing of one report to be complete before the printing of another report commences. Parameters used in reports shall be assignable by the user. Reports shall be processed to avoid interference with normal Master Station computer tasks. The report generation mode, either periodic automatic or request, shall be user assignable. The report shall contain the time and date when the sample was taken, and the time and date when the report was printed. Reports shall be user-definable to show information in the system data base.

2.7.16.2 Periodic Automatic Report Modes

The system shall allow for specifying, modifying, or inhibiting the report to be generated, defining event triggers for automatic report generation, the time the initial report is to be generated, the time interval between reports, end of period, and the output peripheral.

2.7.16.3 Request Report Mode

The system shall allow for the operator to request an immediate printout of any report at any time.

2.7.16.4 Creation of Reports

a. Status Report: The system shall include software to produce reports on the current status of any equipment or parameters in the data base, including:

1. An individual equipment item sensor or control device.

2. A list of equipment, sensors, or control devices, by category, such as substation, building, unit, RTU, or type.

b. Correlated Alarm Reports: The software shall provide for generating a report to include parameters dependent on a specific alarm in order to obtain immediate status of associated equipment when an alarm condition occurs. The software shall include:

1. Identification of the initiating alarm.

2. Identification of correlated dependent parameters.

3. Automatic reporting of current status of each dependent parameter when an alarm condition is detected in the initiating point.

4. Provide for 64 initiating alarms each having up to 16 dependent parameters.

c. Profile Reports: The software shall provide for generating profile reports by sampling and storing defined parameters on an operator assignable and selectable time interval basis such as an interval of 15 minutes for a period of 1 month and shall include:

1. Power consumption (value vs time).

2. Average power demand (value vs time).

3. Equipment subsystem profiles (value vs value or value vs time).

4. Provide for 32 profile reports each having up to 1000 samples of up to 8 parameters.

2.7.16.5 Standard Reports

The following standard reports shall be provided:

a. Electrical Power Utilization Report: An electrical power utilization summary, user selectable for individual meters or transducers, any group of meters or transducers, and all meters or transducers on a daily and a monthly basis. The report shall be automatically printed at the end of each summary period and shall include:

1. Total daily kWh consumption.
2. Total monthly kWh consumption for period beginning on user selectable day of the month.
3. Demand interval kWh peak for the month and day, with time of occurrence.
4. kWh consumption over each demand interval.
5. Average kWh demand during the interval containing the utility company's peak demand.
6. Average kWh demand during the interval containing the base's peak demand.
7. Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.

b. Alarm Report: All outstanding alarms by point, building, substation, installation, and the entire SCADA system, including time of occurrence.

c. Analog Limit Report: An analog limit and differential summary selectable to describe a single point, all analog points within a unit, all analog points within a building, and all analog points for the project. Display and logs shall still indicate the current value of these points even though alarming may have been suppressed. The report shall include:

1. Point analog value.
2. Engineering units.
3. High limit.
4. Low limit.
5. Analog value change differentials.

d. Out-Of-Service Report: A report to list out-of-service devices in the Master Station, each communication channel, and each RTU.

e. Static Database Reports: A listing of the values of fixed parameters and constraints defining the characteristics of the system. Provide operator commands to list the entire static database or to list an operator selected building, substation, unit, point, or RTU. Each value listed shall be identified in English.

f. Real-Time Database Reports: A list of the values of dynamic variables including all digital inputs, analog inputs, and calculated points. These variables shall include year, month, day, hour, and minute on the report. Operator commands shall allow for listing the entire real-time database or to list a user selected building, substation, unit, point, or RTU. Each value listed shall be identified in English.

g. Communication Circuit Report: A listing of all communication circuits from the Master Station to RTUs. The report shall include:

1. Operator selected number (1-99) of retransmissions attempts.
2. Total number of transmissions attempted (0-64,000).
3. Present consecutive retrys (in progress) (1 - 99).
4. Total number of retrys (cumulative to 32,000).
5. Status of communication circuit (enabled or disabled).

h. Communication Outage Report: A listing containing the monthly total downtime for each communication circuit.

2.7.17 Alarm Processing

2.6.17.1 General

Processing and reporting of defined alarm events and conditions shall have the highest system priority. Alarm messages shall be presented in an organized unambiguous manner to the operator. The software shall permit designating which of the applicable alarm types apply to each point in the database on a point by point basis.

2.7.17.2 Alarm Types

The alarm processing software shall recognize the following events or conditions as alarms.

a. Analog input above a preset high limit.
b. Analog input above a preset high-high limit.
c. Analog input below a preset low limit.
d. Analog input below a preset low-low limit.
e. Return to normal for any of the above alarms.
f. Failure to change state when commanded.
g. Uncommanded change in state.
h. RTU not responding.

i. RTU responding (return to normal).

j. RTU/Master Station clock out of limit.

k. On/off line switch - enables and disables RTU communications with Master Station.

l. RTU failure - self-diagnostics activated

2.7.17.3 Alarm Security

The alarm subsystem software shall be structured so that no alarms are lost. The alarm buffering shall queue up to 5000 alarm events and conditions without overflow.

2.7.17.4 Alarm Events

a. When an alarm event or condition occurs, the operator shall be alerted as follows:

1. An audible alarm shall be sounded within 5 seconds after the alarm condition is transmitted from the RTU to the master station.

2. A flashing alarm message shall be generated on the alarm summary display within 5 seconds after the alarm condition is transmitted from the RTU to the Master Station.

3. An alarm message shall be placed in the queue and buffered for printing on the alarm printer on a first-in-first-out basis.

b. When an alarmed condition returns to a normal range or state, the system shall respond as follows:

1. An audible alarm shall not be generated.

2. A flashing return to normal message shall appear on the alarm summary display.

2. A return to normal message shall be printed.

3. After acknowledgment, the alarm message shall be deleted from the alarm summary display.

2.7.17.5 Alarm Acknowledgment

a. Alarm messages shall be acknowledged from the Alarm Summary display using either function key, mouse, or cursor control. Each alarm message shall be acknowledged individually by selecting the point in alarm and executing the acknowledge function. Alarm messages shall be acknowledged before the system will allow the alarm to be deleted. This shall include the initial alarm and the return to normal alarm.

b. When an alarm message is acknowledged, the point shall stop flashing on displays and the alarm message shall be changed from unacknowledged to acknowledged on the Alarm Summary display.

c. A page acknowledge function shall be provided to acknowledge all alarms displayed on the current page displayed.

d. An alarm delete function shall be provided to allow acknowledged alarms to be removed from the alarm summary.

2.7.17.6 Alarm Suppression

An alarm suppression function shall be provided which suspends alarm processing on individually selected points or on selected RTUs. When the alarm processing is suppressed for a point, it shall be scanned and the data processed as usual for the database and displays. However, any change of status or limit violation shall not be processed as an alarm. The point shall be highlighted notifying the operator that this point is being alarm suppressed. A means allowing the operator to restore normal alarm processing to suppressed alarms shall be provided.

2.7.17.7 Alarm Display

Alarm messages shall indicate date and time when the alarm was detected by the RTU (not the time of alarm message printout) to the nearest second, the RTU where the alarm occurred, the device in alarm, and descriptive information. Alarm messages for the system and communication malfunction alarms shall list the date, time, and descriptions of the alarms. The operator shall be able to define alarm action messages which will be printed or displayed on user specified printers/workstation monitors, with a message length of at least 60 characters. The alarm display shall be a chronological listing of the alarm messages, beginning with the most recent alarm. The

display shall clearly indicate whether an alarm is acknowledged but still present or unacknowledged. Alarm displays shall be automatic.

2.7.17.8 Alarm Action Messages

A unique message with a field of 240 characters shall be provided for each alarm. Assignment of messages to a point shall be an operator editable function. Secondary messages shall be assignable by the operator for printing to provide further information, such as telephone lists or maintenance functions, and shall be editable by the operator. The system shall provide for 100 secondary messages with a field of 4 lines of 60 characters each. The system shall provide for redirection of operator-specified alarms to operator-specified workstations.

2.7.17.9 Alarm Classes

Classes of alarms, established for each item during the definition process, include:

a. Class 1: Display, print, and sound an audible alarm at occurrence. Operator acknowledgment shall end audible alarm. Print at return-to-normal.

b. Class 2: Display and print at occurrence and at return-to-normal.

2.7.17.10 Enhanced Alarm Processing

a. Enhanced alarm processing shall include prioritization and sorting of alarms.

2.7.18 Mathematical Operations

2.7.18.1 General

A program that allows for development of calculation routines to be created by the operator shall be provided. Each calculation shall run at regular intervals that are user definable per calculation. Multi-step calculations shall be possible with this program. The calculation and control program shall support a complete set of mathematical and logical operators. All program outputs shall be archived, trended, or put into reports.

2.7.18.2 Calculation Routines

a. A hot button shall be provided to permit the operator to force a calculation of the data.

b. The Contractor shall provide a preformatted display which meets the following requirements for all calculations.

1. Labeled data fields for each type of calculated value.

2. Labeled hot button for dispatcher initiated program functions such as recalculate.

3. Display title, page number, time, and data fields.

4. All averaged data values in the database for use in displays, reports, calculations, and other programs.

2.7.19 Historical Data Processing

2.7.19.1 General

The system shall process all real-time data and store user-selectable data for use at a later time. It shall store scanned values on a periodic basis, the maximum value for a point which occurred within a given time, or a calculated value. It shall generate reports using the historical data base processor and the reporting software. Using the editing software, the dispatcher shall be able to edit or insert new values in the historical database. All historical information shall initially be stored in mass memory and shall be automatically spooled to magnetic tape for long-term storage. The tape drives shall store data in a form that allows historical reports for a workstation user to be readily prepared from the media. Historical trend files saved to the tape drives shall be recallable both as a trend file and as tabular data. All historical data shall be written to appropriately structured files on the Master Station computer’s hard drive, which shall function as 30-day buffers. After the 30-day period is over, the system shall write the 30-day buffer to the tape drive for permanent storage/retrieval and shall then continue with the next 30-day buffer.

2.7.19.2 Structured Query Language (SQL) Interface

The historical database shall provide for SQL interface access. The SQL interface shall be compliant with FIPS PUB 127-2 (SQL).

2.7.19.3 Database Operator Access

The operator shall be able to access the historical data base using graphical programming technique consistent with that of the rest of the SCADA system operator interface.

2.7.20 Security Callback Controller Software

A dial-back security device shall provide access to the system. The security callback controller software shall intercept incoming telephone calls from a remote computer requesting the caller to provide a password or other key information, shall sever the connection, and shall automatically call the originating caller back at a preassigned phone number, after which the caller will be prompted for a correct ID and password.

2.7.21 Portable Workstation Software

The Portable Workstation Software shall allow querying of system information via the dial-up security callback modem, subject to proper passwording and user identification. The Workstation shall be able to access all data at the user's password level, generate and retrieve reports, initiate and retrieve trends, and retrieve alarm data.

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(NOTE:) The designer will review the need for applications software with the installation. This software, and the data required to use it, can be very expensive. If the applications software is required, the installation must provide a complete model of the electric systems at the installation, and must input the data or require the contractor to input the data to the electric power system model for use of the applications software.

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2.8 [APPLICATIONS SOFTWARE]

[2.8.1 General

This section describes the characteristics of special application software required for support of electric operations using the system. The applications software modules shall be able to use either real-time or historical data. The Contractor shall provide preformatted displays for each program described, including:

a. Labeled data fields for each manually entered value.

b. Hot buttons for operator initiated program functions.

c. Labeled data output fields for each calculated operation.

d. Display title, page number, time, and date fields.

2.8.2 Electric Power System Model

The electric power system model shall be a complete description of the electric power system monitored and controlled by the SCADA system. This model shall include all electrical characteristics of sources, transformers, distribution lines and other system elements required for execution of the specified applications software.

2.8.3 Load Flow Analysis

2.8.3.1 General

The Load Flow Analysis software module shall allow the user to analyze the power system behavior for a variety of present and future anticipated operating conditions. The program shall be able to "snapshot" the present system conditions, or load into the model a number of pre-defined "study cases" as the beginning point for simulation. Both 3-phase balanced and 3-phase unbalanced load flows shall be included. Completed studies shall be written to a disk file for later recall and evaluation.

2.8.3.2 Program Inputs

a. Time/date.

b. User entry of the following values to test various situations.

1. Changes in load
2. Tie load flows
3. Transformer tap positions
4. Capacitor bank switches

c. File(s) containing previously created "study cases".

d. Snapshot of all available real-time 3-phase balanced or unbalanced voltages.

2.8.3.3 Program Outputs

a. "Study case" file output for later retrieval.

b. Load flow report to screen or printer, user-selectable, containing the following information:

1. Power flows at each bus
2. Line currents
3. Line losses

2.8.4 Short Circuit Analysis

2.8.4.1 General

The Short Circuit Analysis software module shall allow the user to simulate the distribution system under a line-to-ground, line-to-line, or 3-phase-to-ground fault on any bus in the system. Program output shall provide the user with fault current and voltage information on all buses based on the fault location. There shall be no restriction on the type of line conductor inputted.

2.8.4.2 Program Inputs

a. Time/date

b. User entry of values to test various situations.

c. User entry of fault location and type of fault including:

1. Single line-to-ground
2. Line-to-line
3. Three phase

d. File containing all editable line conductor information.

e. File(s) containing previously created "study cases".

f. Snapshot of all available real-time three-phase voltages.

g. Snapshot of all available real-time three-phase currents.

h. File containing all short circuit interrupting capacities.

i. File containing all motor horsepower ratings.

2.8.4.3 Program Outputs

a. "Study case" file output for later retrieval.

b. Short circuit report with user-selectable output to screen, printer, or file containing the following information:

1. Fault current
2. All line currents

3. Voltage levels at all busses during the fault

2.8.5 Peak Load Analysis

The peak load analysis program shall calculate the load on the system every 15 minutes by summing all loads monitored, in order to obtain an instantaneous total system load. At the end of each 15 minute interval, the loads shall be compared to determine if a peak has been reached. At the end of each hour, the hourly peak load shall be stored in the historical database, along with the coincident load of up to 250 designated data points. Peaks shall be calculated and stored in a like manner for day, week, month, and year.]

2.9 LAN SOFTWARE

2.9.1 General

The LAN software shall provide for transparent communication with any node on the network. LAN software shall support the configured as shown.

2.9.2 Network Operating System

A network operating system shall be supplied as part of the LAN software. The network operating system shall support central and remote database maintenance, servers, file transfer, security, and job entry. A configured and operational shell menu interface shall be provided, and shall be user-configurable.

2.9.3 Network Management and Monitoring Software

a. The software shall query the network to establish all active nodes and their addresses, and gather information on the performance and efficiency of all workstations, peripheral and workstation processors, bridge, and network topology. The information gathered shall be displayed on the LAN manager/peripheral processor monitor as a logical map of the network. The software shall perform node configuration management.

b. The software shall report real-time performance and error statistics of any node on the system and capture the data to an ASCII file. The software shall report network utilization down to the network interface card level. The diagnostic functions shall perform point-to-point connectivity tests to isolate faults.

2.10 FIELD EQUIPMENT SOFTWARE

2.10.1 General

This section specifies software common to all RTUs. Software shall be in a high-level language, and shall possess the characteristics of such languages as C, Pascal, Fortran, or ADA; or in assembly language where required to meet performance requirements..

2.10.1.1 Freeze Command Input Processing

The RTU shall respond to a Master Station generated FREEZE command. The FREEZE command shall cause the contents of the accumulator register to be copied into a separate freeze register. The system shall read the freeze register and transmit the information to the Master Station at any time without changing the contents of the register. Calculated 5 to 15-minute buckets of kWh data shall be treated like a pulse accumulator point.

2.10.1.2 Control Operations

a. When a control point command is received, the RTU shall arm the selected control point, test the output device to determine which point has been armed, encode the address of the point that has been armed, and transmit the encoded address to the Master Station. Checking methods that re-encode the message from a holding register without testing the output device are not acceptable.

b. After selection (point arming), the RTU shall automatically reset (cancel) the point within a user-definable predetermined time if it has not received a valid operator command transmission. Any message that fails a comparison check or attempts to select more than one point shall initiate a control failure alarm and cancel the control actions. Selection of control points shall automatically cancel if more than 30 seconds elapse between the select and execute steps of the control sequence, or if more than 30 seconds elapse between execute commands.

c. The software shall allow multiple execution or "jogging" of the control outputs for tap changer operations without reselecting the point. The selected tap changer control points shall not automatically cancel after execution of the operate command.

2.10.1.3 Diagnostics

Diagnostic software shall be provided for use in the portable tester. The software shall display messages in English to inform the tester's operator of diagnosed problems.

2.10.2 RTU Software

2.10.2.1 RTU Functions

a. The Contractor shall provide software necessary to accomplish the following functions, fully implemented and operational, within the RTU.

1. Scanning of inputs.

2. Control of outputs.

3. Report to Master Station of point changes.

4. Report to Master Station of point status.

5. Maintain real time, updated from the Master Station at least once per hour, and after each communication failure or power interruption.

6. Averaging or filtering of all analog inputs.

7. RTU diagnostics.

8. Portable tester operation as specified.

b. Each RTU shall contain an operating system that controls and schedules RTU activities in real time. The RTU shall maintain a point database in its RAM that includes the latest value or status of all points connected to that RTU. The execution of RTU application programs shall utilize the data in this RAM resident file. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each RTU real time clock shall be synchronized with the Master Station automatically. The time synchronization shall be accomplished without human intervention and without requiring system shutdown. The operating system shall allow local loading of software and data files from the portable tester as specified.

c. Each RTU shall have monitoring and control functions. Each command shall be executed by the RTU only after all select-before-operate checks have been passed. Status changes and analog point values shall be reported to the Master Station when requested. Each individual point shall be capable of being selectively disabled by the operator from the Master Station. Disabling a point shall prohibit monitoring and control of that point.

d. Each RTU shall have SOE input processing functions where shown or specified. At the time of occurrence, each SOE event shall be stored in the RTU memory for later transmission to the Master Station in blocks of security coded data. The RTU shall respond with a block of SOE data where a block equals five events, and shall retain data until the Master Station acknowledges proper receipt of the data. Each RTU shall contain enough time-tagged contiguous memory dedicated to SOE points to store at least 20 blocks (100 events), and shall store events in the order they occur. Overflow from time-tagged memory shall be stored in nontime-tagged memory with point number and type of alarm for the event also retained.

e. Each RTU shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory.

2.10.2.2 RTU Startup

The RTU shall have startup software that causes automatic commencement of operation without human intervention. The startup software shall establish communications with the Master Station and enter the communicating mode of operation; if unable to establish communications, the startup software shall enter the noncommunicating mode of operation.

2.10.2.3 RTU Operational Modes

a. There shall be two operational modes at the RTU:

1. Communicating mode. RTUs communicating with Master Station.

2. Stand-alone (noncommunicating) mode. RTUs not communicating with Master Station.

b. For communicating mode, this software shall perform RTU functions as specified using commands and updated parameters, including updates transmitted from the Master Station. The RTU software shall execute commands after performing constraints checks in the RTU.

c. For stand-alone mode, this software shall perform RTU as specified using data obtained from connected devices and based upon the RTU real time clock function. All information required as specified shall be stored in the RTU data base. Clock updates and parameters will not be received from the Master Station in this mode. A buffer shall be provided to store the latest [32] [...] changes of state for subsequent transmission to the Master Station as a data file.

[2.10.2.4 RTU Resident Applications Programs

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(NOTE:) SCADA system applications do not generally require sequential or closed loop control by the RTU. The designer will review the need for special application programs with the installation. If required, the designer will include this paragraph and add any project-specific requirements.

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RTUs shall execute user-defined programs, such as breaker sequencing and reclosures. The Contractor shall provide the following applications programs as specified, resident and executing in both the communicating and noncommunicating modes.]

2.11 FACTORY DEMONSTRATION

2.11.1 General

The Contractor shall provide a factory demonstration of the SCADA system. The factory demonstration is anticipated to be one day in duration, and shall include the following:

a. Presentation of Contractor's standard SCADA system hardware as specified.

b. Demonstration of Contractor's standard SCADA system operation as specified.

c. Discussion of system operation, testing, training and documentation, including an overview of the Contractor's standard manuals.

PART 3 - EXECUTION

3.1 INSTALLATION

The Contractor may start installation after Government acceptance of the Technical Data Package and successful completion of the factory demonstration

3.1.1 Existing Controls

The Contractor shall connect to and utilize existing controls and devices as shown. Control devices that are usable in their original configuration without modification may be reused. The Contractor shall perform a field survey, including inspection of all existing devices and controls intended to be incorporated into the SCADA system and furnish an existing conditions report to the Government. The report shall identify those items considered nonfunctioning. The Contractor shall provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated cost to correct the deficiency. If a device fails after the Contractor has commenced work on that device, the Contractor shall diagnose the failure and report the failure to the Government. The Contractor shall be held responsible for repair costs due to Contractor negligence or abuse of Government equipment.

3.1.2 Scheduling of Work and Outages

See the CONTRACT CLAUSES regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.1.3 Demolition and Removal

See SECTION 02050 DEMOLITION AND REMOVAL and the CONTRACT CLAUSES for work required.

3.1.4 Installation of Field Equipment

3.1.4.1 General

The Contractor shall install all field equipment as specified and required for a fully functional and operational SCADA system. The Contractor shall exercise caution when drilling holes in panels housing energized equipment. When mounting RTUs, or other equipment, the Contractor shall not allow metal shavings to fall into energized equipment. All work related to power equipment, including installation of instrumentation on high voltage equipment and feeders, shall be as required in SECTION:16370, ELECTRICAL DISTRIBUTION SYSTEM, AERIAL, and SECTION: 16375, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.1.4.2 Grounding

The Contractor shall provide instrumentation grounding in accordance with manufacturer's recommendations. The Contractor shall provide an adequate ground for all enclosure circuits and cable shields to prevent ground loops and electrical noise from adversely affecting operation of the system.

3.1.4.3 Communications Equipment

The Contractor shall be responsible for installing and testing fiber optic modems for RTUs.

3.1.5 Installation of Master Station and Workstation Equipment

The Contractor shall install all Master Station, Workstation, and peripheral equipment as specified and shown for an operational SCADA system.

3.1.6 Installation of Instrumentation and Controls

3.1.6.1 Current Transformers

Each terminal of each current transformer shall be connected to a short circuiting terminal block.

3.1.6.2 kWh Meters and Digital Multi-Meters

The Contractor shall determine the exact mounting locations, cut suitable holes in the existing panel fronts and provide all necessary mounting hardware. The Contractor shall verify clearance and spacing before cutting any holes. Replacement meters shall be mounted in the same location as the existing meters being replaced. The Contractor shall modify the existing mounting holes as necessary for proper installation and fit of new meters.

3.1.6.3 Instantaneous Time/Overcurrent Relays

a. New 50/51 relays shall be mounted in the same location as the old. The Contractor shall modify the existing mounting holes as necessary for proper installation and fit of new 50/51 relays.

b. The Contractor shall set and test each new time/instantaneous relay after installation, and perform a relay coordination test to verify the proper operation of each relay. The Contractor's test equipment shall have been tested and calibrated within the last six months before the testing date, with physical evidence to document this traceable to NIST.

3.1.6.4 Auxiliary Status Relays

Auxiliary status relays shall be wired into the pilot light circuit of equipment being monitored as shown.

3.1.6.5 Transducers

Transducers shall be panel-mounted inside existing compartments and enclosures, unless otherwise indicated, as shown on the drawings. Where the existing enclosures do not have adequate space, new enclosures shall be provided.

3.1.6.6 Watthour and Demand Meters

The Contractor shall install watthour and demand meters and transducers in new enclosures unless otherwise shown.

3.1.6.7 VAR Transducer

The VAR transducer shall be wired in accordance with the manufacturer's instructions, and installed in new enclosures.

3.1.7 Installation of LAN Equipment

a. The Contractor shall install all LAN equipment as specified for an operational system.

b. LAN cable shall be prepared in accordance with the cable and connector manufacturer's instructions. Category 5 rated connectors, as defined by EIA 568A, shall be used for direct connection to the cable. Cables shall be of sufficient length to allow equipment displacement of at least 8 feet in any direction.

3.1.8 Installation of Software

3.1.8.1 General

The Contractor shall install all software as specified and required for an operational system including databases, operational parameters, LAN, system, command, application, and Workstation programs. Upon successful completion of the Endurance Test, the Contractor shall provide original and backup copies of object modules for all accepted software including diagnostics, on each type of media utilized. The hard drive on each workstation shall be partitioned and formatted at the factory, and all workstation software shall be installed on the hard drive at the factory. The Contractor shall provide one master copy and one back-up copy of all software, including the operating system, on CD-ROM.

3.1.8.2 Development of Database

The Contractor shall develop the entire SCADA system database, using data shown, and the Contractor shall supply all other data required for the database.

3.1.8.3 Displays Required

The Contractor shall provide the displays specified and as shown. All real-time inputs and outputs for the displays shall be included. All graphics provided shall be in the format and meet the requirements of Paragraph: Graphics Applications Software.

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(NOTE:) The designer will include this paragraph if applications software is required. The designer will coordinate with the installation to determine the source of network model data, and whether network model data will be input by the contractor or by the Government.

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[3.1.8.4 Electric Power System Model

The contractor shall [enter all data for a complete electric power system model based on the information [shown] [identified in...].] [provide [8][...] hours of expert technical assistance to Government personnel who will enter data in the electric power system model.]]

3.1.9 Initial Stocks

All initial quantities specified below shall be in addition to those needed for running the PVT and Endurance Test.

a. One box of 10-3.5" 1.44 MB diskettes for each Workstation.

b. 1000 sheets 8.5 inch X 11 inch paper and one toner cartridge for each laser printer.

c. Two boxes of 7000-sheet fanfold paper and six ribbons for each dot-matrix printer.

d. Six additional cartridges of each color for the color printer.

e. Ten new 4mm formatted tapes with a capacity of 4 Gbytes before compression.

3.2 SITE TESTING

3.2.1 General

The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all site testing. The Government will witness all PVT and endurance testing, and written permission must be obtained from the Government before proceeding with the next phase of testing. Original copies of all data produced, including results of each test procedure, during PVT and endurance testing shall be turned over to the Government at the conclusion of each phase of testing prior to Government approval of the test.

3.2.2 Testing, Adjusting, and Calibration

The Contractor shall test, adjust, and calibrate all field equipment and verify SCADA system data transmission system operation before the system is placed on line. The Contractor shall calibrate each instrumentation device connected to the SCADA system by making a comparison between the reading at the device and the display at the Master Station, using a standard traceable to the National Institute of Standards and Technology (NIST), which shall be at least twice as accurate as the device to be calibrated. The Contractor shall check each control point within the SCADA system by making a comparison between the control command at the Master Station and field-controlled device. The Contractor shall verify operation of all systems as specified upon SCADA system failure or loss of power, and that all systems return to proper operation automatically upon resumption of SCADA system operation or return of power. The Contractor shall deliver a report describing results of functional tests, diagnostics, and SCADA system calibrations including written certification to the Government that the installed complete system has been tested, adjusted, and calibrated, and is ready to begin the PVT. The report shall also include a copy of the approved PVT procedure.

3.2.3 PVT

The Contractor shall demonstrate compliance of the completed SCADA system with the contract documents. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated and shown. The PVT as specified shall not be started until after receipt by the Contractor of written permission by the Government, based on the Contractor's written report including certification of successful completion of Contractor Field Testing as specified, and upon successful completion of training as specified. The PVT shall be performed as an integrated test with the data transmission system, and with all equipment specified operating and exchanging actual data under fully loaded conditions.

3.2.4 Endurance Test

3.2.4.1 General

The Contractor shall use the endurance test as specified to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall be conducted in phases as specified. The endurance test shall not be started until the Government notifies the Contractor in writing that the PVT is satisfactorily completed, training as specified has been completed, correction of all outstanding deficiencies have been satisfactorily completed, and that the Contractor has permission to start the endurance test. The Government may terminate testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

3.2.4.2 Phase I (Testing)

The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing. If the system experiences no failures during the Phase I test, the Contractor may proceed directly to Phase III testing after receipt by the Contractor of written permission from the Government.

3.2.4.3 Phase II (Assessment)

After the conclusion of Phase I, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing shall be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the PVT. Based on the Contractor's report and the test review meeting, the Government shall determine the restart point, and may require

that the Phase I test be totally or partially rerun. The Contractor shall not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed. If the retest is completed without any failures, the Contractor may proceed directly to Phase III testing after receipt by the Contractor of written permission from the Government.

3.2.4.4 Phase III (Testing)

The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

3.2.4.5 Phase IV (Assessment)

After the conclusion of Phase III, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing shall be resumed, if any deficiencies appeared during Phase III. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the PVT. Based on the Contractor's report and test review meeting, the Government may require that the Phase III test be totally or partially rerun. The Contractor shall not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase IV assessment shall be repeated as if Phase III had just been completed.

3.2.4.6 Exclusions

The Contractor shall not be held responsible for failures resulting from the following:

a. An outage of the main power supply in excess of the capacity of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the system performed as specified.

b. Failure of a Government furnished communications link, provided that the RTU automatically and correctly operates in the stand-alone mode as specified, and that the failure was not due to Contractor furnished equipment, installation, or software.

c. Failure of existing Government-owned equipment, provided that the failure was not due to Contractor-furnished equipment, installation, or software.

3.3 TRAINING

3.3.1 General

The Contractor shall conduct training courses for designated personnel in the maintenance and operation of the system as specified. The training shall be oriented to the specific system being installed under this contract. Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. The Contractor is responsible for furnishing all audiovisual equipment and all other training materials and supplies. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government either as a part of the printed training manuals or on the same media as that used during the training sessions. A training day is defined as eight hours of classroom instruction, including two 15-minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor shall assume that attendees shall have a high school education or equivalent, and are familiar with utility systems. Approval of the planned training schedule shall be obtained from the Government at least 30 days prior to the training.

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(NOTE:) the designer will coordinate the number of personnel to attend each training session with the installation.

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3.3.2 Operator's Training I

The first course shall be taught at the project site for a period of five consecutive training days during or after the Contractor's field testing, but before commencing the PVT. A maximum of [10] [...] personnel will attend the course. No part of the training given during this course shall be counted toward completion of the PVT. The course shall include instruction on the specific hardware configuration of the installed system and specific instructions for operating the installed system. Upon completion of this course, each student shall be able to start the system, operate the system, recover the system after a failure, and describe the specific hardware architecture and operation of the system. This course shall include:

a. System architecture.

b. Functional operation of the system.

c. Dispatcher commands.

d. User commands.

e. Color graphics generation.

f. Database entry.

g. Reports generation.

h. Alarm reporting.

i. Diagnostics.

j. LAN operation

3.3.3 Operator's Training II

The second course shall be taught while the endurance test is in progress for a total of 4 hours of instruction per student. A maximum of [10] [...] personnel will attend the course. The Contractor shall schedule his activities during this period so that the specified amount of time is available during the Endurance Test for instructing the students. The course shall consist of hands-on training under the constant monitoring of the instructor. The instructor shall be responsible for determining the appropriate password to be issued to the student commensurate with each student's acquired skills at the beginning of each of these individual training sessions. Upon completion of this course, the students should be fully proficient in system operations. The Contractor shall prepare a written report describing the skill level of each student at the end of this course.

3.3.4 Operator's Training III

The third course shall be taught at the project site for a period of one training day approximately 3 months after completion of the Endurance test. The Government will determine the specific date of the training session. A maximum of [10] [...] personnel shall attend the course. The course shall be structured to address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should have no unanswered questions regarding operation of the installed SCADA system.

3.3.5 Maintenance Training

The maintenance course shall be taught at the project site after completion of the endurance test for a period of two training days. A maximum of [10] [...] personnel will attend the course. The training shall include:

a. Physical layout of each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Repair instructions.

d. Preventive maintenance procedures and schedules.

e. Calibration procedures.

3.4 RELIABILITY CALCULATION

This exponential calculation depends on the test duration and assumes that the Mean Time Between Failures (MTBF) does not change after each repair; and that the probability of failure is constant throughout the useful life of the component regardless of how many failures the system has experienced. This calculation does not account for effects of aging.

3.4.1 Definition of Reliability

System reliability is calculated in terms of overall MTBF where the component reliability furnished by vendors is already expressed as MTBF. The mathematical combination of the component MTBF values is defined as the system reliability, R(t); the probability that the system will perform its function during a given time period under specified conditions. In this calculation, each component reliability is determined; the component reliability's are combined as dictated by the system configuration; and the overall MTBF is computed as follows:

R(t) = e(-t/MTBF); where:

MTBF = mean time between failure

t = duration of test period

e = base of natural logarithms

When t/MTBF is less than 0.1, the reliability can be approximated as follows:

R(t) = 1 - (t/MTBF)

A specific reliability value can be interpreted by noting that a value of R(t) greater than 1/e (which equals 0.37) indicates that the MTBF value is greater than the test duration.

3.4.2 Series and Parallel Components

Components are in series if failure of one component causes a system failure. Reliability of components in series is a product of the individual reliability's:

R = 1 - (r1)(r2)(r3). . .(rn)

If components in a system are redundant (parallel), reliability is computed as follows:

R = 1 - { (1-r1)(1-r2). . . (1-rn)}

If a system has parallel components, an equivalent series reliability is computed for each set of parallel components. The reliability of the system is then computed as the product of series and equivalent series reliability's.

3.4.3 Calculation Procedure

The Contractor shall prepare a table showing the following data:

a. Name and quantity of each component.

b. Identify each component as series or parallel. (For example, if there are 2 printers, the failure of 1 will not cause a system failure).

c. MTBF for each component.

d. Single unit reliability: R = e(-t/MTBF), where t = 1,000 hour test period.

e. Total Component Reliability (TCR) where TCR = Rn, and n = number of components. For parallel components, TCR = 1 - (1-R)n, where n = number of components.

f. Cumulative Reliability (CUMR) is the product of total component reliability; for example: CUMR 4 = (TCR1) (TCR2) (TCR3) (TCR4) = (CUMR3) (TCR4)

g. Cumulative MTBF = -1,000/LN (CUMR); where LN (CUMR) is the natural logarithm of (CUMR). As an example: CUM.MTBF = -1,000/LN (CUMR4)

End of Section