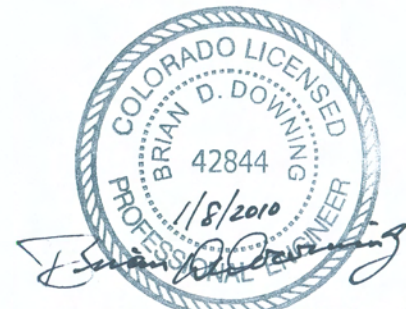




Electrical and Instrumentation, and SCADA System Design Standards

Prepared for Arapahoe
County Water
Authority

DLT&V Project Number
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January 8, 2010

DESIGN CONSTRUCTION INTEGRATION

Problem solved.



ARAPAHOE COUNTY WATER & WASTEWATER AUTHORITY SCADA, ELECTRICAL, AND INSTRUMENTATION DESIGN STANDARDS

**Revision 3.0
January 8, 2010**



Section 1 - Revision History

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I. INTRODUCTION

The Arapahoe County Water and Wastewater Authority (ACWWA) SCADA, Electrical and Instrumentation design standards document provides a standardized approach to SCADA system and infrastructure development and implementation within its jurisdiction. In order to ensure consistency in SCADA and control system design as well as electrical and instrumentation equipment procurement and implementation, which may from time to time be completed by different consultants for a given project, it is imperative that the standards be followed. ACWWA requires that these standards are followed by those consultants wishing to carry out work within its jurisdiction.

II. PURPOSE OF SCADA SYSTEMS DESIGN STANDARDS

The purpose of this section is to provide standards and other technical information from which vendors, contractors and ACWWA personnel can create PLC, computer and SCADA programs, graphics and other documents. In addition, this section will provide specific information on PLC and input-output module hardware as well as electrical and instrumentation equipment manufacturers.

This section provides a set of guidelines, that when followed, will result in software that is consistent with the rest of ACWWA operations.

III. NOMENCLATURE

The following table lists acronyms used throughout this document.

Acronym	Definition
HMI	Human-Machine Interface. A set of graphics driven screens run on a standard PC and used to control and monitor processes.
I/O	Input / Output. Field devices connected to a PLC that interface with instrumentation, equipment and communications gear.
IT	Information technology. For the purposes of this document, IT will collectively refer to office-level computer equipment, services and networks.
Logix	A family of PLCs from Allen-Bradley (AB) used at ACWWA installations. The Logix family is a newer, more powerful family of controllers over their SLC counterparts.
OIT	Operator Interface Terminal. A graphical interface, usually from the same vendor as a PLC that serves as an operator interface to the process. Generally located near the PLC, and thus the equipment and process being controlled.
PLC	Programmable Logic Controller. A small process computer located in the field or near the equipment being controlled.
RTU	Remote Telemetry Unit. A unit in the field, a well site, for example, that consists of a PLC, I/O cards, radio link and an enclosure.
SCADA	Supervisory Control And Data Acquisition. A broad term that covers computer programs that provide a graphical interface to all processes that make up the ACWWA operation. Historical data collection, trending and reporting also fall under this umbrella.
SLC	Small Logic Controller. A family of PLCs from Allen-Bradley



(AB).

IV. PROGRAMMABLE LOGIC CONTROLLERS

The purpose of this chapter is to describe the PLC standards required to be implemented in all automation and controller programming developed for ACWWA. ACWWA has a substantial investment in programming already deployed for use in operating its existing facilities. The standards are aimed at protecting that investment by requiring all future program and automation development to follow these standards.

It is not intended that these standards dictate any specific approach to the developing, testing, or commissioning of control strategies to meet any particular required project functionality. Rather, it is the intent of these standards to provide a common structure for all programs to aid in the understanding, troubleshooting, and future modification of them by ACWWA personnel or other designated contractors.

No standards can conceive of every possible eventuality. It is the intention of ACWWA to establish the following standards for implementation where possible. If these standards do not seem applicable for a particular project it is the responsibility of the contractor for the project to notify ACWWA and suggest alternatives for consideration. It is further necessary that any resultant deviation of, or amendment to, the standards be documented and approved by ACWWA or its designated representatives.

Standards have been developed in the following categories:

- o Controller Hardware
- o I/O Modules
- o Programming Software
- o Programming Languages
- o Add On Instruction Library
- o Naming Conventions
- o Standard Names
- o Software Component Descriptions
- o PLC Drawing Formats
- o HMI Interface Requirements



These requirements are further defined in the sections that follow.

A. Controller Hardware

The ACWWA standard platform is the Allen-Bradley family of PLCs, I/O cards and programming software. The ControlLogix PLC system will be used at water treatment plants, wastewater treatment plants and larger booster and tank sites. The CompactLogix PLC system will be used in booster stations, potable and non-potable wells and lift stations. The MicroLogix PLC will be used at small remote sites where there is limited I/O as well as low power requirements.

1. ControlLogix PLC system

ACWWA standardizes on the ControlLogix 1756-L61 Controller for large sites such as water treatment and wastewater treatment plants.

ControlLogix 1756-L61 Specifications:

Specifications	Description
User Internal RAM Memory	2 Mb
Built-in Communication Ports	1 Serial
Communication Options	Ethernet TCP/IP ControlNet DeviceNet DH+

2. CompactLogix PLC system

ACWWA standardizes on the CompactLogix 1769-L35E Controller for sites such as booster stations, lift stations, and potable as well as non-potable wells.

CompactLogix 1769-L35E Specifications:

Specifications	Description
User Internal RAM Memory	1.5 Mb
Built-in Communication Ports	1 RS-232 Serial Ethernet/IP
Max number of I/O Modules	30 I/O Modules

3. MicroLogix PLC

ACWWA standardizes on the MicroLogix 1761-L20BWB-5A Controller for small sites that have limited I/O and low power requirements.

MicroLogix 1761-L20BWB-5A Specifications:

Specifications	Description
User Internal RAM Memory	1Kb EEPROM
Built-in Communication Ports	1 Serial
Digital Inputs	12



Digital Outputs	8
Analog Inputs	4 (2 Voltage; 2 Current)
Analog Output	1

B. I/O Modules

I/O modules are input/output modules that slide into the rack and connect to the backplane of the controller. Three (3) types exist: Discrete I/O (Digital), Analog I/O and specialized communications modules. Digital modules have single on/off points that are controlled by the CPU. Analog modules require scaling of the input or output value between two limits to produce a typical 4-20mA signal output. These modules are available in different part numbers and provide different features such as number of inputs or output points, operating voltage levels, current handling limits etc. Communications modules are available for providing interfacing with:

ControlNet networks

Additional Ethernet connectivity

Modbus networks

Standard I/O Modules for ControlLogix PLC system:

ControlLogix	Part Number
24 VDC, 16-Digital Inputs Module	1756-IB16
24 VDC, 16-Digital Output Module	1756-OB16I
8-Channel Analog Input Module	1756-IF8
8-Channel Analog Output Module	1756-OF8
Ethernet adapter	1756-ENBT
Controlnet interface	1756-CNB
ProSoft Modbus Interface	MVI56-MCM

Standard I/O Modules for CompactLogix PLC system:

CompactLogix	Part Number
24 VDC, 16-Digital Input Module	1769-IQ16
24 VDC, 16-Digital Output Module	1769-OB16
8-Channel Analog Input Module	1769-IF8
8-Channel Analog Output Module	1769-OF8C
Prosoft Modbus Interface	MVI69-MCM
Controlnet Interface	1768-CNB

C. Programming Software

All controllers shall be programmed using RSLogix5000 from Rockwell Software. Legacy controllers, such as the SLC series and the MicroLogix, shall be programmed using RSLogix500. The two programming software packages are similar and show a natural evolution from 500 to



5000, but their capabilities are quite different. RSLogix500 offers traditional Ladder Logic programming using the limited file-based architecture used in the smaller processors.

1. RSLogix 5000 Features

RSLogix5000 offers a superior set of features that should be exploited for all future development projects. The main features of interest are:

IEC 61131 Programming Languages

I/O Tag Aliasing

Symbolic Tag Naming

User Defined Tag structures

Multi-dimension arrays

Add-On Instructions

These features allow programming to proceed quicker, force consistency among programs, allow blocks of tested and debugged code to be reused, allow use of standard tag names.

D. Programming Languages

RSLogix5000 is IEC 61131 language compliant. The following languages are offered:

Traditional ladder diagrams (LD)

Function Block Diagrams (FBD)

Instruction List (IL)

Sequential Function Chart (SFC)

Structured Text (ST)

The standard languages used shall be Ladder Diagrams and Function Block Diagrams. LD (Ladder Diagram) programming must be used for Boolean logic or sequential control operations, while Function Block Diagrams will be required for all regulatory control. These two types of programming may be mixed within a given program if desired. PLC programming shall be done using RSLogix 5000 software. Where function blocks are used they shall be drawn from the standard function blocks supplied with RSLogix 5000 or the standard ACWWA library of Add-On Instructions. Deviation from this will only be allowed with written permission from ACWWA. The use of custom function blocks will only be permitted in special circumstances when ACWWA believes it is in their best interest to do so. Furthermore, the use of special function blocks will be contingent on provision of adequate documentation in a similar format and detail to that provided by Allen Bradley with the RSLogix 5000 software for the standard function blocks.



The other three languages shall not be used in any ACWWA programming.

E. Add-On Instruction Library

As systems continue to be developed and evolve, a standard Add-On Instruction Library will be developed for major equipment and control functions that are a part of ACWWA's control system. These templates will reside in an RSLogix5000 export library project titled ACWWA.acd. Each AOI may have an associated User Defined Data Type (UDT). The UDT allows for creation of custom groupings of tag variables that can be reused throughout the entire Logix project. The ACWWA AOI library will be imported as a normal matter of course of program development and thus available to all new program development. The AOI Library remains the exclusive property of ACWWA and may not be used by any contractor on non-ACWWA projects. All Add-On Instructions will be documented according to the standard format described in Appendix A.

If new AOIs are developed in conjunction with an ACWWA project, once approved and documented by ACWWA, they shall be placed in the standard library and be available for future projects. New AOIs will remain the property of ACWWA.

F. Naming Conventions

All controllers, programs, tasks, routines, tags and variables shall follow the ACWWA Naming standard. Program naming is described in the program organization section. All names throughout the ACWWA system should be unique. By prefixing all tag names with a site or location prefix, this will be possible. The value in having system-wide unique naming is the ability to build a tag dictionary describing each point. Not only will information about the tag be able to be maintained in one location, it will facilitate the construction and use of automated tools used in the software development process in the future.

1. Project / Controller Naming

The RSLogix5000 Project File and Logix Controller names should be representative of the Controller's primary control function and should be comprised of the ACWWA site name, name of the system being controlled and the controller slot number in the system. The Controller's name is set when the original RSLogix5000 project is created. The project name is entered in the RSLogix5000 programming software when a File-Save As is performed. The Controller's name can be modified under the General tab of the Controller Properties dialog box. The nomenclature selected allows easy identification of a project file since the site name and system name are contained within. The processor slot number is included to allow for a potential situation when there are multiple processors in the same rack. The following syntax should be used when naming the RSLogix Project file and the Logix Controller:

Syntax:

AAAAAAAAA_Bbbbbbbbbb_cc

Where:



AAAAAAA: Site name (i.e., LTC)

Bbbbbbbbbb: System (i.e., Aeration)

cc: Processor Slot# in the ControlLogix Chassis (i.e., 02)

Note: The Name must start with an Alpha character to meet IEC 61131 standards.

Example:

LTC_Aeration_02 is running in the processor in slot 2 of the PLC controlling the aeration basins at the Lone Tree Creek facility.

Chaparral_Booster_00 is running in the processor in slot 0 of the PLC controlling the booster station at Chaparral.

2. Tag Naming

Names used within programs should follow the loop naming standards to maintain consistency. RSLogix5000 tags are flexible enough to allow this standard.

General Rules for Tag Names

All “Names” used in RSLogix5000 have some common rules which are re-printed below for convenience.

Only alphabetic characters (A-Z or a-z), numeric characters (0-9), and underscores (_) can be used.

All Names must start with an alphabetic character or an underscore.

No Name can contain more than 40 characters.

No consecutive or trailing underscore characters (__) may be used.

Names are not case sensitive

Tags will follow a superset of the ISA standard described in document ISA 5.1-1984.

The root tag will use a standard ISA name. For example the root tag LIT301 specifies a Level Transmitter. An index of the prefixes and modifiers used in constructing tag names can be found in the ISA document.

A three letter location code followed by an optional PLC number should there be multiple PLCs at a site will prefix the tag names to indicate the location of the tag. This will insure tags that are unique to a site are indeed unique to the entire ACWWA system. A list of location codes shall be provided by ACWWA.



Example:

DEN_LIT301 would be the previously mentioned level transmitter located at the Denmark well site.

LTC3_AIT211 would be an analog signal transmitter from an analyzer located at the Lone Tree Creek facility, connected to PLC 3.

3. Tag Attributes

Each “tag” will actually be a set of values. An analog input tag usually consists of the following:

Raw Input Value

Scaled Process Value

Alarm Limits

Alarm Signals

Scaling factors

Since all these values are associated with a single “tag”, attributes will be used to make the names unique. The attribute will either be a member element of a structure (see UDTs below) which is noted by the attribute name suffixing the tag name separated by a “.” As in: LTC3_AIT211.HiSetpt. If the attribute is not part of a user defined type (UDT), it will be separated by an underscore (“_”) as in: LTC3_AIT211_PV.

4. I/O Signal Tag Aliases

When I/O modules are added to the Project’s I/O Configuration, generic tags representing those modules are automatically created in the Controller Tag Database. These automatic tags identify the I/O rack, slot, channel, and data type of the point. As a benefit of a tag database environment, tags with descriptive process function names can also be created and linked to the generic module tags, thus serving as an alias and making documentation of the logic easier to understand. However, should the module layout ever have to be modified, the tag aliases linked to the module will have their link broken as the module has its slot number property modified. This would then require every alias linked to the relocated module’s points to have its alias link re-established manually. To prevent this, an intermediate tag alias should be created and linked to the entire Input or Output word associated with the module rather than just an individual bit or point. The individual alias tags for the logic can then be linked to the word which represents the entire module. Thus any future I/O configuration changes would only require re-aliasing a single tag as opposed to many tags.

I/O signal tag aliases will be used to describe the Module or I/O function and linked to the Base Tags. They shall consist of the site name and tag name. If a suffix is required to make



the tag unique, as would be the case when a UDT uses the ISA tag name, the suffix “IO” should be used.

Syntax:

AAAAAAAA_Bbbbbbbbbb_IO

Where:

AAAAAAAA: = Site name (i.e., LTC)

Bbbbbbbbbb: = ISA Tag name (i.e., AIT201)

IO = “IO”, if necessary to make the tag unique.

Example:

LTC_YC201 is the alarm input from the discharge valve no. 1 on the aeration basin at the Lone Tree Creek facility

5. User Defined Tags (UDT)

A User Defined Tag (UDT) is a template for a custom data structure that can be used throughout a program in the same manner as any data type such as an integer or float. A UDT is defined as a collection of other data types, either basic, such as integers, or complex, such as another UDT.

The UDT’s allow for creation of custom groupings of Tag Variables that can be reused throughout the entire Logix project. These groups greatly organize related tags and the code they are used with. The basic premise of when to create and use a UDT is “repeatability”. Should a piece of logic be used repeatedly and can be viewed as a generic starting point then a UDT can greatly benefit the effort in standardizing the logic. All of the Add-On Instructions (AOI) have an associated UDT.

An example of how UDT’s can be used is with a modulating valve with actuators. All modulating valves with actuators, regardless of their use, require status indication, control commands, failure alarms, etc. Also, the logic for reporting and performing these functions is generally the same regardless of valve use. Therefore, UDT’s grouping related variables together for each logic function can be used to make the logic easier to understand and create for multiple instances of a modulating valve with actuator.

G. Program Organization

1. Program Naming

An RSLogix5000 program consists of the following hierarchy:

Task



Program

Routine

There can only be a single scheduled task with the controller. It shall be named MainTask.

Each task consists of multiple programs which are scheduled to run one after another within the MainTask. There will be 5 programs present and described later in this section.

Each of the component programs will consist of one or more routines. There will always be a main routine for each program. Its name is <program>_Main and its primary purpose is to call the other routines within the program. <program> as above is the one-word name of the program as denoted below. All routines within the program are names <program>_<function> where <program> is the one-word name of this program and <function> is a one-word function name for the routine. This scheme will insure all routines have a unique name and can be readily placed within the over task structure by name alone.

2. Standard Programs

a. SYSTEM

The first program called on every scan. It is responsible for initializing values, performing housekeeping, global definitions, functions that are a required on a global level for the entire PLC. There is at minimum the routine SYSTEM_Main that calls the other routines in the program.

b. IO_MAPPING

This program is responsible for moving data from physical modules into the internal controller tags where it can be acted on by the program logic. Changes in the IO configuration will require corresponding changes be done within this routine.

c. CONTROL_MODULES

The processing of field equipment is simplified by using object oriented programming techniques. An external device is represented and processed by an AOI built for the purpose with its associated UDT containing the data. The AOIs must be placed in a program and the appropriate I/O “wired in”. This program is where that takes place.

d. PROCESS_MODULES

Application logic unique to this program is organized here. This will be a collection of routines organized by a PROCESS_Main routine that orchestrates the interaction of objects managed by the previous program.

e. MESSAGE

This program manages all inter-PLC messaging.



3. Optional Programs

The following programs may or may not exist with a PLC task depending on process requirements.

a. SECURITY

This program is only present if there is a need to interface PLC points to a security system.

b. PROSOFT

If there is a need to interface to Modbus communications due to interfacing with packaged systems, management of the Prosoft module used is placed here.

4. Alarming

Alarm detection shall take place in PLC logic and not rely on HMI software alone. Alarm conditions are determined by the PLC and shall result in PLC bits being set. OIT / HMI software can make use of these bits to extend the alarm conditions to graphical displays, annunciators, and alarm call-out systems. If required the alarm bits can be mapped to digital output signal lines to trigger alarm autodialers that utilize such signals.

H. Program Descriptions and Comments

The RSLogix5000 programming environment has provisions for copious descriptions and comments to be added throughout. It is important that these facilities are not overlooked and all programs delivered to ACWWA must have an adequate level of commentary in the source code.

1. Descriptions

Programming components need to have descriptions applied which serve to clarify their purpose. Descriptions are free-form text fields of limited size that identify the purpose and functionality of the software components.

RSLogix5000 allows descriptions to be attached to tasks, programs, routines and tags, including the constituent fields within a UDT. It is important that useful descriptions be applied that offer succinct identification of all tags created. This greatly improves the ability to maintain and enhance programming, especially when done many years after the original programming. Tag descriptions added to UDT definitions will propagate to the instances created.

Task, program and routine descriptions must, at a minimum, describe the purpose of the code.

2. Code Comments

All code must contain comments describing in plain language what functionality is being performed in the code. Not every rung needs to be commented. Providing a synopsis block



of comments preceding a section of code is often the most useful. Individual rung comments are useful for particularly difficult code, or where the actual functionality is not obvious. Sheets of function blocks can make use of text boxes to contain comments. External conditions that affect code sections must have comments explaining those conditions and the effects they drive.

I. PLC Drawing Formats

In order to document PLC hardware properly, standards have been developed for drawings so that technicians will be able to use the drawings effectively in troubleshooting system problems. The drawings must include a Distributed Control System Block Diagram, PLC Layout Details, and PLC Card Wiring Details.

1. Distributed Control System Block Diagram

The drawing must include media, protocol, and network level information. The media must be designated by line type as shown in figure 7-1. The protocol must be identified for each media line by using callouts such as the following standard Rockwell Software designations:

CN = ControlNet

DN = DeviceNet

EN = Ethernet

RIO = Remote I/O

The network level must also be indicated by using the following abbreviations written parallel to the media line on the drawing. Possible network levels are:

HMI

PLC

I/O

See figure 3-1 for an example.

The Distributed Control System Block Diagram drawing must also include protocol converters (i.e., Fiber to Ethernet) which are external to network devices.

2. PLC Layout Detail

The PLC Layout Detail must indicate the physical location of every device. It also includes the PLC rack and slot board location, the power supply part number, the processor part number, and the I/O card name and part number. See figure 3-2

3. PLC Wiring Detail



The PLC Wiring Detail must include the I/O card part number and name, and the I/O tag name. This drawing also includes the rack, slot, and point number. The reader is referred to The ACWWA Electrical and Instrument Standards Document, Appendix D. Drawings D3 and D4 illustrate the Analog Input and Output respectively and drawings D5 and D6 illustrate Discrete Input and Output wiring.

The PLC wiring detail drawings shall be functionally equivalent to the ISA Standard S5.4, Instrument Loop Diagrams. They shall show all conductors and terminations fully labeled to aid maintenance activities. In addition, the drawings shall identify field equipment brand and model as shown in the O&M manual for the equipment. All field instruments shall be labeled with the tag name as well as brand and model. Tag names as used on the drawings shall exactly match the tag names indicated on the ISA Standard Form S20 furnished for the instrument

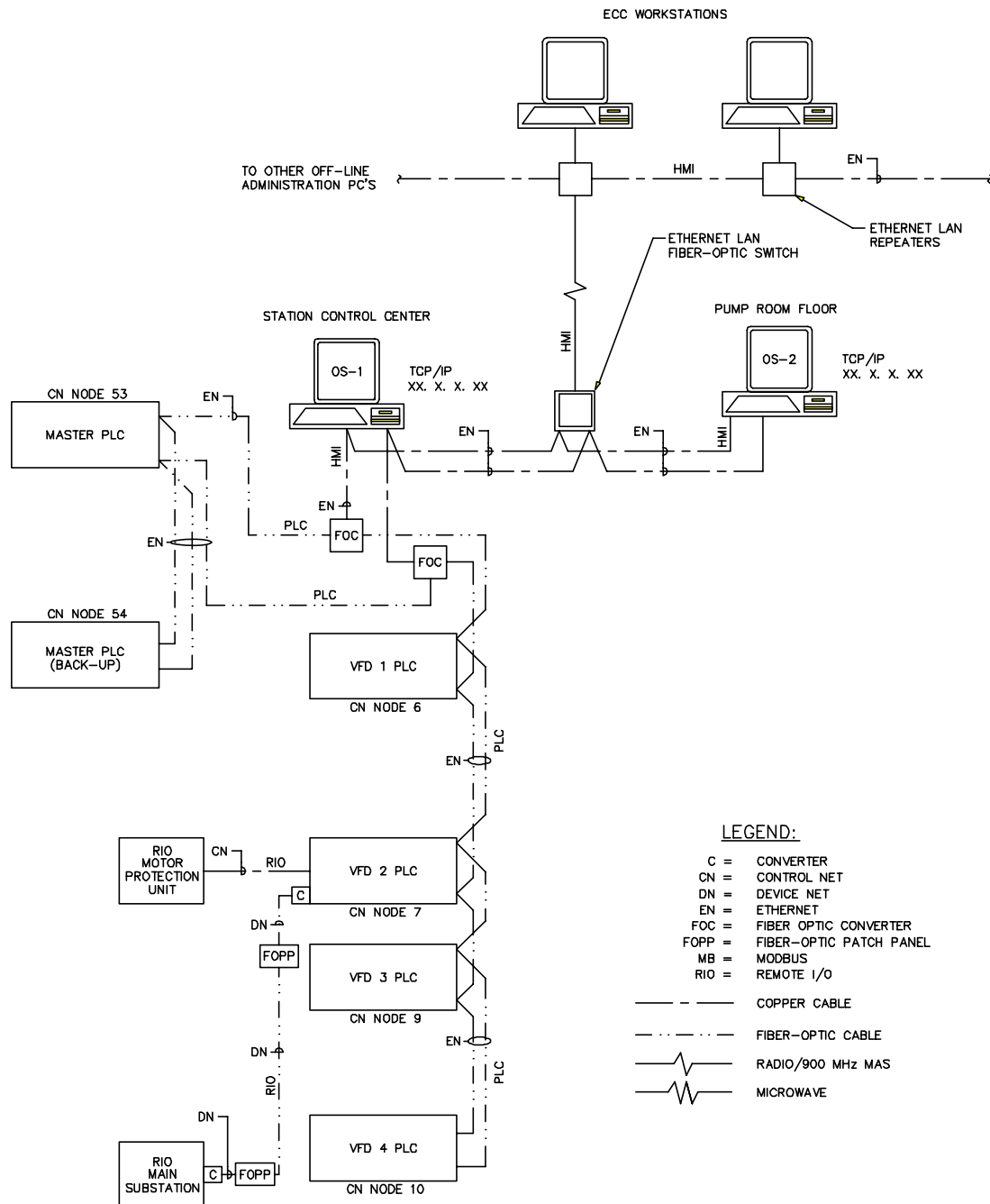


Figure 3-1 Distributed Control System Block Diagram



J. HMI Interface Requirements

1. PLC Coding for HMI Support

To meet ACWWA's HMI standards the HMI interfaces with each PLC in the control system to determine the state of the I/O and devices that are controlled by each PLC. The HMI shall rely on PLCs exclusively to supply I/O and device state information as follows where appropriate (i.e. a valve would be open or closed or in transition but not off or running):

No Communication

Hand/Off/Auto

In Alarm

Open

Closed

Running

Off

In Transition

The PLCs shall indicate state information for I/O and devices by using individual memory address bits. When the bit associated with a particular state of a device is set, the HMI will assume that the device is in that state. Devices may be in more than one state at a time. For example, a device may in Auto Mode, In Transition, and In Alarm at the same time.

V. HMI STANDARDS

Human-Machine Interface standards are critical the ACWWA in order to maintain a consistent look and feel throughout all the SCADA applications and screens. This is important not only for a smooth operation but for safety as well. Colors used to indicate energized equipment must mean the same thing wherever it is used.

A. Introduction

The purpose of this chapter is to describe the Human Machine Interface (HMI) implementation standards required in all automation applications developed for ACWWA. ACWWA has a substantial investment in the automation implementation already deployed for use in operating its existing facilities. The standards delineated herein are aimed at protecting that investment by requiring all future automation development to follow the format and style of the existing automation facilities including their associated control strategies.

To provide a cohesive control system, all HMI developers must implement the HMI in a uniform and consistent manner. As the HMI evolves through the addition of new facilities, modification of



existing control procedures, and implementation of additional member agencies and operator interfaces, the HMI system must maintain its original uniform and consistent cohesiveness. ACWWA will enforce strict adherence to these standards.

The chapter defines standards for both how the operators interact with the HMI, as well as how the control system integrates with the HMI. Topics related to the HMI/operator interaction include screen layout and navigation, screen contents and functionality (including graphic views, configuration and other tools, reports, and help documents), and visual screen elements (such as graphic symbols, colors, and fonts). Topics related to the HMI/control system integration include HMI maintenance and distribution; relationships between graphical elements, control tags, and I/O; alarm generation and handling; network layout of application servers, data servers, and workstations; data collection and retrieval methods; backups and redundancy; and integration of the HMI system with the enterprise network.

B. Nomenclature

Term	Definition
Popup	A window smaller than full screen resolution that displays on top of the current graphic. This graphic expects user input and for the user to either acknowledge or dismiss the window when the input is complete.
Overlay Window	A window that displays on top of the current screen at the screen's full resolution, thus replacing it as the top level screen.
Menu	A list of screens, when clicked, invokes that particular screen.

C. Standard Screen Layout

1. Standard Screen Resolution

All HMI screens shall be built for a resolution of 1920 x 1200. This is a 16 x 9 widescreen ratio.

2. Fixed Windows

The screen shall be divided into three regions of fixed size.

Title Banner

The top region shall occupy the full screen width of 1920 pixels at a height of 60 pixels. This region shall consist of a banner, screen title, and hot-link buttons that allow the operator to get to other screens quickly.

Alarm Summary

The bottom region shall occupy the full screen width at a height of 75 pixels and shall be an alarm summary region. All the latest alarms shall be displayed in this region. Clicking on an alarm will invoke the alarm detail display.



D. Window Hierarchy and Navigational Elements

1. Overview

The initial screen of the application shall be a system overview depicting a close-to-scale graphical representation of the entire system or plant. Key values and states are shown on this screen. Navigation to the various plant or remote areas is accomplished by clicking on the graphic on the screen representing that part of the operation. This provides a visual, intuitive method for navigating the system.

2. Menus

A menu shall be provided as a fixed menu on the left side of the screen that allows the user to jump directly to the screen of interest rather than be required to navigate through unnecessary graphical elements. The menu will always be visible so it may be accessed no matter the detail screen currently being displayed.

3. Screen Navigation

Screens are navigated via the overview and plant area / site specific screen or the main menu.

E. Tag Naming

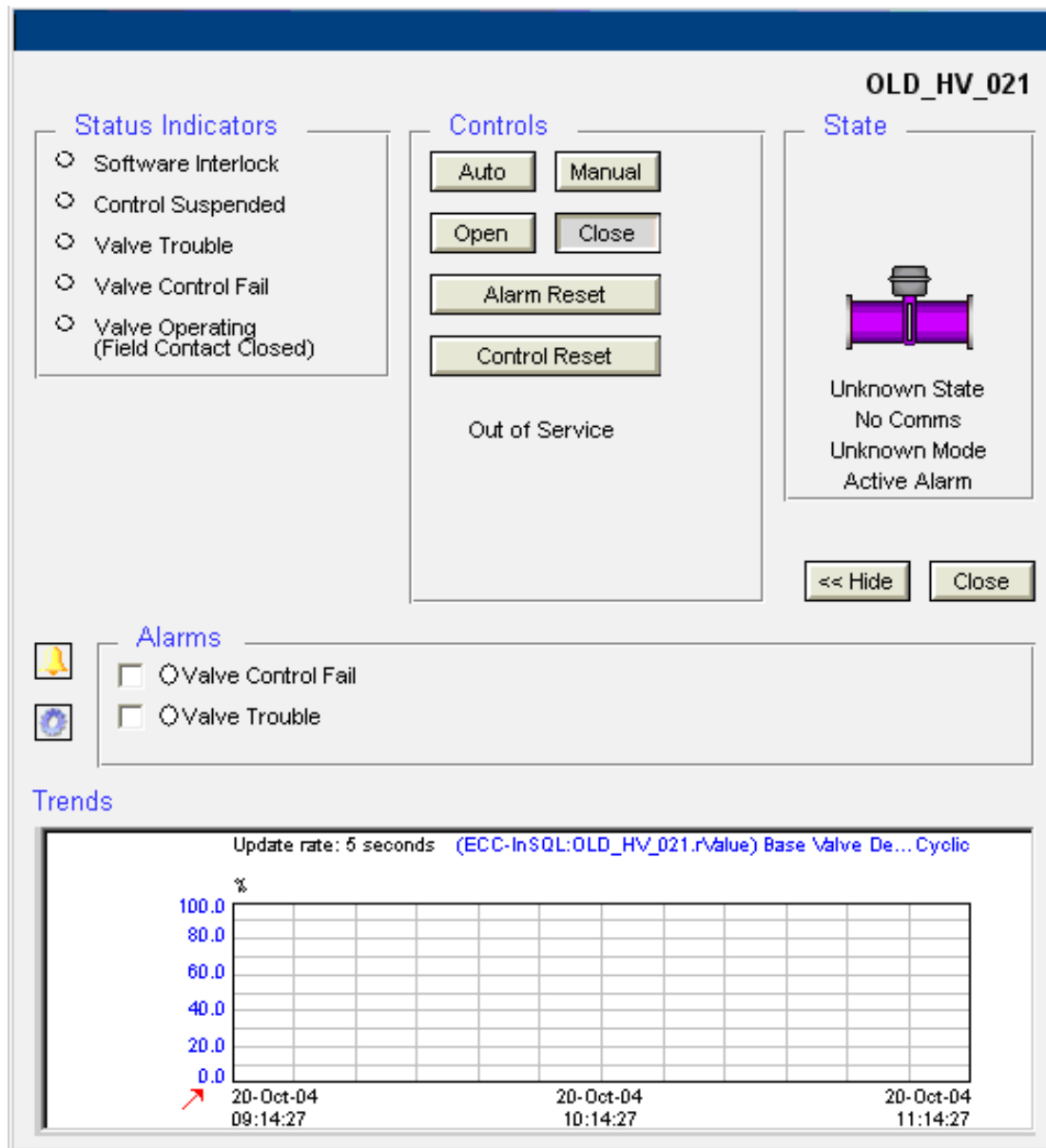
Tags in the HMI should follow the same naming conventions as used in the PLC as close as possible. The use of User Defined types within the PLC will aid the naming of tags in a similar manner within the HMI. This is especially important in the Master SCADA system which will use the Wonderware Application Server platform.

F. Alarming

The bottom portion of the screen will always show the alarm summary.

G. Equipment Faceplates

All equipment represented on a display by a graphical object, shall have a common faceplate that, when the graphical object is clicked, will popup. The faceplate will contain detailed information about the equipment and have inputs that allow changing of the equipments operating parameters and status. See the following illustrations for examples of a faceplate.





OLD_P200

Run Time (in hours)

0.0 Cumulative
0.0 Yesterday
0.0 Today
 Set New Time

Accept New Time Reset

Controls

OnOff

AutoManual

Alarm Reset

Control Reset

Out of Service

State



BAD Rpm
No Comms
Unknown Mode
Active Alarm

Status Indicators

☐ Drive Ready
☐ Software Interlock
☐ Control Suspended
☐ Pump Control Fail

Control Variables

Current Motor Speed0 rpm

Output to Motor0 rpm

Auto Speed Setpoint0 rpm

Manual Speed ROC Limit
 rpm/s

Manual Speed Setpoint
 rpm

<< HideClose

Alarms

☐ Motor Control Fail☐ Alarm1☐ Alarm3

☐ Common Alarm☐ Alarm2☐ Alarm4

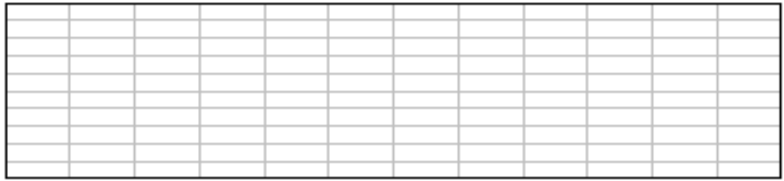
☐ Alarm5

Trends

Update rate: 5 seconds (ECC-InSQL:OLD_P200.rvalue) Base Motor De... Cyclic

Rpm

50000.0
40000.0
30000.0
20000.0
10000.0
0.0



20-Oct-04 09:15:4220-Oct-04 10:15:4220-Oct-04 11:15:42

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H. Visual Screen Elements

Visual screen elements include such topics as graphic symbols, GUI controls, icons, colors, and styles. Although sounds are not visual elements, they are also discussed in this section. In order to maintain consistency in the appearance of graphic views all new graphics must utilize elements from the existing libraries where possible. If no appropriate element is available a new element must be proposed and approved by ACWWA to add it to the libraries.

1. Graphic Symbols

The following figures display the existing 3D graphic symbols:

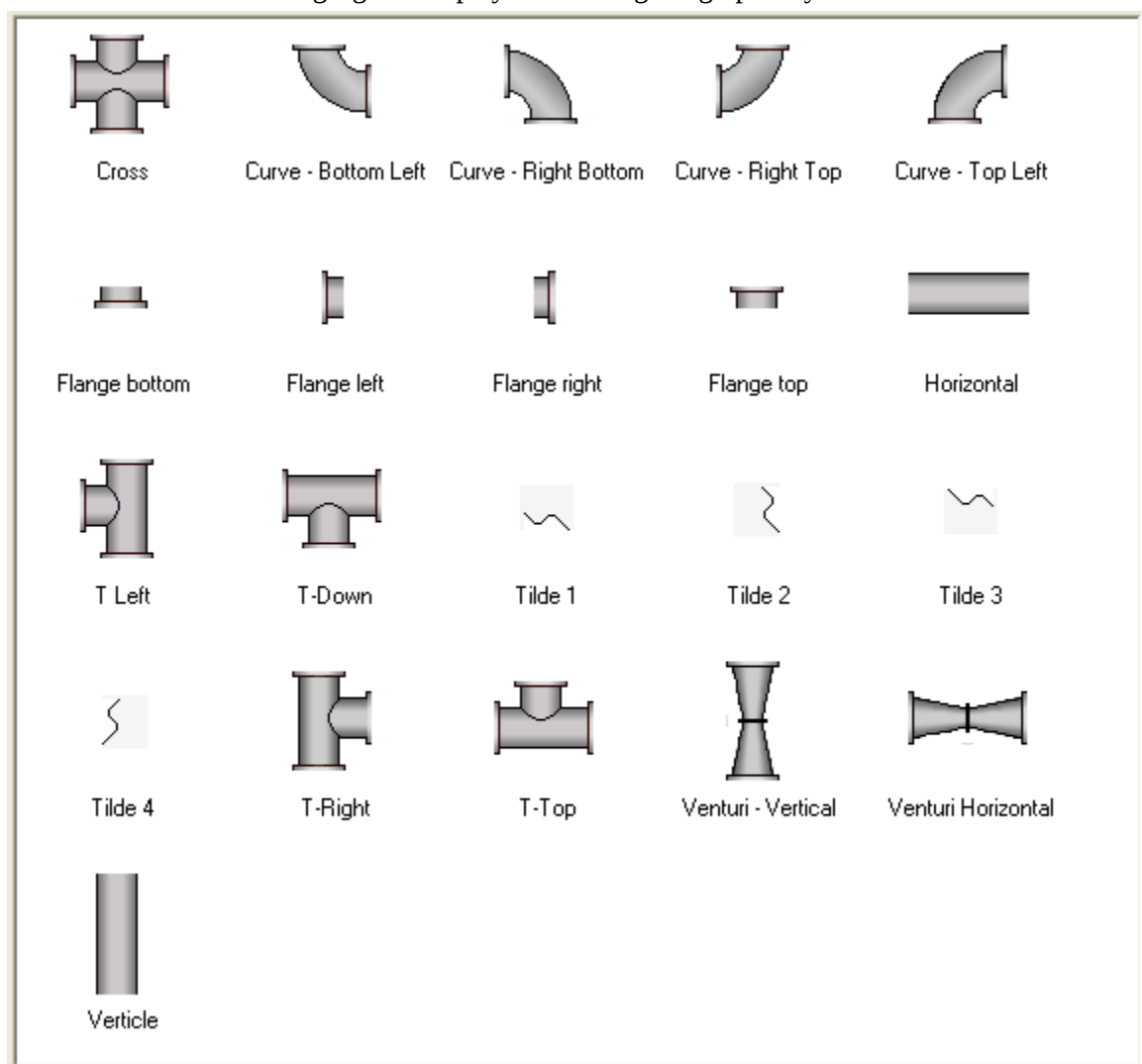


Figure 10a - Graphics Library – Pipes

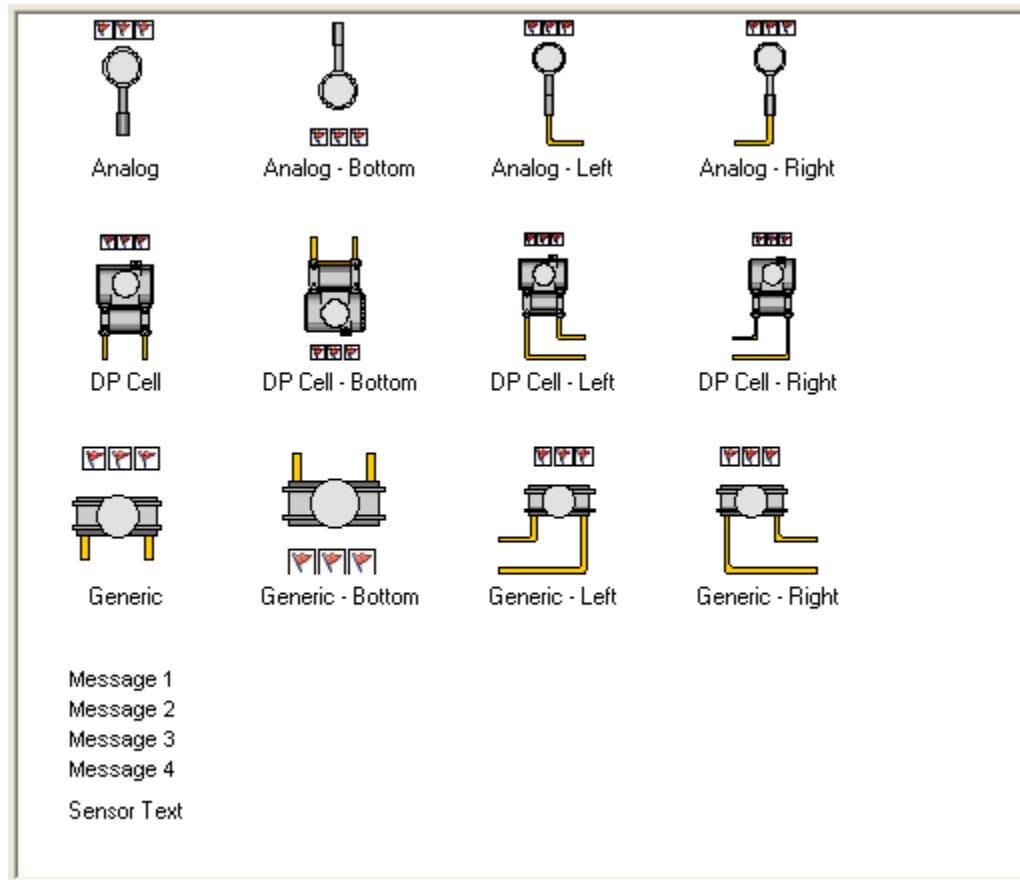


Figure 10b - Graphics Library – Sensors

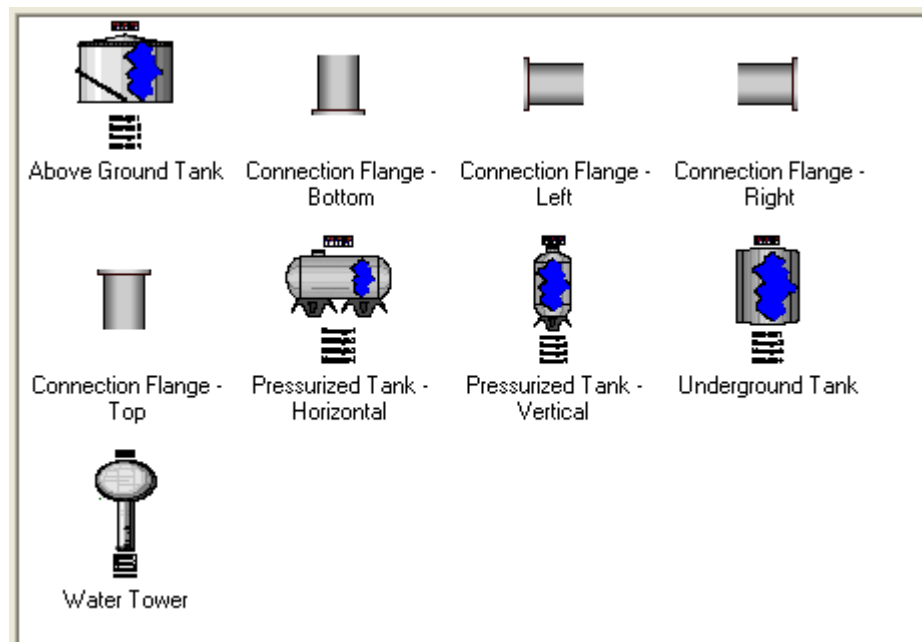


Figure 10c - Graphics Library – Tanks

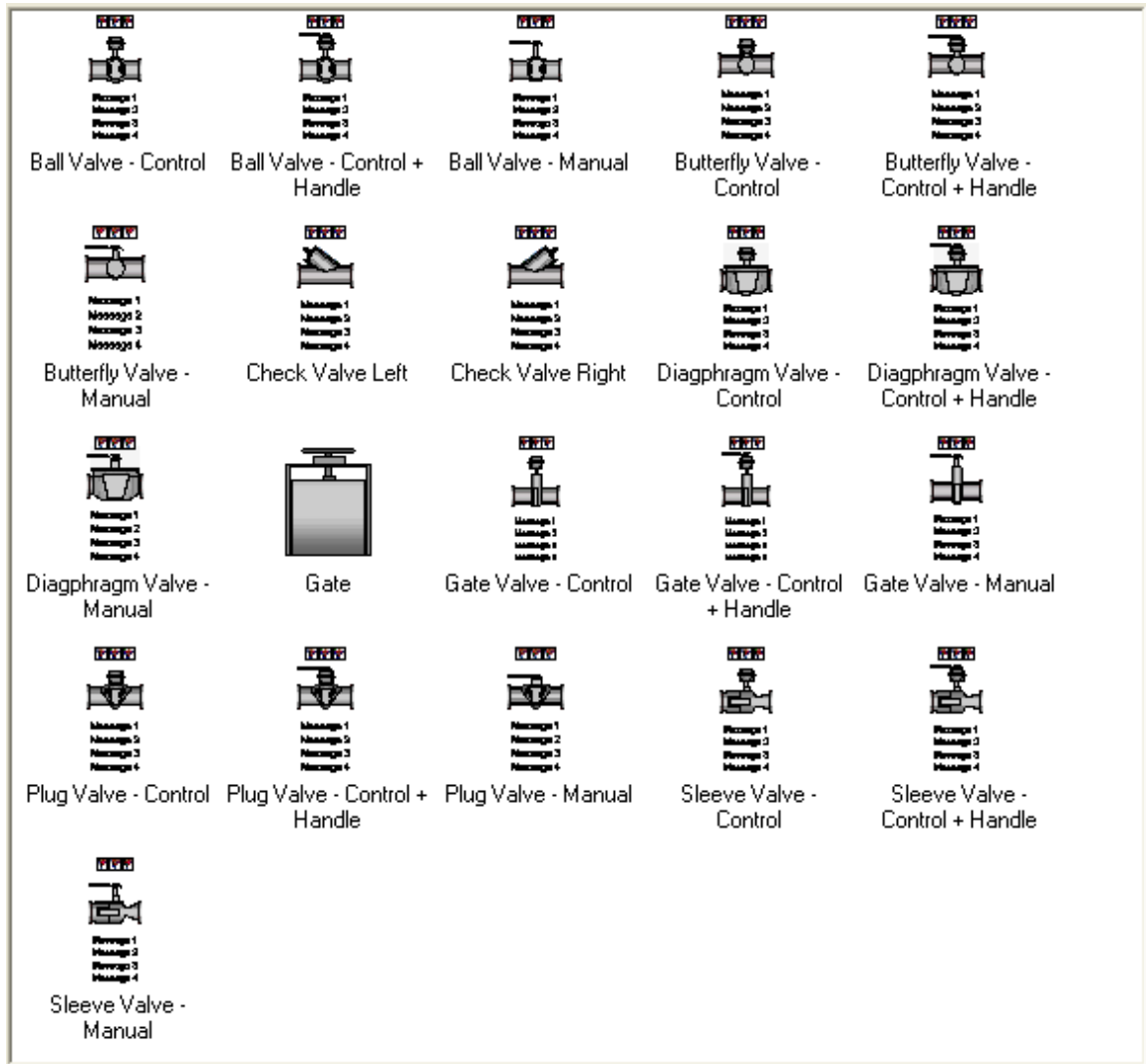


Figure 10d - Graphics Library – Valves

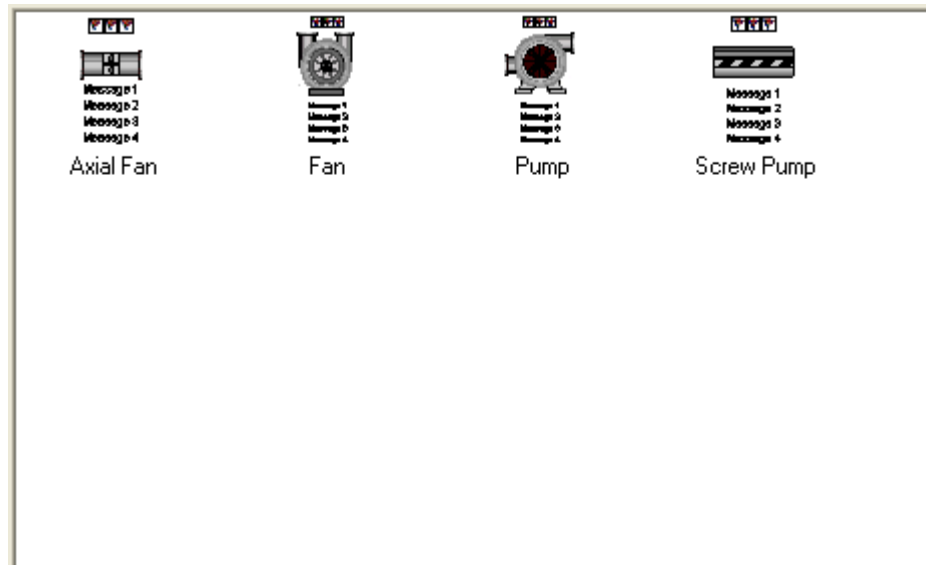


Figure 10e - Graphics Library – Pumps

3D graphic symbols are used on the HMI graphic views to represent individual components. In some cases, different drawings may be used to represent the same component in various states. For example, when a fan is running, its fan blades may be animated. Also, the image of a tank may indicate its level and contents (treated or raw water).

The appearance of each 3D graphic symbol should resemble that of the actual component. The graphic symbols may or may not resemble line drawings used to represent the components on a schematic drawing.

I. GUI Controls

GUI controls include such things as command buttons, check boxes, radio (option) buttons, edit fields, static fields, drop-down lists, list boxes, grids, tree controls, and popup menus.

There are several standard styles of GUI controls, including traditional Wonderware InTouch controls, HTML (Web-based) controls, Microsoft Windows classic (pre-XP) controls, Microsoft Windows XP (.NET) controls. Functionality of controls between each of these styles is very similar; however, the appearance and animation of controls between each of these styles is very different.

Since the HMI will be running on Microsoft Windows XP and Windows 2003 operating systems, the .NET control style would give the HMI the most cohesive look compared with other ActiveX controls, dialog boxes, and 3rd-party applications integrated into the HMI. The .NET style controls shall be used consistently on each HMI screen, pop-up screen, and dialog box.

J. Icons



Icons are small images used to denote item functionality, type, and status. For example, a operator will be able to quickly and easily locate and identify a print button on the screen if the print button contains an icon of a printer. If the printer icon is grayed-out, this will indicate to the operator that the print function is not currently available.

A flashing printer icon will be displayed in a status area to denote that the printer is currently processing a print job. An icon to denote the item's type will precede items in a tree or list. For example, an icon of a generic graphic within a window may precede process graphic entries in a list, and an icon of a gear may precede tool screen entries.

All icons within the HMI should be standard sizes. Icons used on ribbon buttons or within status areas or within lists and trees should be 16 x 16 pixels. Icons used for navigation in the main display area should be 32 x 32 pixels. Also, all icons within the HMI should be roughly the same style, including color depth. Icons shall use a minimum color depth of 8 bits (256 colors) and a maximum color depth of 24 bits (16 million colors).

K. Colors and Styles

Colors and styles are used to convey useful information about the state of a system, and the state of a subcomponent of the system. Text color may be set; text may be bold, italicized, or flashing; text background color may be set; graphic symbols may be filled with one or more colors; and graphic symbols may flash. The fonts shall be Arial or other if a third party control is being utilized with ACWWA's approval.

Style	Detail	Usage
Window Title	24 pt Bold	Main Title Bar Label
Heading 1	18 pt Bold	Control Windows Heading
<i>Heading 1</i>	14 pt Bold Italics	Tabular Titles
Label and Control Text	10 pt	Normal Style
Detail	8 pt	Used in object detail listing

The state of the system or a device may be represented using color. These states include: On, Off, Open, Closed, Running, Stopped, In Transition, Un-initialized, Out of Service, In Alarm, and Not Communicating. In cases where the device is making a transition, the device shall flash between two colors.

Following is a table that shows the relationship between the color and state of a device. The colors and states are listed in order of priority; for example, the No Communication state supersedes the In Alarm state.



	Color	Usage
1	Gray	Device state is Unknown or Not Initialized. In development mode, all of the devices will be in this state. In runtime mode, the devices will be in this state before the associated device drivers are running.
2	Magenta	Device state is No Communication. Devices in this state are unintentionally off scan and the available status, state, and raw data values associated with this device may not be accurate and should be suspect.
3	Magenta/Gray Flashing	This state applies only to Devices that have been out of communication but that are coming back into communication.
4	Orange	This state applies only to controllable devices. Devices that are not controllable such as manual valves will not use this color. Manual devices do not have an HAO status, but instead are tagged as Manual. A controllable device will be orange if it is Out of Service, Control Suspended, Hand, or Off. A device enters the Out of Service state when an error occurs that prevents the device from continuing normal operation. A device enters the Control Suspended state when an event occurs that requires the control system to suspend operator control to the device. A device enters the Hand and Off state when the operator places the device in manual mode or turns off the device using the field HOA switch.
5	Yellow	Device state is In Alarm
6	Green	Device is On, Running, or Fully Open
7	Red	Device is Off, Stopped, or Fully Closed
8	Blue	Device is Partially Open (Multi-State Devices Only)
9	Green/Gray Flashing	Device is Opening to Fully Open
10	Red/Gray Flashing	Device is Closing to Fully Closed
11	Green/Blue Flashing	Device is Opening to Set-Point (Multi-State Devices Only)
12	Red/Blue Flashing	Device is Closing to Set-Point (Multi-State Devices Only)

Graphics that represent a group of devices shall be colored based on the state of the device group as a whole, as well as based on the state of the individual child devices themselves. For example, a single site facility graphic overview shall be colored yellow in the event of a facility-wide alarm such as an intrusion alarm. Also, the facility graphic shall be colored yellow if ANY of the devices within the facility are in Alarm mode, and the facility graphic shall be colored orange if ALL of the devices within the facility are in Hand mode.

Devices shall not use color exclusively to represent the state of the device. Different graphics symbols shall be used to represent different states of a device. For example, an open valve shall be represented by a green graphic symbol that appears to be open.

The following figure shows a controllable plug valve using the previously defined color and graphic scheme. This scheme is valid for valves represent any dual or multi-state device. Different devices use different symbols but share the color scheme. The numbers here are keyed to the previous table. The arrows between the valves indicate that the device is flashing back and forth between the two colors.

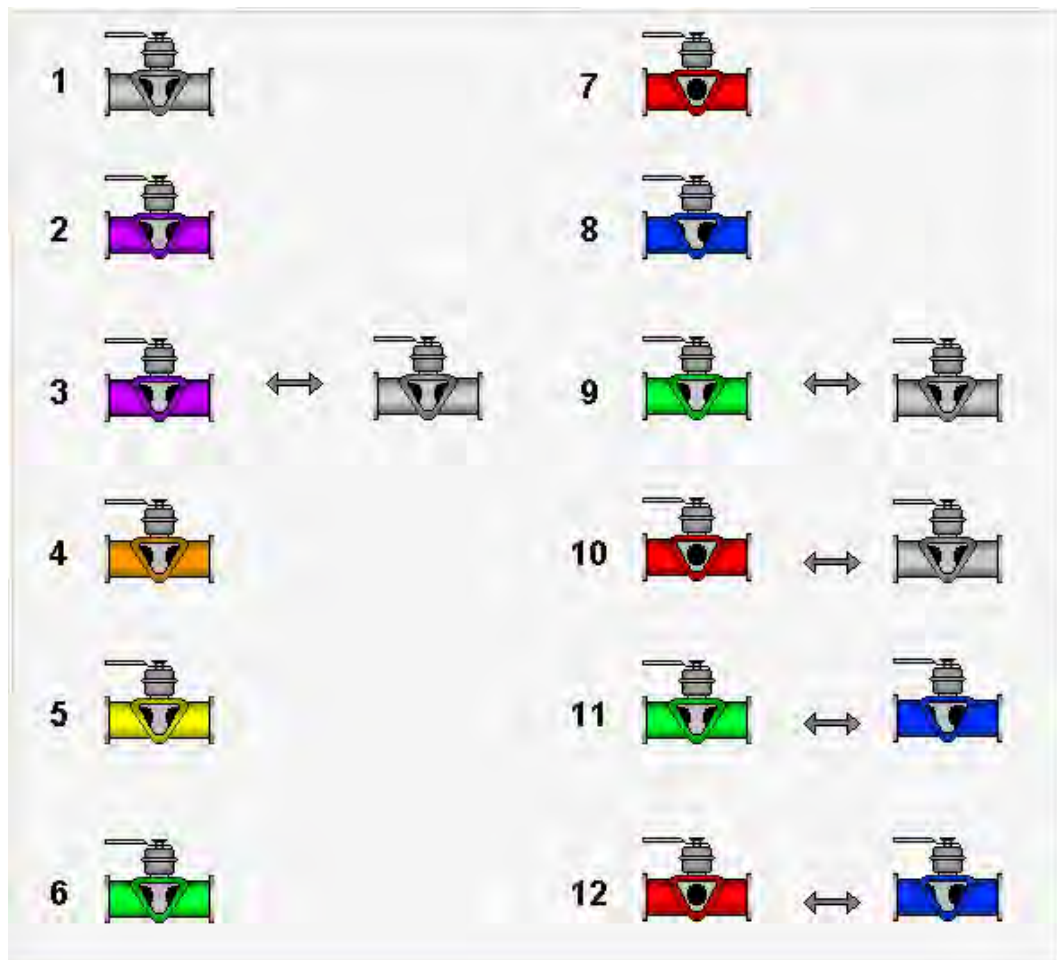


Figure 13 – Graphics Using Color Scheme



L. Sounds

Sounds have an important role in the HMI. Sounds can be used to convey information such as acceptance or denial of operator input, to alert the operator when a previously requested task has been completed, and to notify the operator of unsolicited alerts such as alarms or reminders. Most people are accustomed to the typical sounds integrated with the Windows operating system. In general, this scheme should be followed to draw on the intuition most operators already have. Sounds used for acknowledgement of operator input should be of relatively low volume. Sounds denoting negative acknowledgement should use a lower tone, while sounds used for positive acknowledgement shall use a higher tone. Sounds used to denote the arrival of unsolicited information should be a higher volume, and two tones are used to denote different levels of severity.

In the case of a sound used to alert the operator of the activation of a new critical alarm, the operator is able to squelch the sound. If a new critical alarm becomes active, the HMI will re-enable the sound. Although sounds are used, they are also used exclusively to denote a particular event. Flashing or colored screen elements are also used in conjunction with sounds to denote the same event. This is especially important for hearing impaired operators, but it is also important because some workstations that are running the HMI may not be equipped with sound, such as a laptop for example.

M. Event Logging

Critical SCADA values will use Event Logging to record the entering or changing of the values from the HMI. The database will log the date and time of the change, the operator making the change, the previous value and the new value. Setpoints and other key values will log all changes made.

N. Alarm Handling

Alarms of varying severity shall be generated by the control system. The HMI is responsible for relaying these alarms to the operator, and notifying the control system when the operator wishes to reset an alarm. The HMI employs several methods to relay the alarms to the operator, including audible signals, flashing alarm messages, recording alarms for historical retrieval, and alarm callout (paging). The operator has the ability to configure how alarms are handled, suspend alarms, acknowledge alarms, and annotate the alarm record. Alarm conditions are determined by the PLC and reported to the HMI. Once an alarm is reported to the HMI, the alarm handling code takes over that reports it to the operator, records the alarm in a database and optionally passes it on to the paging system. The following subsections describe the standard alarm processing currently configured in the ACWWA. When a point (real or calculated) is added to the system, or anytime thereafter, it can be configured to be an alarm and its priority can be set.

1. Alarm Occurrences

An alarm is generated when a process variable exceeds an alarm limit (in the case of analog points) or is equal to the alarm state (for discrete points). Alarms processed by the



Wonderware system are handled by two significant services in the system. The Alarm Logger creates the historical record of the alarms, which are loaded into a relational database. Optionally, these alarms can also be directed to an alarm printer, though this feature is not used in the ACWWA SCADA system. The Alarm Manager, which runs as a service on each individual workstation computer, communicates with the alarm log database and provides the alarm summary screen objects with alarm information that is found in the alarm database. These services, in combination with the alarm summary objects that present alarm data to a graphic screen, make up the alarming system in the ACWWA SCADA HMI system.

The Alarm Logger receives alarm indications from SCADA and stores them in a relational database. In the event the relational database is unavailable, the Alarm Logger will buffer up to 10,000 alarm messages. When communications to the relational database is restored, the buffer is then forwarded to the relational database. The alarm information includes:

Time and date of the alarm

Point information such as: name, alarm priority, current value, and alarm limits

Acknowledgement time, operator acknowledging and optional comment

Return to normal.

2. Alarm Presentation

As alarms occur, various methods are used to indicate the alarm condition. On graphics that show a device or system that is in alarm, the alarm indication is typically provided by coloring and notating the device in a way that indicates an alarm. On a popup screen for a device that is in alarm, an indication of the specific alarm is typically provided. Alarms are also logged into the alarm summary that is always visible at the bottom of the workstation screen on Monitor #1. The alarm summary has been configured to display the alarm in certain ways based on the specifics of the alarm. The following display characteristics have been defined:

3. Color

Text colors are used in the alarm summary to convey information about the state of the alarm:

Red	indicates the alarm is active and unacknowledged
Black	indicates the alarm is active and has been acknowledged.
Blue	indicates the alarm condition has returned to normal, but the alarm indication has not yet been acknowledged

When an acknowledged alarm returns to normal condition, it is removed from the alarm summary. No acknowledgement of the return to normal condition is required. The alarm log (the historical relational database) retains the information about the alarm, its



acknowledgement and its return to normal condition until it is manually purged by a system administrator. It is not expected that administration of the alarm database will be necessary within the first five years of operation.

Time	Priority	Type	Name	Value	Limit	Operator	Alarm Comment
09/17/2004 10:16:44	500	DSC	DDE_OL_CLX.ICommFail_OlivP200	true	true	DefaultUser	A comment
09/17/2004 08:33:53	500	DSC	DDE_OL_CLX.ICommFail_OlivValve	true	true		DDE-Suitleink connection to ControlLogix processors located at Olivent
09/17/2004 08:33:53	500	DSC	DDE_OL_CLX.ITSCCommFail_OlivDam	true	true		DDE-Suitleink connection to ControlLogix processors located at Olivent
09/17/2004 08:33:53	500	DSC	DDE_OL_CLX.ICommFail_OlivTower	true	true		DDE-Suitleink connection to ControlLogix processors located at Olivent
09/17/2004 08:33:53	500	DSC	DDE_OL_CLX.ITSCCommFail_OlivPS	true	true		DDE-Suitleink connection to ControlLogix processors located at Olivent
09/17/2004 07:06:56	500	DSC	OLD_Res_Level.fHIAAlarm	false	true		Base Analog input template
09/17/2004 07:02:43	500	DSC	OLD_Res_Level_DSFS1.fHIAAlarm	false	true		Base Analog input template
09/17/2004 07:02:43	500	DSC	OLD_Res_Level_DSFS1.fHIAAlarm	false	true		Base Analog input template
09/17/2004 07:00:18	500	DSC	OLD_Res_Level_DSFS1.fLOAlarm	false	true		Base Analog input template
09/17/2004 07:00:18	500	DSC	OLD_Res_Level_DSFS1.fLOAlarm	false	true		Base Analog input template
09/17/2004 06:56:43	500	DSC	OLD_Gate_4_Position.fLOAlarm	true	true		Base Gate template
09/17/2004 06:56:43	500	DSC	OLD_Gate_3_Res_Temp.fLOAlarm	true	true		Oliventmain Dam Gate Temperature Sensor
09/17/2004 06:56:43	500	DSC	OLD_Gate_3_Res_Temp.fLOAlarm	true	true		Oliventmain Dam Gate Temperature Sensor

Figure 14 - Alarm Summary Example

4. Priority

Alarms are assigned one of five different priorities. Each alarm priority has specific signaling that is performed when the alarm occurs. By default the alarms are sorted in the alarm summary in order of priority (followed by order of time), with the most recent critical alarm at the top of the alarm summary.

Priority	Graphical Indication	Audible Alarm	Severity	Callout	Acknowledge
1	Yes	Critical Tone	Critical	Yes	Required
2	Yes	Serious Tone	Serious	No	Required
3	Yes	None	Warning	No	Required
4	No	None	Informational	No	Required
5	No	None	Event	No	Auto Ack

Critical Tone – This is an audible tone that is sounded to indicate that a critical alarm has occurred. It can be silenced via the normal silencing mechanisms described elsewhere.

Serious Tone – This is an audible tone that is different from the critical tone. It is sounded to indicate that a serious alarm has occurred. It can be silenced via the normal silencing mechanisms described elsewhere.

Graphical Indication – This refers to there being an indication of the alarm on graphics other than the alarm summary graphic. For example, an alarm that is indicated elsewhere might be shown on an overview page as a graphical symbol displayed in a color that represents the alarm condition.

Callout – Critical alarms are called out to personnel on the active callout list. See the description of alarm callout for a more detailed description.

Acknowledge Required – Indicates that the operator must acknowledge the alarm in order for it to be removed from the alarm summary. The operator may optionally provide an acknowledgement comment to the acknowledgement.



Auto Acknowledgement – Indicates that the alarm is automatically acknowledged by the system, creating an event indication which shows up in the historical log, but is typically not seen by the user.

O. Alarm Windows

When an alarm occurs, there are a number of locations where an indication of the alarm is displayed. On the graphical representations of the system, the alarm is displayed by coloring the device that is in alarm yellow. On a device detail popup for a device that is in alarm, indicators are displayed in red to indicate an alarm. These indicators flash when the alarm is unacknowledged and cease flashing when the alarm has been acknowledged. Information is also displayed in alarm summary objects.



Popup Normal Condition



Popup Alarm Condition

Each device is colored yellow when the device is in an alarm condition. Additionally, text indicating that the device is also in alarm is shown. Displaying a device in yellow indicates a general alarm condition, meaning that at least one of the possible alarm conditions for the device is true. To get additional specifics about an alarm for a device, the device popup should be displayed or the alarm summary should be consulted.

On the device popup, each possible alarm condition for the device is individually shown. When the alarm condition occurs, the indication will change color to red and flash. When the alarm is acknowledged, the indication will cease flashing but continue to be displayed in red. When the alarm condition returns to normal, the indication will be displayed in grey. The user may acknowledge an alarm in one of two ways. The first is to use the alarm acknowledgement tools for the alarm summary, which is described below. The second is to click on the flashing alarm indication on the device popup.

There are two places where alarm summary information is displayed. One is the alarm area found at the bottom of Monitor #1 on all workstations. This alarm area displays approximately 12 alarms and is always visible. The second location is the alarm summary page, a larger version of the same information, where approximately 50 entries are displayed. The alarm summary page can be navigated to via the usual navigation methods. Scroll bars will be available if the number of alarms exceeds the number of alarms that can be shown at any given time.

The alarm summary page and the alarm area at the bottom of Monitor #1 have many capabilities. When the alarm summary page is displayed, it operates completely independently of the alarm area at the bottom of Monitor #1. These capabilities are described as follows:

Acknowledging – A user can select one (or more) alarms, all visible alarms, or all alarms and acknowledge them. An alarm comment is requested (but not required) of the operator. Should a



comment be entered, it will be recorded in the alarm log in the comment field of the acknowledgement record. The alarm comment will be applied to all alarms being acknowledged.

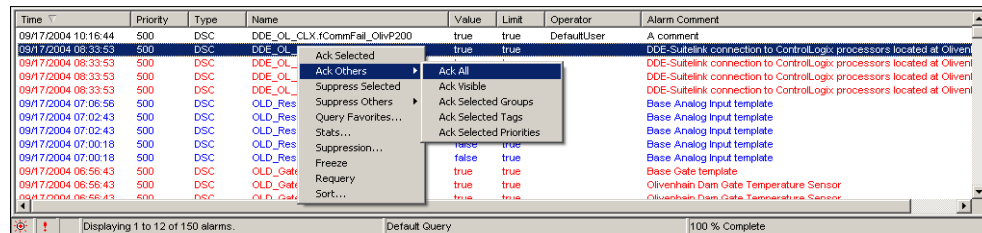


Figure 15 - Alarm Summary Menu with Acknowledgement Menu Selected

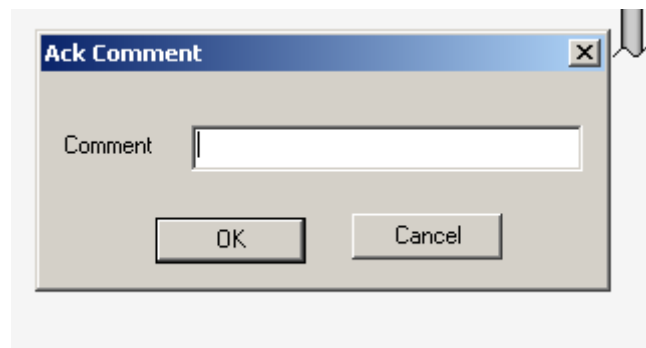


Figure 16 - Acknowledgement Comment Entry Form

Silencing – The audible alarm tones can be silenced by using the silence button in the NavPane.

1. Alarm Filtering

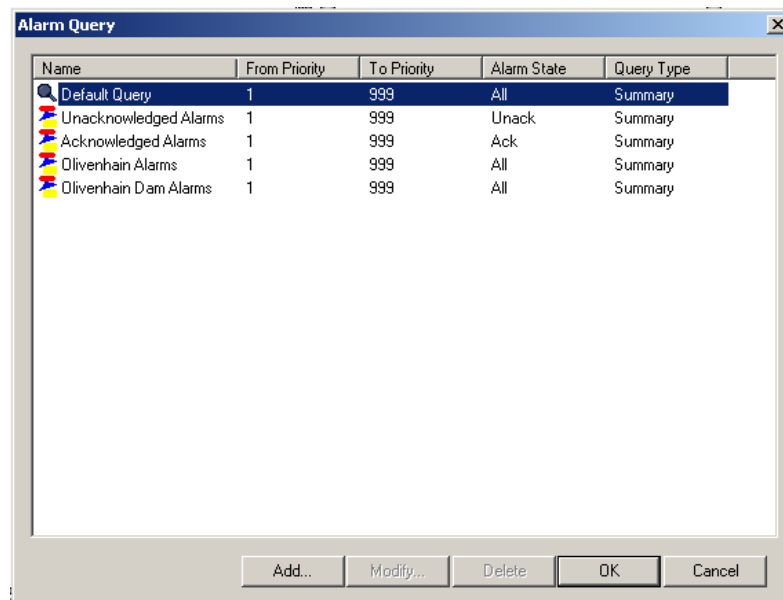


Figure 18 - Alarm Filter Selection Page



Suppress – Alarms can be suppressed from the alarm summary. This inhibits the display of the alarm in the alarm summary, but does not otherwise interfere with alarming. A list of suppressed alarms is available, and alarms can be unsuppressed as desired by the operator.

Sorting – When the workstation starts, alarms in the alarm summary area are sorted first by priority then by time of alarm. The user can choose which column (alarm characteristic) provides the primary sort criteria, and they can choose to sort by ascending or descending order. The secondary sort criteria is always time. There will be an indication as to what the sort order is on the alarm summary. The column width for any column can be adjusted.

Data displayed – For each alarm, the following information will be displayed;

(Unacknowledged Alarm) Time the alarm occurred/(Acknowledged alarm) Time the alarm was acknowledged

Priority of the alarm

Name of the tag that is in alarm

(Unacknowledged Alarm) The description of the tag that is in alarm / (Acknowledged Alarm) The acknowledgement comment, if any

Type of alarm (e.g. Hi, Lo)

The value (without units) of the tag when it went into alarm

The alarm limit for that tag

(Unacknowledged Alarms) Blank / (Acknowledged Alarms) The operator that acknowledged the alarm.

P. Alarm Configuration

Alarm limits are configured on a per-point basis. For discrete points that require alarming on one of the two discrete states, the indication of the alarm is typically preprogrammed into the object. For analog points, the alarm limits can be configured on the configuration panel of the appropriate device popup. These limits can be changed by a user with appropriate authorization credentials.

System alarms, meaning alarms that are caused by a malfunction at the system level, are handled in the same fashion as process alarms. System alarms are defined points in the IAS database which are connected to system indications rather than PLC registers. Alarm priority for system alarms has been predetermined by the developer, but the priority can be modified in the same way that the priority of any other alarm is changed.

Q. Alarm Callout

ACWWA has two standard alarm callout systems: one connected directly to the PLC and the other integrated with the SCADA system. Each is addressed individually below.



1. PLC integration with Autodialer systems

The standard autodialer is the RACO Verbatim Series VSS autodialer configured for monitoring dry contact, normally closed type digital inputs. When the digital signal opens, the unit dials out a programmed phone number. These units can be purchased to handle up to 32 separate digital signals. This system is considered the primary line of defense against field problems. Autodialers will be located at two levels: in the field and at the main office, the main office autodialer providing backup for critical field problems. Major field facilities, such a booster pump and tank facility, will have an autodialler installed and configured.

The main office autodialler shall be connected to the central PLC and have up to 16 critical alarms connected. Communications failures between the central PLC and remote telemetry units will be monitored by the main office autodialler.

2. SCADA Alarm Dialer

The SCADA Alarm dialer shall be capable of interfacing directly with the SCADA system software, reading values and alarms as recorded on the SCADA system. The Alarm dialer ideally shall have the following features:

The ability to use any TAPI compliant modem

User defined vocal prompts and responses, ideally stored as WAV files

Work equally well with telephones, email and SMS text messaging

The current Alarm dialer is Win-911 from Specter Instruments.

Critical alarms at the SCADA system are called out to the user. These alarms can act as a backup to field autodialer alarms, or in the case of extremely critical alarms, a backup to the backup. When a critical alarm occurs, a sequence of events will begin which will result in the system calling a list of phone numbers, one at a time, attempting to notify a user of the presence of a critical alarm. It will continue to call users until the alarm is acknowledged. Acknowledgement can be done at an HMI workstation or via the phone. Once the critical alarm has been acknowledged, the callout system will terminate any phone call that is in progress.

The callout system maintains lists of users to call when an alarm occurs. Each list consists of 10 telephone numbers which will be called, in order, when a critical alarm occurs. The system chooses a particular list to use based on the day of the week and the time of the day, and therefore can handle shift based callouts. It is possible to manually choose a list should circumstances warrant that condition.

When the callout system is activated, it chooses the first telephone number from the active list and places a call. If the call is not answered, the callout system moves on to the next phone number in the list. If the call is answered, the callout system announces itself and requests a password. Once authenticated, the alarm is annunciated to the user and an option



of acknowledging the alarm is provided. If more than one critical alarm exists at the same time, each will be annunciated and can be acknowledged. Once the call is terminated, if there are any unacknowledged alarms remaining, the callout system will go to the next phone number on the list. When the end of the list is reached, the system starts again from the top of the list.

VI. SECURITY

This chapter will cover security of the physical remote sites, code security and that of the SCADA system. The first two are interested in the protection of assets, the letter covers security as it pertains to the operation of the SCADA system.

A. Site security

Site security includes all measures taken to secure the assets of a remote site. At a minimum this shall include the necessary hardware to detect intrusion into remote telemetry cabinets and facilities. These intrusions are reported to the master SCADA system and to the local autodialer, if present. Intrusion detection shall be wired into the local PLC. If desired, more sophisticated monitoring measures can be taken, such as video surveillance systems. These can also be integrated into the SCADA system..

B. PLC Security

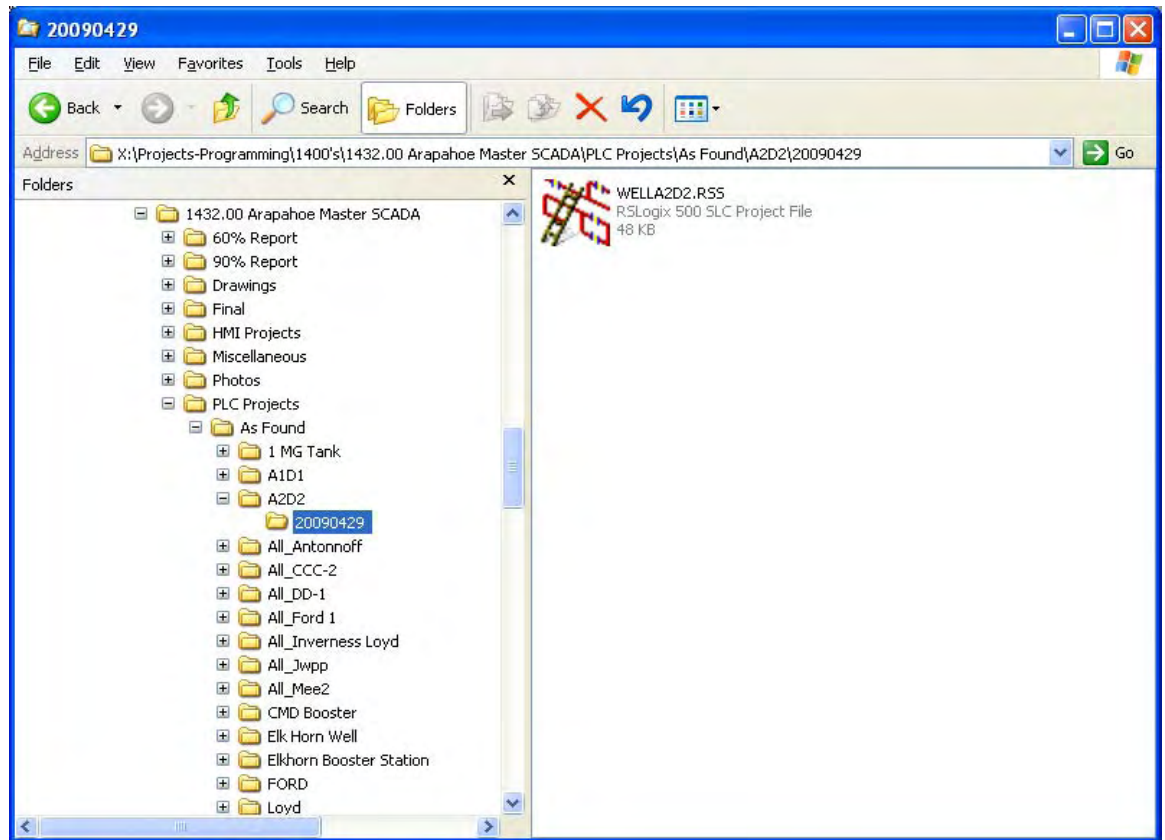
PLC security involves protected the running code from unauthorized modification. Care should be taken before implementing this type of security, as the inability to modify the code due to a security lockout has the potential to be disastrous. Physically securing the PLC may be all that is required. If this type of security is desired, Allen-Bradley provides FactoryTalk Security which enables multi-level and multi-function security to be implemented.

C. PLC Code Backup

The most critical aspect of securing PLC code is insuring correct and timely backups of all PLC code. Because the PLC code can reside in multiple places there is no absolute guarantee that when a programmer connects up to the PLC that the version of code he brought with him is identical to what is running. Upon connection, the RSLogix code will indicate if it is the same revision as what is running in the PLC. The programmer should upon connection is upload the program and data from the controller to the computer and save it in a new folder with today's date in YYYYMMDD format under the appropriate site directory under the "As Found" folder. This provides a backup of the program and data as it existed. Once program modifications are complete, the project should be saved in the date folder under the site directory under the "As Left" folder. The following figure shows an example of this structure.

In this example, project WELLA1D1.RSS was uploaded from the PLC in the field on April 29, 2009 and saved in \PLC Projects\As Found\20090429.

While often overlooked, project file management is an important element in asset protection.



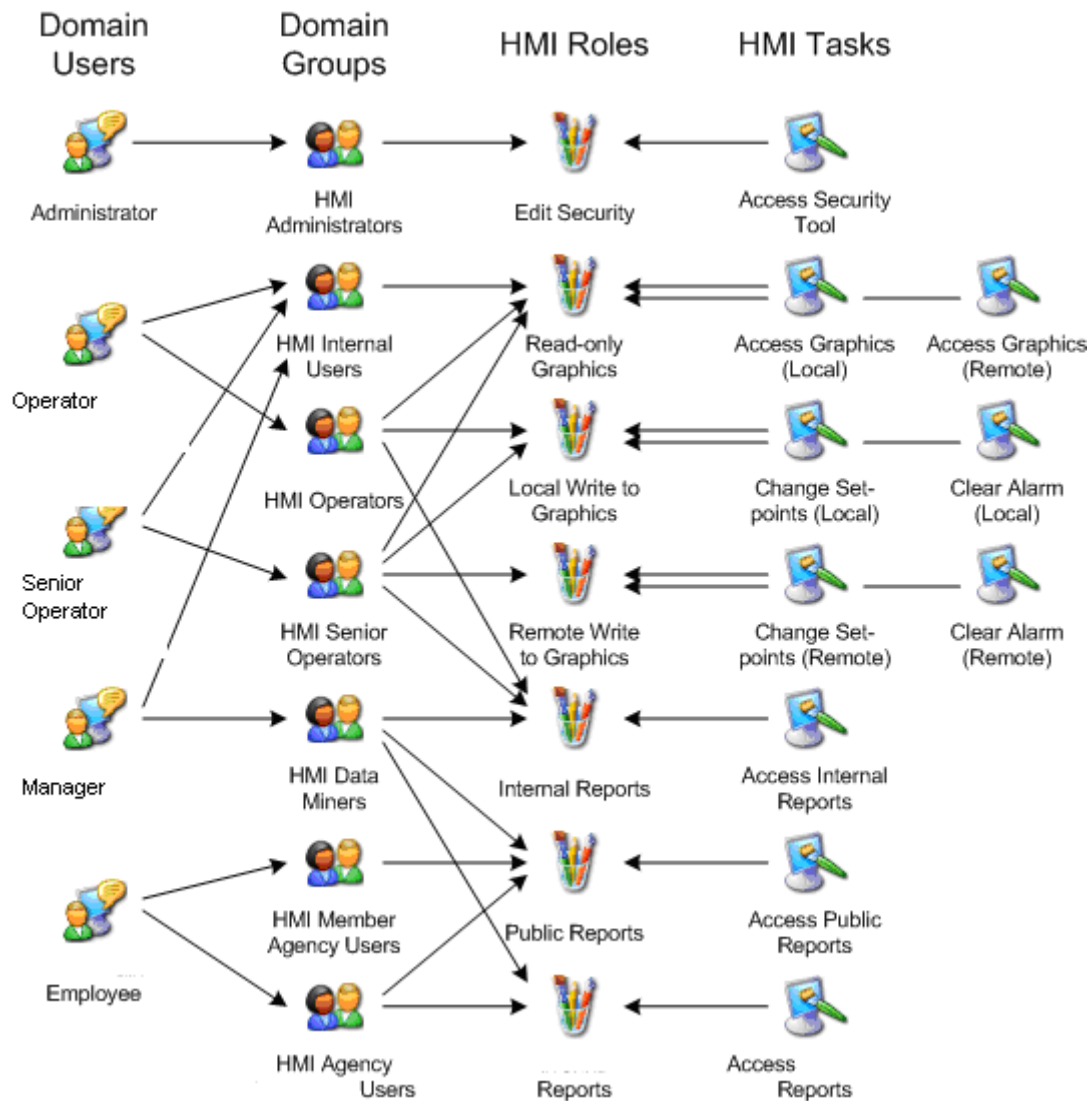
D. SCADA System Security

The SCADA system shall be integrated into its own domain. It is the desire of ACWWA to maintain a separate security domain for the SCADA systems and not have them integrated into other office level systems. This requires the setup and maintenance of a Windows security domain.

1. Domain

The domain controller shall be a Windows Server 2003R2 or Windows Server 2008 in keeping with the current ACWWA office standard, platform running as an active directory domain in native mode. All system and users interacting with the SCADA system must be authorized through the domain.

Security is modeled on the Role Based Access Control model. This is the model that has been adopted by Microsoft for its security implementation, and it fits well with the ACWWA SCADA application. It is relatively simple to understand and it reduces the complexity of managing security. The following figure shows sample relationships between the security objects, which are users, groups, roles, and tasks.





2. Users

A user is a uniquely identified individual. The user is determined by the authentication credentials provided when the user logs in. Users are typically members of one or more groups.

3. Groups

A group is a collection of users that have equivalent permissions. Groups are used to simplify the management of security. Rather than require the security administrator to explicitly identify roles and permissions for each user, a user can be assigned to a group, which causes the user to inherit all the permissions of that group. A user may be a member of more than one group.

4. Roles

A role is the construct around which access control policy is formulated. It can be thought of as a job description. Each role is a job that has a certain task or set of tasks that are permitted by the security system. Roles are relatively stable and unchanging because they are built around the processes of the organization.

The security architecture is simple enough that groups and roles are essentially equivalent. Therefore, the group concept will be eliminated and incorporated into the roles.

5. Tasks

A task represents a unit of control that can be referenced by an individual role. It is a specific function or operation that a user may or may not be able to perform, based on the permissions granted or denied to user's role.

E. SCADA System Implementation

The previous section gave an overview of the theories behind role-based security. This section will discuss the actual implementation.

F. Users

Users represent an individual user. There should be one user in the security model for each user of the system. The security configuration tool permits the addition, deletion and modification of user information. When a user is created, they can be assigned to one or more roles.

G. Roles

There are six roles identified in the system. Each of these roles is granted specific permissions. They are:

1. Administrator



Users in this role have full read and write access to each view, including all graphic views, all tools (including security), and all reports. The built-in Administrator account is a member of this group

Tasks in this role: All

2. Programmer

Users in this role may edit the HMI source code, redistribute the HMI source code, and edit the tables that contain configuration and enumeration data. This group does not have the ability to acknowledge alarms or the ability to change process parameters.

Tasks in this role:

View Public Reports

View Custom Tab Screens

View Trends

Configuration of SCADA Software

3. Senior Operator

This role includes operators with full access to operator-related functions. Users in the group have full access to graphic views and reports, and full access to all tools except the security tool. Users in this group have full access to all operator-related functions including suppressing alarms, changing tuning parameters for PID loops and changing process parameters used to control remote stations.

Tasks in this role:

Silence Alarms

Acknowledge Alarms

Suppress Alarms

Disable Alarms

Alarm Reset

Modify Alarm Limits

Modify Process Setpoints

Manually Control Device



- Force Device Out of Service
- Override Interlocks
- Override Supervisory Control
- Resume Control
- View Internal Reports
- View Public Reports
- View Trends

4. Operator

This role includes operators with limited access to operator-related functions. Users in this group have access to graphic views, and reports. Users in this group have read only access to most tools and have no access to security and document control tools. Users in this group may not perform certain functions such as disabling alarms, deleting annotations, and modifying tuning or alarm parameters at remote stations.

Tasks in this role:

- Silence Alarms
- Acknowledge Alarms
- Alarm Reset
- Modify Process Setpoints
- View Internal Reports
- View Public Reports
- View Trends

5. Technician

This role includes technicians that are responsible for the operation of the various devices that make up the water distribution system. Users in this group have access to the tuning and configuration parameters for devices that have them. Additionally, technicians have the ability to tune process PID loops, configuring the tuning parameters as necessary. Technicians may not operate the pipeline and cannot acknowledge alarms.

Tasks in this role:



Modify Process Tuning Parameters

Modify Device Tuning and Configuration Parameters

Force Device Out of Service

Override Interlocks

View Trends

6. Guest

This group is the default group and is enabled by default. Members of this group may view any graphic or previously generated report, but have no ability to change any parameter or initiate any action in the system.

Tasks in this role: None except View Public Reports

H. Tasks

The granularity of control from a security standpoint depends on tasks. If the tasks are very specific and highly detailed, more options regarding security are provided. For example, the task “Change Setpoints” is much broader than “Change Setpoints at Chaparral Well A1D1” and “Change Setpoints at 4MG Tank”. The “Change Setpoints” task does not give the security administrator the ability to configure a user’s security such that changing setpoints at the Well is permitted while restricting changing setpoints at a Tank. Conversely, if the more detailed tasks are used, the security administrator must assign both “Change Setpoints at Chaparral Well A1D1” and “Change Setpoints at 4MG Tank” appropriately in order to properly configure security for a user that can change all setpoints. When the number of tasks gets large, this can be a daunting effort.

The goal is to create tasks with sufficient granularity to permit appropriate security without creating unnecessary complexity. To that end, the following list of tasks has been created:

Silence alarms –	This task permits a user to silence audible feedback that an unacknowledged critical or serious alarm exists.
Acknowledge Alarms –.	This task permits a user to utilize the alarm acknowledgement features of the alarm summary, as well as the ability to acknowledge an alarm from a popup
Modify Alarm Limits –	This task permits a user to modify process and device alarm limits.
Suppress Alarms –	This task permits a user to suppress alarms from the alarm summary.
Disable Alarms –	This task permits a user to disable an alarm.
Reset Alarms –	This task permits a user to transmit an indication to a PLC which causes it to unlatch any latched alarms. Alarm



	conditions that continue to exist will re-alarm.
Modify Process Tuning Parameters –	This task permits a user to modify process tuning parameters. For example, for PID loops, it would permit the modification of the Proportional, Integral and Derivative parameters
Modify Process Setpoints –	This task permits a user to modify setpoints that are process (as opposed to device) related. For example, a user with this permission would have the ability to change a flow rate, but would not have the ability to change the rate at which a flow control valve opens.
Modify Device Tuning and Configuration Parameters –	This task permits a user to change setpoints and other configuration data for devices.
Manually Control Device –	This task permits a user to change a device mode from automatic to manual. Once a device is placed in manual mode, automatic computer control of the device ceases. Additionally, the user has the ability to manipulate the device through manual control elements on the popup graphic.
Force Device Out of Service –	This task permits a user to set the “Out of Service” indication for a device. When a user places a device out of service, the device no longer reacts to computer commands.
Override Interlocks –	This task permits a user to set the “Override Interlocks” indication for a device. When a user sets the override interlocks indication for a device, it permits the user to operate the device without regard to the software interlocks that may protect the equipment. Hardware interlocks, if any, continue to protect the equipment. OVERRIDING INTERLOCKS AND OPERATING EQUIPMENT COULD RESULT IN DAMAGE TO EQUIPMENT AND/OR UNSAFE CONDITIONS FOR PERSONNEL.
Override Supervisory Control –	This task permits a user to tell the system to disregard setpoint changes from the supervisory control program and instead recognize user provided setpoint changes. This does not permit the user to manually control a device or set of devices, rather, this task permits the user to control the setpoints.
Resume Control –	This task permits a user to send an indication to the PLC that it should resume control of a device that previously had its control suspended.
View Internal Reports –	This task permits a user to view reports intended for ACWWA internal use only.
View Public Reports –	This task permits a user to view reports intended for use outside the ACWWA organization.



View Trends –	This task permits a user to construct, view and save trends.
Add/Modify/Delete Users –	This task permits a user to add a user to the security scheme, delete a user from the security scheme or modify the groups, roles, and tasks that are associated with an existing user.

I. Authentication

Individual HMI workstations are to be connected to the network, and are members of the domain. The workstations are to be configured to require domain login. Individual operators shall not have login to the HMI using their own username and password. The Domain level security credentials will be used throughout the SCADA system to maintain one set of credentials. Based on the role(s) to which the user belongs, the user will have full or limited access to various aspects of the HMI. When a user exits a facility or completes a shift, the user shall logout of the workstation and allow a new user to login. Logout occurs automatically after 15 minutes of inactivity.

For remote workstations, such as laptops and home computers, the computer must be connected to the network via a virtual private network connection. Only users that have been granted remote access by ACWWA may connect to the virtual private network.

VII. NETWORKING STANDARDS

Networking of the components of the SCADA system should follow accepted principles for construction of a private network. Unless otherwise explicitly stated, the guidelines and rules as described in Top-Down Network Design, Second Edition, 2004 Cisco Press are to be followed.

A. Security

All SCADA components shall be behind a firewall with the only off-site access being allowed is through a VPN appliance managed by ACWWA personnel. All SCADA components shall remain isolated from general purpose office networks to physically restrict access, even internally.

B. Subnet Allocation

Each distinct unit or site of the SCADA network shall be allocated a unique IP subnet within the private address space. Networks shall all fall under the 192.168.y.x space, where y represents the particular subnet and x ranges from 1 to 253 representing an individual node on the network. The subnets shall be allocated by the ACWWA network administrator and where possible be unique for a distinct site or function. As ACWWA migrates to Ethernet radio technologies, care needs to be taken to balance a site-based address allocation scheme with a practical and manageable system.

VIII. HISTORIAN INTEGRATION

Process history from the entire ACWWA SCADA system shall be stored in a Wonderware Historian system. The Historian software shall reside on its own server and interface directly with components within the SCADA system. The Historian will have the capability of communicating and obtaining data directly from PLCs and other SCADA systems. The HMI may use this data to generate trends, and to generate record sets for reports. Historical data includes digital and analog I/O values and device state values.



The HMI shall also store and retrieve enumeration data and settings in a SQL database on a data server. This data includes data-driven information such as the names of graphic views, member agencies, and alarm text strings. The data includes operator-specific settings such as Navigation tree layout, custom view design, etc.

A. Enterprise Network

The HMI application is indirectly connected to the enterprise network, including connections to a domain controller, remote access server, enterprise data base(s), document control, and Web services.

B. Enterprise Database

Historic data is processed and condensed then made available to enterprise network operators. To accomplish this, the HMI application migrates data from the historian data tables to SQL data tables in Microsoft SQL in the enterprise data server.

C. Web Services

The HMI application contains an integrated reports library. This report library is accessible from outside of the HMI application, by remote operators via a Web interface. The HMI application itself needs no direct access to the Web services of the enterprise network to accomplish this.



IX. PURPOSE OF ELECTRICAL AND INSTRUMENTATION DESIGN STANDARDS

The purpose of this section is provide electrical and instrumentation standards for the Arapahoe County Water & Wastewater Authority (ACWWA). The sample specifications and drawings provided in this section pertain to all of ACWWA's water works facilities. These facilities include water treatment, water distribution, collection systems, non-potable water systems, and wastewater treatment systems. The recommendations regarding electrical and instrumentation standards were developed in workshops and meetings with ACWWA personnel.

The design criteria presented in this section are not all inclusive but are intended to serve as a guide to the electrical and instrumentation design of water works facilities. Any design specification, electrical equipment or instrumentation equipment that is not found within this section or deviates from the design criteria presented in this section shall be submitted to ACWWA for review. This section incorporates standards that will simplify maintenance and operation of ACWWA facilities by ACWWA personnel. This section will also help reduce design and construction costs associated with ACWWA facilities. It is the role of the design consultant to use this manual while working with ACWWA personnel to arrive at the proper engineering equipment application and selection. The design consultant is also responsible for the appropriate use of the guidelines, figures and tables and for submitting all necessary calculations, specifications and drawings to ACWWA.

X. PROJECT PROCEDURE

A. Conceptual Design

A Conceptual Design report shall be submitted to the ACWWA for approval. The purpose of the report is to allow the design consultant to state the design assumptions, parameters and the characteristics of associated electrical and instrumentation equipment in writing and to review these items with ACWWA before starting on the design effort. The report shall include a brief description of the proposed power distribution system which includes the name of the utility, any new electrical loads, service size, service entrance equipment size, and load calculations. The Conceptual Design Report Shall also include information on proposed site lighting, Remote Terminal Unit control panels, Instrumentation Equipment, and any site standby power source such as diesel or natural gas generator. Remote Terminal Unit information shall include programmable logic controller model number, voltages for digital inputs and outputs, size of Operator Interface Terminal (if required), and the method of communication to remote sites. Instrumentation Equipment information shall include the type of instrument, voltage and power source, location, and information on the parameters that they will communicate to the RTU.

B. Preliminary Design 30%

After the Conceptual Design Report is approved, the preliminary design report shall be submitted to ACWWA for review. Comments from the Conceptual Design Report review should be incorporated into the Preliminary Design Report. The drawings submitted should represent approximately 30% completion level of detail. These electrical drawings submitted should include the following:

- o Single Line Diagram
- o Load Calculations



- o Process and Instrumentation Diagrams

The Single Line Diagram should include utility transformer sizing information as well as conductor and conduit sizing.

- C. 75% Design Submittal

After the 30% Preliminary Design drawings are completed and submitted to ACWWA for review, the 75% design shall be submitted. Comments from the Preliminary Design submittal should be incorporated into the 75% Design Submittal. The 75% Design Submittal should consist of the following:

- o Single Line Diagram
- o Load Calculations
- o Short Circuit Calculations
- o Panel Schedules
- o Schematic Diagrams
- o Connection Diagrams
- o Construction Details
- o Process and Instrumentation Diagrams
- o Electrical and Instrumentation Equipment Specifications

- D. Preliminary Design 95%

After the 75% Preliminary Design drawings are completed and submitted to ACWWA for review, the 95% design shall be submitted. Comments from the 75% Preliminary Design submittal should be incorporated into the 95% Design Submittal. The 95% Design Submittal should consist of the following:

- o Single Line Diagram
- o Load Calculations
- o Short Circuit Calculations
- o Panel Schedules
- o Schematic Diagrams
- o Connection Diagrams
- o Lighting and Grounding Plan
- o Electrical Power Plan
- o Construction Details
- o Process and Instrumentation Diagrams



- o Electrical and Instrumentation Equipment Specifications

E. Final Design

After the 95% Preliminary Design drawings are completed and submitted to ACWWA for review, the Final Design plans and specifications should be submitted. Comments from the 95% Preliminary Design submittal should be incorporated into the Final Design Submittal. The Final Design Submittal should consist of the following:

- o Single Line Diagram
- o Load Calculations
- o Short Circuit Calculations
- o Panel Schedules
- o Schematic Diagrams
- o Connection Diagrams
- o Lighting and Grounding Plan
- o Electrical Power Plan
- o Construction Details
- o Process and Instrumentation Diagrams
- o Electrical and Instrumentation Equipment Specifications
- o The Final Design Submittal drawings and specifications should be signed and sealed by registered Electrical Engineer in the State of Colorado.

F. As-built requirements

The contractor shall keep a complete set of full size drawings at the construction site. The drawings shall be the final design drawings sealed by a registered Electrical Engineer and issued for construction. During construction, the drawings shall be marked to show any deviations from the construction drawings. The color red shall be used to indicate all additions and the color green shall be used to indicate all deletions. The resulting field-marked drawings shall be marked as “As-Built Drawings” and shall be made available to the contractor’s technical representative for review and inspection. Approved As-built drawings shall be submitted to the Engineer for incorporation into Record Drawings. Examples of the type of information that the As-built drawings should show includes:

- o Changes in conduit routing due to unforeseen field conditions
- o Changes in electrical equipment including dimensions, installation and erection
- o Changes in conductor and conduit size, type and number
- o Changes in panel, conduit and cable schedules



XI. START-UP AND COMMISSIONING

Start-up and commissioning of a project is generally the period of project development that occurs at the end of the construction phase. The project start-up and commissioning shall be a continuous event, held 24 hours per day for a period of up to 30 calendar days, depending on the size of the project and ACWWA requirements. Project Start-up and commissioning shall commence only on entire systems that are complete, and ready to run. A complete system implies that all station input/output as well as alarm points and remote telemetry functions have been verified and tested by the contractor without failure, 24 hours a day for a period of seven consecutive days.

The project startup and commissioning phase shall be performed using process flow. If there is no flow or if there is low flow at the station, ACWWA should be notified so that potable water can be introduced into the system and recirculated for testing purposes. ACWWA will be responsible for operating the site after the Start-up and commissioning has been demonstrated to be successful.

A. Equipment Start-up and Testing

The contractor shall start-up and place all electrical, instrumentation and control equipment installed into successful operation according to the manufacturer's instructions and as instructed by the manufacturer's field representative. All system and subsystem components must be tested and proven operable before they can be started up for continuous operation. Start-up is considered complete when the facility operates for 7 days continuously without any equipment failures.

B. Training

Manufacturer instruction of ACWWA maintenance and operations personnel is required for all major electrical, instrumentation and control equipment placed on site. The contractor shall provide the services of a factory-trained maintenance specialist to provide instruction on the operation and preventative maintenance procedures of electrical equipment.

C. O&M Manual Preparation

Operation and Maintenance manuals should be submitted to the city before any electrical, instrumentation and control equipment is placed in service. These instructional manuals consist of operation and maintenance information to be used by ACWWA personnel for all electrical equipment.

Operation and maintenance data that should be provided by the equipment manufacturer includes but is not limited to the following:

- o Complete, detailed written operating instructions for each product or piece of equipment
- o Complete written preventative maintenance instructions
- o Recommended list of spare parts which includes title and part numbers as well as local sources of supply for these parts.
- o Written explanations of all safety considerations pertaining to operation and maintenance procedures.



- o Name, address, phone number, fax number, email address, and website of manufacturer as well as manufacturer's local representative
- o Copy of warranty and service contract as applicable
- o As-built circuit diagrams, wiring diagrams, schematics and functional drawings.
- o Final test data shall be submitted when completed.
- o The design consultant/Engineer will provide ACWWA with a copy of each final approved shop drawing for every piece of electrical equipment at the site.

D. Final Acceptance

Acceptance of the electrical, instrumentation and control system will be based on the verification that the Contractor has furnished the proper electrical and instrumentation equipment, hardware, and services as required by the contract specifications. Also, final acceptance will take place following successful completion of any punchlist items and verification that the required documentation has been provided.

XII. ELECTRICAL SYSTEM

This section provides general design criteria for the design of an electrical system for an ACWWA site. The design criteria presented in this section are intended to serve as a guide to the uniform electrical power system design of ACWWA water works facilities. Coordination with the electric utility regarding the electric service voltage, transformer size, motor starting limitations, and metering requirements are crucial factors in the electrical design of a project and must be initiated very early in the design of the project.

A. General Electrical Design Guidelines

The electrical systems for ACWWA water works facilities design shall comply with the National Electrical Code (NEC) and all applicable local codes. The electrical equipment will be manufactured in accordance with the standards of the Institute of Electrical and Electronic Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA). The electrical equipment will require a "label" indicating compliance with the standards of the applicable codes. Provide electrical equipment with a manufacturer's 2-year warranty. Electrical equipment shall be provided with spare fuses and pilot lights in accordance with the specifications. Refer to Appendix A for a preferred list of electrical equipment, Appendix B for electrical equipment specifications and Appendix E for sample electrical drawings.

The electrical design will include service entrance sections, switchgear sections, motor control sections, VFD cabinets (if required), standby and/or dual-power systems, conduit and wiring. In general, the electrical equipment specified shall be suitable for outdoor installations, mounted on concrete pads. VFD cabinets and MCC panels should be housed only in an air-conditioned space if the project site permits. If larger pumps are to be added in the future and/or the site is to otherwise be expanded, oversized conduits, cabinets, floor space, and additional conduits shall be provided to meet the future needs. Each design shall include load calculations that include power demand information for ACWWA to apply for the electrical service from either XCEL Energy or the Intermountain Rural Electrical Association (IREA), depending on the location of the project.



B. System Reliability

Power distribution systems for wastewater lift stations, booster stations, water treatment facilities and wastewater treatment facilities that are owned by ACWWA shall be designed such that no single fault or loss of the preferred primary power source will result in the disruption of greater than 30 seconds of electrical service to more than one motor control center (MCC) associated with vital components. To satisfy this requirement, the electrical primary power distribution system shall incorporate redundant power sources.

C. Standby Power Systems

Wastewater lift stations, booster stations, water treatment facilities and wastewater treatment facilities must be provided with two separate independent sources of electrical power. The primary source shall be commercial power from either utility substations or transmission lines. The standby power source shall be either a second commercial power feed from an electrically separate utility substation or from an on-site, natural gas/diesel-fueled engine generator tied to the on-site distribution system. To select the appropriate standby power source, it is recommended a study be performed as part of the project Conceptual Design Report. This study should include a cost analysis focusing on whether or not there is dual electrical service in the area of the station, the cost to bring this service to the station, appropriate size of the backup electrical substation and its electrical lines, the need for a back-up transformer, motor starting limitations, etc. These costs must be factored in the study if the comparison of cost between a second commercial power source and an on-site power generation unit serves as the sole selection method. For facilities that will be upgraded in phases, the study must address the need to supply standby power for the sites build-out configuration.

If the standby source is derived from a natural gas/diesel-fueled engine generator, then the standby source capacity should be able to, at minimum, provide power to the critical loads of the site. If a second commercial power (utility substation) source is used as the standby source and transformation of the power is required to step down to the utilization voltage, separate transformers shall be used. The transformers, their interconnecting cable, and connections shall be physically and electrically separate so that they are protected against common mode failures. If the second power source is from a separate substation, the power lines from the primary and secondary substation cannot be on the same poles. The second commercial power source capacity shall be 100% redundant of the primary power source.

Each station that requires a standby power source shall be designed with an Automatic Transfer Switch (ATS). This switch shall be located downstream of the SES Panel, utility power meter, and the main fused disconnect switch but shall be located upstream of the transient voltage surge suppression system (TVSS), primary disconnect switch or circuit breaker, and the local power monitor. The ATS shall conform to the requirements of NEMA Standard ICS 2-447 and Underwriter's Laboratories UL-1008.

D. Power System Protection

Short Circuit Fault calculations that show the available fault currents at the major electrical equipment shall be prepared for each source of power. Faults shall report to the SCADA or an alarming (Autodialer/Cellular Data Service) system. A coordination study for the selection and



setting of proper protective devices shall be performed for each installation. If one of the sources is an engine generator, special care shall be taken in selecting and setting fault protective devices to ensure proper operation when the station is being powered by its standby power source (i.e. engine generator).

E. Equipment Sizing and Rating

Electrical equipment shall be sized to continuously carry all electrical loads without overloading. Equipment and materials shall be rated to withstand and/or interrupt the available fault current, with at least a 20% reserve margin for electrical load growth. Electrical power conductors shall be sized per applicable NEC articles. Type XHHW insulated conductors shall be used for all wire, power, and control cable applications. Conductors #1 and larger shall be Type XHHW-2.

The number and size of electrical power and control conduits provided shall take into account ultimate build-out conditions. Electrical power conductors shall be installed in separate conduits from instrumentation and control conductors. For conduits installed in concrete or under base slabs, etc., the design consultant shall provide and stub-up at all major equipment and panels a minimum of 10% spare conduits. The minimum size of underground and spare conduits shall be 1-inch diameter. These spares are not for anticipated future expansion but to permit installation of additional ancillary equipment if desired.

F. Motor Control Centers

All motor control centers shall be provided with a solid state power quality monitor. Low-voltage motor control assemblies should conform to the standards for NEMA Class II, Type B assemblies. Each assembly shall consist of vertical, free-standing sections each approximately 90 inches high, a minimum 20 inches deep, and in multiples of 26 inches wide. The door of each unit containing a disconnect device shall be interlocked so the door cannot be opened unless the device is in the "OFF" position, thus preventing the unit from being energized when the door is open. All unit doors shall be swing doors, with locks and continuous length hinges. All indicator lights mounted on the MCC shall be of the push-to-test type. Each wire, terminal strip and conduit shall be identified with a unique number.

G. Switchgear

The construction of the switchgear shall be of the universal frame type using die formed welded and bolted members; panels should be 11-gage steel bolted in place. Bus bars shall be copper, fully insulated, and silver plated at its joints. A full-length ground bus should be provided at the bottom of the switchgear enclosure. Incoming and outgoing switch or circuit breaker sections shall have ample spaces for medium voltage, 133% shielded, jacketed single conductor stress-cone terminations, and lightning arrestors.

XIII. INSTRUMENTATION AND CONTROL

The design criteria presented in this section are intended to serve as a guide to the uniform instrumentation and control system design of ACWWA water works facilities. The criteria for selecting the appropriate instruments include compatibility with existing inventories, required accuracy, reliability, environmental and process compatibility, and minimum maintenance.



A. General Design Guidelines

The instrumentation and control systems for ACWWA water works facilities designs shall comply with the National Electrical Code (NEC) and applicable local codes. The electrical equipment shall be manufactured in accordance with the standards of the Institute of Electrical and Electronic Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA). Where applicable, the instrumentation and control equipment shall require a “label” indicating compliance with the standards of a nationally recognized testing organization, such as Underwriters Laboratory (UL).

In all applications, 4-20mA current transmission is the standard for transfer of process information between field instruments, peripheral devices, and the controller. Where loop impedance is not a consideration, 2-wire, 24VDC sourced devices are preferred. Refer to the ACWWA SCADA Master Plan for information on standardized part numbers for Programmable Logic Controllers and Input/Output communication modules. Also refer to Appendix A for a preferred instrument list, Appendix C for instrumentation specifications and Appendix F for sample instrumentation drawings.

Where required by contract documents or requested by ACWWA, an I/O list and an instrument list shall be submitted to ACWWA. Refer to Appendix G for a sample I/O list and Appendix G for a sample instrument list.

B. Remote Terminal Unit Configuration

This section provides guidelines for the overall layout of the Remote Terminal Unit as well as criteria for typical components. Refer to Appendix D for example RTU layout, power distribution and I/O card wiring diagrams.

1. Programmable Logic Controller Power Supply

The PLC shall be powered from a 120VAC power source. The PLC shall be protected by an input power surge protector that is connected to the incoming line downstream of the main breaker. Also at the input, provide a control relay which monitors for 120VAC power failure. The PLC and other critical instrumentation components such as PLC input/output cards, flowmeters, level transmitters, operator interface terminals, and power supplies shall be backed up by an uninterruptible power supply (UPS). The UPS should be sized to provide 30 minutes of power in the event of utility power failure.

2. 24VDC Power Distribution

Provide a 24VDC Power Supply with sufficient capacity to provide power to all 24VDC equipment, analog loops, 24VDC relays, and PLC Input/Output modules. The power supply should be provided with over current protection and the power distributed via fused terminal blocks. Analog loop wiring that leaves an outdoor RTU enclosure shall have a din rail-mounted surge protector. Analog loop wiring that leaves a building which houses an indoor RTU enclosure shall have a din rail mounted surge suppressor.

C. Local-Remote Standards



1. For electrical equipment that is controlled via an HOA switch:
 - a. In Hand mode the equipment will run continuously at constant full speed. If the equipment is controlled via a Variable Frequency Drive, the speed will be controlled via a preset speed or operator input.
 - b. In Auto mode the equipment will be controlled by either a field device contact or a PLC digital output and will run at constant full speed. If the equipment is controlled via a Variable Frequency Drive, the speed will be controlled by a PLC and the equipment will run at a speed proportional to the speed reference output signal from the PLC.
 - c. In either Hand or Auto mode the equipment operation is subject to equipment and personnel safety permissives or interlocks.

Appendix A - Sheet 1 of 3
ACWWA Preferred Electrical and Instrumentation Equipment

RTU/Networking Equipment	Manufacturer	Model Number	Comments
PLC			
SLC 5/05	Allen Bradley	1747-L552	32K words, Ethernet Port, RS232 Port
ControlLogix	Allen Bradley	1756-L61	2MB RAM Memory, Serial Port, Optional Ethernet Port
CompacLogix	Allen Bradley	1769-L35E	1.5MB memory, 1 Ethernet port, 1 RS232 port
Micrologix	Allen Bradley	1000 Series	Features vary with model number
Radio			
	Freewave	FGR-115RC	Spread spectrum radio, 902-928MHz, Serial Interface
	MDS	iNET-II	Spread spectrum radio, 902-928MHz, Ethernet and Serial Interface

Appendix A - Sheet 2 of 3
ACWWA Preferred Electrical and Instrumentation Equipment

Electrical Equipment	Manufacturer	Model Number
Variable Frequency Drive	Allen Bradley	1336 Series
	Baker Hughes Centrillift	4000 Series
	Baker Hughes Centrillift	2000 Series
	Baker Hughes Centrillift	1100 series
	Cutler Hammer	SVX Series
	Square D	CPX Series
	General Electric	Fuji AF-300 Series
Solid State Starter	Cutler Hammer	S801 Series
	Nordic	91WD Series
	General Electric	ASTAT Plus
Motor Control Center	Cutler Hammer	Various
	Square D	Altivar Series
	Allen Bradley	Various
Transfer Switch	Asco	Series 7000
	Cutler Hammer	
Safety Switches	Cutler Hammer	Various
	Siemens	Various
	Square D	Various
Dry Type Transformers	Cutler Hammer	Various
	Siemens	Various
	Square D	Various
Panelboards	Cutler Hammer	Various
	Siemens	Various
	Square D	Various
Generators	Cummins	DFCE Series
	Generac	2030 Series
	Onan	ODFM Series
	Caterpillar	SR4B Series
	Detroit Diesel	20GS Series
Switchboard	Cutler Hammer	Various
	Siemens	Various
	Square D	Various
Metering Pump	Pulsatron	MP
Autodialer	Raco	Chatterbox
	Raco	Verbatim
	Raco	Guardit
Power Quality Meter	Cutler Hammer	IQ Data
	Electro Industries	Shark 200 Transducer
	Allen Bradley	Powermonitor 3000

Appendix A - Sheet 3 of 3
ACWWA Preferred Electrical and Instrumentation Equipment

Instrument	Manufacturer	Model Number
Magnetic Flowmeter	Endress & Hausser	Promag W
	Siemens Sitrans FM	Magflo Mag 3100W
	Rosemount	8712DR12NOM44
	Danfoss	Mag 5000
Propeller Flowmeter	McCrometer	Water Specialties ML11-06
	Sensus	Model 101/102
	Water Specialties	TR16
Pressure Transmitter	Rosemount	3051TG2A2821AS5E5DXK5
	Setra	2561200PG2M11
	Ashcroft	0-100 psi
	Endress & Hausser	Cerabar
Level Transmitter - Ultrasonic	Flowline Ultrasonic	LU20-5001
	Endress & Hausser	Prosonic
	Endress & Hausser	FMU 860-RIE2B8
	Milltronics Multi Ranger 100	7ML5033-1AA001A
	Milltronics	Hydroranger
Level Transmitter - Submersible	Dynotek	SLIMLINE; PTX SERIES
Chlorine Analyzer	Hach	CL 17
pH Analyzer	Endress & Hausser	Liquisys-M
Hydrogen Sulfide Analyzer	Scott	Quad Scan 2 Series 7400
	MSA	Ultima XE
	Scott	Freedom 5000
Magnetic Flowswitch	Endress and Hausser	Magphant DTI
Pressure Switch	United Electric	2WLP41
	Mercoïd	DA series
Float-type Level Switch	W.E. Anderson	F7-SS2 Series
	U.S. Filter	9G-EF
Temperature Transmitter	United Electric Controls	2WLP

SECTION 16161
CONTROL PANELS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes control panels.

1.02 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society for Testing and Materials (ASTM):
 - a. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
2. Joint Industrial Council (JIC):
 - a. EMP-1, Mass Production Equipment.
3. National Electrical Manufacturers Association (NEMA):
 - a. ICS 4, Terminal Blocks for Industrial Use.
 - b. ICS 6, Enclosures for Industrial Controls and Systems.
 - c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
4. National Fire Protection Association (NFPA):
 - a. National Electric Code (NEC).
5. Underwriters Laboratory (UL)
 - a. UL 508A, Standard for Industrial Control Panels

B. Miscellaneous:

1. Prior to placement of conduit feeds, assure approved control panel layouts available.
2. Assure completely matching color tones for any individual color specified.
3. Provide panel with the required NEMA rating per NEMA Publication No. 250 to meet classifications shown on drawings or specifications.

1.03 SUBMITTALS

A. Shop Drawings:

1. Scaled panel face and subpanel face instrument and nameplate layout drawings.
2. Panel and subpanel materials of construction.
3. Panel and subpanel dimensions and weights.
4. Panel access openings.
5. Conduit and wiring access locations.
6. Internal wiring and terminal block drawings.
7. Nameplate text.
8. Scaled layouts of any graphic panels.

- B. Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Enclosures:
 - a. Hoffman
 - b. Rittal
 - c. Hammond
 - d. Or equal.
- B. Submit requests for substitution in accordance with the Contract Documents.

2.02 MATERIALS

- A. Front Panel, Subpanel or Front Door: Steel.
- B. Frame and Bottom Angles: Steel.
- C. Top, Sides, Back, Sides, and Back Door: Steel.
- D. Hinges: Stainless steel.
- E. Nameplates: Phenolic.
- F. Filler Panels: Steel.

2.03 ACCESSORIES

- A. Control Panels:
 - 1. Single function pilot lights.
 - a. Flush, non-protruding.
 - b. Heavy-duty lights with glass lenses.
 - c. Colors:
 - 1) Red: "OFF" or "STOPPED."
 - 2) Blue: "REQUIRED" or "STAND-BY."
 - 3) Amber: "Alarm."
 - 4) Green: "ON" or "RUNNING."
 - d. Lens-type with LED illumination.
- B. Panel Nameplates and Identification:
 - 1. Identify each item on the control panel with rectangular nameplates.
 - 2. Provide nameplates with black letters on white background.

3. Minimum letter height is 1/2 IN for instrument description and 1/4 IN height for instrument tag number.
4. For all panels which have a panel identification number, provide 2 IN high white nameplate with black, 1 IN high lettering with panel identification number.

2.04 FABRICATION

A. General:

1. Fabricate panels with instrument arrangements as shown on the Drawings.
2. Prime control panels with rust inhibitive shop applied primer and paint with two coats of UV resistant white water-based paint.
3. Finish interior of panel with epoxy glass white.
4. Provide control panel which meets the following requirements:
 - a. Panel depth per JIC EMP-1-1967, E7.1.4.
 - b. Door opening per JIC EMP-1-1967, E7.1.5.
 - c. Data pocket per JIC EMP-1-1967, E7.1.6.
 - d. Rigidity per JIC EMP-1-1967, E7.1.7.
 - e. Door alignment and reinforcement per JIC EMP-1-1967, E7.1.8.
 - f. Panel holes and openings per JIC EMP-1-1967, E7.3.2, E7.3.3, and E7.3.4.
 - g. Doors per JIC EMP-1-1967, E7.5.
 - h. Clear panel mounting space per JIC EMP-1-1967, E8.2.9.
 - i. Panel mounted control device location per JIC EMP-1-1967, E8.3.4.
 - j. Clearances in enclosures per JIC EMP-1-1967, E8.4.

B. Free-Standing Panels:

1. Minimum construction thicknesses:
 - a. Front panel, subpanel, or front door with cutouts: 0.123 IN.
 - b. Top, sides, back, filler plates and side or doors with no cutouts: Minimum thickness per, NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Completely enclosed, self-supporting, and gasketed dust tight.
4. Edges turned back minimum of 2 IN.
5. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
6. Arrange control panel faces continuous and flush with face of adjacent electrical motor control centers.
7. Provide filler panels where necessary to close gaps between panels or back of panel and wall. Provide full length flush pan doors.
8. Provide full length piano hinges rated for 1.5 times door plus instrument weight.
9. Furnish doors with keyed alike locking handles and three point catch.
10. Provide appropriate conduit, wiring, and instrument openings in accordance with best panel design.
11. After cutouts have been made, finish opening edges to smooth and true surface condition.
12. Provide each panel with lifting eyebolts. Furnish hot-dipped galvanized steel base channels.

13. Slotted bolt holes in base, 1 1/2 long for field adjustment.

C. Wall Mounted Panels:

1. Minimum construction thicknesses:
 - a. Front panel, subpanel or door with cutouts:
 - 1) Width or height not exceeding 42 IN: 0.093 IN.
 - 2) Width or height exceeding 42 IN: 0.123 IN.
 - b. Side, top, back and doors without cutouts: minimum thickness per NEMA ICS 6, Tables 3-8,9.
2. Seams continuously welded and ground smooth.
3. Body stiffeners for extra rigidity if either height or width exceeds 28 IN.
4. Rolled lip around all sides of enclosure door opening.
5. Gasketed dust tight.
6. Three-point latching mechanism operated by oil tight key-locking handle.
7. Key doors alike.
8. Continuous heavy GA hinge pin on doors.
 - a. Hinges rated for 1.5 times door plus instrument weight.
9. After cutouts have been made, finish opening edges to smooth and true surface condition.
10. Front full opening door.
11. Brackets for wall mounting.

D. Panel Front Construction:

1. Minimum construction thicknesses: per NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Edges turned and ground smooth to touch and visual appearance.
4. At joints where panel face meets side walls, provide dustproof sponge rubber gasket entire height and face.
5. Use full length piano hinges rated for 1.5 times door weight for panel access door.
6. Equip doors with locking devices and handle and three point catches.
7. Finish all instrument cutouts smooth and true.

E. Panel Wiring and Piping:

1. Factory pipe and wire panels to identified terminal blocks equipped with screw type lugs.
2. Install all wiring without splicing in factory in raceways:
 - a. Size raceways per the requirements of NEC Article 312.
 - b. Raceways shall have removable covers.
3. Wire bending space shall be in accordance with Tables 307B, C in NEMA ICS 6.
4. Keep AC power lines separate from low-level DC lines, I/O power supply cables, and all I/O rack interconnect cables.
5. Keep AC signal wires separate from DC signal wires.
6. When I/O wiring must cross AC power wiring, it shall only do so at right angles.
7. Arrange circuits on terminal blocks plus any spare conductors on adjacent terminals.
8. Provide necessary power supplies for control equipment.

9. Equip each panel with a main thermal magnetic circuit breaker. Limit load to maximum of 80 percent of circuit breaker rating.
10. Provide all necessary stabilizing voltage transformers, balancing potentiometers and rectifiers as necessary for specific instrument requirements.
11. Assure each panel mounted device is bonded or otherwise grounded to panel or panel grounding system by means of locknuts or pressure mounting methods.
 - a. Equip panel with grounding terminals.
12. Arrange wiring with sufficient clearance for all leads.
13. Wiring to subpanels or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without disconnecting wiring.
14. Identify all wires with plastic sleeve type wire markers at each end. Markers shall:
 - a. Identify circuit numbers.
 - b. Identify function and polarity.
15. Provide all wiring according to color code as follows:

COLOR OF INSULATION	120 V, 60 Hz SERVICE	LOW VOLTAGE DC SERVICE
Black	Phase Conductor	
Red	Signal Wire	
White	Neutral	
Brown		DC Common
Orange		24VDC/12VDC Power
Blue		Signal Wires
Green	Ground	Ground

- a. For intrinsically safe instruments, provide uniform and compatible additional color scheme.
16. Termination requirements:
 - a. Terminal block markings, mechanical characteristics and electrical characteristics shall be in accordance with NEMA ICS 4.
 - b. Terminals shall facilitate wire sizes as follows:
 - 1) 120 V AC applications: Wire size 12 AWG and smaller.
 - 2) Other: Wire size 14 AWG and smaller.
 - c. Provide terminal blocks with continuous marking strip.
 - d. Tag each I/O terminal to indicate tag number of the connected device.
 - e. Provide terminals for individual termination of each signal shield.
 - f. Provide 20 percent excess terminals for future expansion.
17. Pneumatic tubes and appurtenances:
 - a. Provide 1/4 IN OD pneumatic control tubing.
 - b. Main headers within panels shall be minimum 1 IN.
 - c. Compression-type pressure fittings.
 - d. Equip panel instrument leads with globe type isolation valve.
 - e. Connection to devices not in the panel shall be terminated on tubing terminal plate.

- f. Install tubing neatly and mount securely.
- g. Do not route tubing in front of or in wiring raceways.
- h. Code terminal plates.
- i. Supply and install dual function filter regulator to serve pneumatic devices.

F. Panel Lighting and Power:

- 1. Receptacles:
 - a. Panels less than 4 FT long:
 - 1) One electrical outlet.
 - 2) One incandescent light fixture with switch(es) and separate circuit breakers.
 - b. Panels or panel faces greater than 4 FT long:
 - 1) One electrical outlet per 6 FT of length.
 - 2) Continuous fluorescent lighting strip with switches and separate circuit breakers.

G. Environmental Controls:

- 1. Furnish circulation fans near hot spots where required to prevent temperature from exceeding instrument rating.
- 2. Over-temperature switches shall be utilized to provide special cooling if required to maintain operating temperatures within the manufacturer's specified range.
- 3. Air conditioning applications shall include means of preventing moisture condensation.
- 4. For panels or control cabinets located outside, or in area classification requiring a NEMA 4 or 4X rating:
 - a. Provide printed circuit boards with "Humiseal" conformal coating, covering entire components on both side of board except not covering adjustable components.
 - b. Furnish gold plated edge connectors on circuit board and socket contacts.
 - c. Install thermostatically controlled condensation protection heaters or 10 CU IN desiccant packs in enclosures housing electronic equipment.
 - 1) Provide one pack for each 10 CU FT of panel capacity.

2.05 MAINTENANCE MATERIALS

A. Extra Materials:

- 1. Replacement Bulbs. Provide minimum 25 percent or 25 bulbs, whichever is greater, for replacement indicating light bulbs for each type of indicator furnished in this Project.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install free-standing panels on concrete pads as detailed on the Drawings.

- B. Anchor panel fronts rigidly into wall system with approved anchorage devices.

3.02 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16427

LOW-VOLTAGE INSULATED CASE SWITCHBOARD

PART 1 - GENERAL

1.01 SCOPE

- A. The Contractor shall furnish and install, where indicated on the drawings, a dead-front type, low-voltage switchboard, utilizing individually mounted insulated case circuit breakers as specified herein, and as shown on the contract drawings. Switchboard shall be rated as Service Entrance Equipment. Provide a utility metering section in compliance with EUSERC Standards.

1.02 REFERENCES

- A. The low-voltage switchboard assembly and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards:
 - 1. UL 891
 - 2. UL 869
 - 3. NEMA PB-2.

1.03 SUBMITTALS

- A. The following information shall be submitted to the Engineer in accordance with the Contract Documents:
 - 1. Master drawing index
 - 2. Front view and plan view of the assembly
 - 3. Three-line diagram
 - 4. Schematic diagram
 - 5. Nameplate schedule
 - 6. Component list
 - 7. Conduit space locations within the assembly
 - 8. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current rating
 - 9. Major component ratings including:
 - a. Voltage
 - b. Continuous current rating
 - c. Interrupting ratings
 - 10. Cable terminal sizes.
- B. Where applicable, the following additional information shall be submitted to the Engineer:

1. Busway connection
2. Connection details between close-coupled assemblies
3. Composite front view and plan view of close-coupled assemblies
4. Key interlock scheme drawing and sequence of operations
5. Mimic bus.

C. The following information shall be submitted following equipment installation prior to startup:

1. Final as-built drawings and information for items listed in section 1.04
2. Wiring diagrams
3. Certified production test reports
4. Installation information
5. Coordination study based on the new and existing breakers shown on the Single-Line Diagram in the Drawings. The study shall include time-current curves for each path, and recommended trip unit settings for proper coordination of upstream devices. Devices to be included in the study shall be loads of 50 KVA and larger, and protective devices rated 100 Amps and larger. The Contractor shall be responsible for gathering field data on the existing breakers and devices. The study shall be sealed by an engineer registered in the State of Colorado.

D. The final as-built drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.04 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the insulated case circuit breaker installed within the assembly.
- B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The switchboard assembly and circuit breakers shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC). Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 0.75g, and a ZPA of 0.38g. The tests shall fully envelope this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1.05 REGULATORY REQUIREMENTS

- A. Switchboard shall comply with the latest applicable standards of NEMA PB-2 and UL Standard 891. The assembly shall bear a UL label.
- B. The equipment specified herein shall meet or exceed the local electric utility and building code specifications and requirements.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. Square D

2.02 RATINGS

- A. Voltage rating shall be as indicated on the drawings. The entire assembly shall be suitable for 600 volts maximum AC service.
- B. The assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected directly to a power source having available fault current of 65,000 amperes symmetrical at rated voltage, as shown on the drawings.

2.03 CONSTRUCTION

- A. The switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the roof of the switchboard over the breaker and bus compartments to ensure adequate ventilation within the enclosure.

- B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills provided the floor is level to 1/8 inch per 3-foot distance in any direction.
- C. Furnish fixed mounted circuit breakers having the following features:
 - 1. Insulated rigid bus connections shall extend from the load side of individually mounted overcurrent feeder devices into the rear compartment where outgoing cable connections may be made without reaching into or near the main horizontal or vertical busses.
 - 2. Distribution sections shall be sectionalized to provide a front device section, an intermediate bus section and a rear feeder cable section. There shall be a vertical barrier of glass polyester between the device compartment and the bus compartment.
- D. Provide a rear compartment steel barrier between the cable compartment and the main bus to protect against accidental contact with main or vertical bus bars.
- E. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.
- F. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment.

2.04 BUS

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three (3) phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).
- B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.
- C. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
- D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

2.05 WIRING/TERMINATIONS

- A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required.
- B. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle-type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the

switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

- C. Crimp-type terminals shall be provided for all line and load terminations suitable for copper cable rated for at least 75 degrees C of the size as indicated on the drawings.
- D. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

2.06 CIRCUIT BREAKERS

- A. All protective devices shall be fixed insulated case circuit breakers. Frame ratings shall be as shown on the Drawings. All breakers shall be UL listed.
- B. Breakers shall be manually operated (MO). The breaker control face plate shall include color-coded visual indicators to indicate contact OPEN and CLOSED positions as well as mechanism CHARGED and DISCHARGED positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker.
- C. Insulated case circuit breakers shall have a minimum symmetrical interrupting capacity that is above the available fault current from the utility.
- D. A selective override circuit shall be provided on breakers having short-time adjustments but without instantaneous adjustments that will allow selectivity up to its RMS symmetrical short-time rating. This selective override circuit shall allow the breaker to ride through a fully offset (asymmetrical) fault equal to its RMS symmetrical short-time rating in a system having an X/R ratio of 6.6 with a maximum single-phase peak current of 2.3 times the RMS symmetrical short-time rating. No deviations from this specification shall be acceptable.
- E. All breakers shall be provided with a true, two-step stored energy mechanism providing a maximum of five-cycle closing. All the energy required for closing the breaker shall be completely stored and held in readiness pending a release to close action. Manual operated breakers shall be convertible to electrical operation by insertion of an internally mounted motor operator without voiding UL label. Both manual and electrically operated breakers shall have multiple charge/close provisions providing the following possible sequence: Charge-close-recharge-open-close-open. As a safety feature, provisions shall be available to manually discharge the stored energy without closing the breaker. Anti-pump provisions shall be provided as standard for manual breakers with spring release solenoids.
- F. The insulated case breakers shall have high endurance characteristics being capable of no-load and full-load interruptions at rated current equal to or exceeding the UL endurance ratings for molded case breakers without maintenance.

- G. Main insulated case circuit breakers shall be provided with trip units as specified in paragraph 2.07.A through S.

2.07 TRIP UNITS

- A. Each insulated case circuit breaker shall be equipped with a solid-state tripping system consisting of three (3) current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.
- B. Interchangeable rating plugs shall establish the maximum continuous trip ratings of each circuit breaker. Rating plugs shall be fixed-type as indicated. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
- C. Complete system selective coordination shall be provided by the addition of the following individually adjustable time-current curve shaping solid-state elements:
 - 1. All breakers shall have adjustments for long delay pick-up and time.
 - 2. Main shall have individual adjustments for short delay pick-up and time, and include selective flat or I²t curve shaping.
 - 3. Main shall have an adjustable instantaneous pick-up.
 - 4. Breakers, where indicated on the drawings, shall have individually adjustable ground fault current pick-up and time, and include selective flat or I²t curve shaping.
- D. The microprocessor-based trip unit shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.
- E. Trip units shall include zone interlocking capability for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream circuit breaker and allow the circuit breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the pre-set time delay.
- F. For trip units that do not have an instantaneous adjustment, a discriminator circuit shall be provided to prevent the breaker being closed and latched onto a faulted circuit.
- G. Internal ground fault protection settings shall not exceed 1200 amperes. Provide neutral ground fault sensor for four-wire loads.

- H. The trip unit shall have an information system that utilizes battery backed-up LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A trip reset button shall be provided to turn off the LED indication after an automatic trip. A test pushbutton shall energize an LED to indicate battery status.
- I. The trip unit shall be provided with a representation of the time-current curve on the trip unit that indicates the protection function settings. The unit shall be continuously self-checking and provide LED indication that the internal circuitry is being monitored and is fully operational.
- J. The trip unit shall contain an integral test panel with a test selector switch and a test pushbutton. The test selector switch shall enable the user to select the values of test current within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker shall be capable of being tested in either the TRIP or NO TRIP test mode. Provide a keyed receptacle for use with an optional auxiliary power module. The auxiliary power module shall allow the breaker trip unit to be tested with a 120-volt external power source.

2.08 UTILITY METERING

- A. Where indicated on the drawings, furnish a utility metering compartment separated by full barriers complete with hinged sealable door. Bus work shall include provisions for mounting utility company current transformers and potential transformers or potential taps as required by the utility company. Provide service entrance label and necessary applicable service entrance features per NEC and local code requirements.

2.09 ENCLOSURES

- A. Outdoor NEMA 3R Enclosure
 1. Outdoor enclosure shall be non-walk-in and meet applicable NEMA 3R UL requirements.
 2. Enclosure shall have sloping roof downward toward rear.
 3. Outer sections shall be the same widths as indoor structures, except each end of the outdoor assembly shall have an end trim.
 4. The enclosure shall be provided with bolt-on rear covers for each section.
 5. Doors shall have provisions for padlocking.
 6. Ventilating openings shall be provided complete with replaceable fiber glass air filters.

2.10 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating.

- B. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.
- C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.11 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be the manufacturer's standard.

2.12 TRANSIENT VOLTAGE SURGE SUPPRESSION

- A. Provide transient voltage surge suppression.

PART 3 - EXECUTION

3.01 FACTORY TESTING

- A. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested to assure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground and between opposite polarities.
- B. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute or 1800 volts for one (1) second between live parts and ground.

3.02 INSTALLATION

- A. The contractor shall install all equipment per the manufacturer's recommendations and the contract drawings.
- B. All necessary hardware to secure the assembly in place shall be provided by the contractor.

3.03 TESTING

- A. Test in accordance with contract documents.

3.04 FIELD QUALITY CONTROL

- A. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section for a period of two (2) working days. The manufacturer's representative shall provide

technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

- B. The contractor shall provide three (3) copies of the manufacturer's field start-up.

3.05 MANUFACTURER'S CERTIFICATION

- A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.
- B. The contractor shall provide three (3) copies of the manufacturer's representative's certification.

3.06 TRAINING

- A. The contractor shall provide a training session for up to three (3) owner's representatives for four (4) hours at the job site.
- B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers and major components within the assembly.

3.07 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End Of Section

SECTION 16430

CUSTOMER POWER METERING SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This specification covers the customer power monitoring system installed on the service entrance section(s), motor control center(s), and other distribution panel(s) as indicated on Plans.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with the Contract Documents, prior to installation.
- B. Submit manufacturer's catalog cut sheet indicating all options to be supplied as specified herein.
- C. Submit shop drawing indicating wiring connection diagram and elevation drawing indicating location of component(s) on the service entrance section.

1.03 MANUFACTURERS

- A. Acceptable manufacturers subject to compliance with the specifications herein are as follows:
 - 1. Electro Industries
 - 2. Cutler Hammer
 - 3. Square D
 - 4. Allen Bradley

PART 2 - PRODUCTS

2.01 GENERAL

- A. The system shall consist of electronic circuit monitors as required to obtain signals as specified herein. Components shall include CT's, PT's, CPT, etc. and other devices as required.
 - 1. The electronic Circuit Monitors shall report metering values such as frequency, temperature, current, voltage, power factor, power, demand current, and real power, and accumulated energy.
 - 2. Each Circuit Monitor shall retain historical circuit data, time and date, setup and configuration values, and diagnostics data in the event of a control power failure without the need for an internal battery.

3. Each Circuit Monitor shall be capable of capturing current and voltage waveforms which may be exported to a personal computer where waveform or other power quality analysis may be performed.
4. The Circuit Monitor shall include an LED readout which will allow local display of the following electrical parameters:
 - a. Current, per phase RMS
 - b. Voltage, phase-to-phase & phase-to-neutral
 - c. Real power, 3-phase total
 - d. Reactive power, 3-phase total
 - e. Apparent power, 3-phase total
 - f. Power factor, 3-phase total & per phase
 - g. Frequency
 - h. Peak demand current, per phase
 - i. Peak demand, real power
 - j. Accumulated Energy, (MWH and MVARH)
5. Reset the following electrical parameters shall also be allowed from the front of the Circuit Monitor:
 - a. Peak demand current
 - b. Peak demand power
 - c. Energy (MWH)
 - d. Reactive energy (MVARH)
6. Circuit Monitor setup for system requirements shall be allowed from the front of the Circuit Monitor. Setup provisions shall include:
 - a. CT (Size as needed)
 - b. PT (Size as needed)
 - c. System type (3-wire and 4-wire)
 - d. Demand interval (5-60 min.)
7. All reset and functions shall be keyswitch protected to prevent unauthorized/accidental changes.
8. Unit shall be capable of providing four (4) analog output channels for connections with PLC analog inputs for Amps, Phase Voltage, Watts and Vars and the option to communicate over Modbus RTU protocol using RS-485 cable network connections with a remote PLC.

- B. The system shall have System Display units which display data from the Circuit Monitors. The display unit shall contain the following:
1. Each System Display shall provide real-time access to all metering data available for each circuit (present as well as historical data).
 2. Each System Display unit shall access and display the data available from selected electronic Circuit Monitors connected on the individual data transfer network.
 3. The System Display unit shall utilize a 4 line by 20 character, high contrast LCD technology display with backlighting to provide high reliability and superior readability in all light conditions.
 4. The level of backlighting as well as the contrast shall be adjustable.
 5. The System Display unit shall allow for easy operation by providing a keypad with large keys for operator selections.

6. The keys shall have a raised perimeter and tactile feedback to ensure a positive response even with gloved hand operation.
7. The keys shall be clearly marked to indicate the function and separated into meaningful groups with display prompting to assist the user in operation.
8. Each System Display unit shall be configured by the manufacturer with all necessary data such as CT ratios, PT ratios, main and feeder device nameplates, demand alarm set points, etc.
9. It shall be possible to change the configuration for each System Display unit using the keypad provided on each display.
10. This capability shall be password protected to prevent unauthorized modification of the configuration.
11. All data with the exception of the captured waveform shall be accessible by the System Display unit.
12. Data shall be displayed in a logically organized manner complete with the proper scaling and units.
13. It shall be possible to sequentially view all available data from a selected Circuit Monitor by single keystroke advancing through the various display pages.
14. It shall be possible to view the same pages of data from other Circuit Monitors by single keystroke advancing back and forth from Circuit Monitor to Circuit Monitor.

C. Configure Power Metering System per manufacturer's recommendations.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. System Display units shall be installed by the manufacturer in the switchgear as indicated on the plans.
- B. The System Display units shall be flush mounted on switchgear door panels.
- C. Electronic Circuit Monitors shall be installed by the switchgear manufacturer for all circuits as indicated by the project drawings.
- D. All control power, CT, PT, and communications wire shall be factory wired and harnessed within the switchgear lineup.
- E. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.
- F. The metering components included within the service entrance sections shall be factory installed, wired and tested prior to shipment to the job site.

- G. All wiring required to externally connect the personal computer shall be installed by the Contractor per manufacturer's requirements and per other portions of these specifications.
- H. Contractor interconnection wiring requirements shall be clearly identified on the metering system drawings to be submitted for approval.

3.02 TESTING

- A. Test in accordance with the contract documents.

3.03 TRAINING

- A. On-site start-up and training of the metering system shall be included in the project bid.
- B. Start-up shall include a complete working demonstration of the system with simulation of possible operating conditions which may be encountered.
- C. Training shall include any documentation and hands-on exercises necessary to enable operations personnel to assume full operating responsibility for the system after completion of the training period.
- D. The project bid shall include 2 days start-up assistance and 1 day training.

3.04 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16440

DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers electrical disconnecting switches.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

- A. Disconnect switches shall be heavy-duty safety switches with a quick-make, quick-break operating mechanism, with full cover interlock, and indicator handle. The disconnect switches shall be furnished with fuses of the size indicated on the Drawings. One set of spare fuses shall be furnished for each fused disconnect switch. Disconnect switches shall be NEMA type HD heavy duty construction, UL 98 listed.
- B. Enclosures shall be rated NEMA 12 for indoor use, and NEMA 3R for outdoor use, unless otherwise indicated on the Drawings.
- C. Disconnect switch handle shall be padlockable.
- D. Disconnect switches in the corrosive areas as indicated on the Drawings, shall be NEMA 4X, 304 stainless steel.
- E. Disconnect switches shall be as manufactured by Square D, Cutler Hammer, or Siemens.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Disconnect switches shall be installed as indicated on the Drawings.
- B. Provide grounding per NEC, and Section 16170.

3.02 TESTING

- A. Test in accordance with contract documents.

3.03 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16461

TRANSFORMERS - DRY TYPE

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers dry type transformers used for low voltage, single and three phase, power distribution and lighting.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with the Contract Documents prior to installation.

1.03 QUALITY ASSURANCE

- A. ANSI C57.12.01, dry-type transformers
- B. ANSI C89.2, dry-type transformers
- C. NEMA ST-20, dry-type transformers
- D. UL-506, specialty transformers

PART 2 - PRODUCTS

2.01 DISTRIBUTION - LOW VOLTAGE LIGHTING AND POWER

- A. Transformers shall be premium high efficiency quiet type, and shall be installed where indicated on the Drawings. The primary winding of the transformers shall have two 2-1/2 percent taps above, and below normal.
- B. The transformers shall have a BIL of 10 KV with a temperature class of 185 degrees C for transformers up to 25 KVA, and a temperature class of 220 degrees C for larger transformers.
- C. The sound level shall not exceed 44 dB measured at 5 feet from the transformer after installation. Core and coil assemblies 30 KVA and larger, shall be mounted on rubber vibration isolators, designed to reduce harmonics generated noise.
- D. Transformers shall be types manufactured by Cutler-Hammer, Square D or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Transformers shall be installed as indicated on the Drawings, and in accordance with the manufacturer's instructions and recommendations. Contractor shall provide painted metal wall brackets, when required.
- B. Grounding shall be provided per NEC, and Section 16170.

3.02 TESTING

- A. Test in accordance with the contract documents.

3.03 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Panelboards furnished in accordance with the Plans and this specification.
 - 1. Service entrance rated main distribution panelboards.
 - 2. Distribution panelboards.
 - 3. Lighting and appliance branch circuit panelboards.

1.02 CODES, STANDARDS, AND REGULATORY REQUIREMENTS

- A. All parts, materials, assembly, installation, testing and commissioning shall meet the requirements of the latest edition of the following Codes and Standards, and Regulatory agencies. In case of the conflict between the codes' requirement, the most stringent shall apply.
 - 1. Underwriters' Laboratories:
 - a. Panelboards: UL 67
 - b. Enclosures for Electrical Equipment: UL 50
 - c. Molded Case Circuit breakers and Circuit Breaker Enclosures: UL489
 - 2. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.
 - 3. FS W-P-115 - Power Distribution Panel.
 - 4. NEMA AB 1 - Molded Case Circuit Breakers.
 - 5. NEMA PB 1 - Panelboards.
 - 6. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 - 7. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment.
 - 8. NFPA 70 - National Electrical Code.
 - 9. UBC - Uniform Building Code.
 - 10. NETA - International Electrical Testing Association.

1.03 SUBMITTALS

- A. Shop drawings for equipment and component devices.
- B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker arrangement, sizes and numbering system.
- C. Include information on all the accessories, locking hardware, shunt trip, under-voltage release mechanism, typical thermal magnetic curves for each size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Cutler Hammer
- B. Square D

2.02 BUS AND HARDWARE

- A. Panelboards shall be completely factory assembled and equipped with the type, size and number of branch circuit breakers, arranged and numbered as shown on the Plans. Panelboards shall be fully rated. Series rated panelboards are not acceptable.
- B. All multi-pole breakers shall be common trip. Branch circuits shall be arranged using double row construction. Bus sequence shall be ABC top to bottom, left to right for both top and bottom fed panels. Provisions or space for future breakers shall be located at the bottom of the panel and be fully bussed, complete with all necessary mounting hardware. Use at least 100 ampere breaker-connecting bus straps and mounting hardware.
- C. Where SPARE is indicated on the panel schedule(s), the specified circuit breaker and at least 100 ampere branch-circuit busing and mounting hardware shall be installed.
- D. Where SPACE is indicated on the panel schedule(s), 100 ampere branch-circuit busing and mounting hardware shall be installed, ready for future installation of circuit breakers, furnished by others. At least 20% spare pole spaces, grouped in multiples of three, shall be provided in each panelboard, for future installation by the Owner. Provide single pole filler plates in the spaces, as required.
- E. A nameplate shall be provided, and located near the top of the front trim on the exterior surface, listing panel type and ratings, as required by UL. Each circuit shall be permanently numbered to agree with the panel schedule, using plastic or metal buttons mounted adjacent to the breaker and secured by rivets or grommets with an engraved or depressed number. Adhesive numbering tape, painted numbers, or use of more than one number per breaker is not acceptable.
- F. Main vertical bus bars shall be copper and silver or tin plated per UL requirements. Bus bars shall be supported by glass-filled polyester-type insulators. All bolts, used to connect current-carrying parts together, shall be accessible for tightening from the front of the panel. Bus bars shall be factory drilled and tapped with spacing arranged to permit breaker interchange, from the front, while the panel is energized.
- G. Neutral bus shall be copper and insulated from the cabinet and all other parts. It shall be rigidly mounted in the panel and shall be provided with a solderless cable connector for each circuit breaker and each space in the panelboard and the main connecting lug(s).
- H. A 1/4-inch (8mm) thick copper equipment ground bus, of sufficient width and length, shall be solidly bolted and grounded to the enclosure at the bottom and shall leave clear

space for the bottom cable entries. The bus shall be drilled and tapped for 1/4" (8mm) - #20 machine screws in number to agree with branch circuits and spaces. A solderless connector, for No. 2 to No. 4/0 cable size, shall be bolted to the ground bus.

- I. Copper bus bars shall be of sufficient size to provide a current density of not more than 1000 amperes per square inch of cross section, and not more than 200 amperes per square inch at bolted connections.
- J. Minimum Short Circuit Rating for Bus Bracing: The bus shall be braced for the minimum symmetrical short circuit rating of the panel, as shown on the panel schedule.
- K. Provide main bus pressure connectors (main lugs) and separately supported sub-feed pressure connectors (lug landings) where noted. Provide additional bottom raceway space to accommodate pressure connectors and lug landings. In no instance shall the gutter space be less than required by NFPA-70.
- L. Provide Transient Voltage Surge Suppression where required on Plans.
- M. Where required on Plans, provide re-installed locking devices for locking each circuit breaker in the OPEN position, by means of a padlock. Locking devices shall not be removable from the front of the panel with the trim in place. Attachment of the locking device to the panel with adhesives is not acceptable.

2.03 CIRCUIT BREAKERS

- A. Molded Case Circuit Breakers: NEMA AB 1; provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole and common trip handle for all poles. Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type SWD, for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where shown on Plans.
- B. Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame sizes above 100 amperes.
- C. All breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.
- D. The minimum width of one pole shall be 1-3/8 inches. The breaker shall be "E" frame minimum.
- E. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panel schedule(s). Series rated breakers are not acceptable.

2.04 CABINETS (BOXES)

- A. All details of construction and methods of assembly shall meet the requirements of the "Enclosures for Electrical Equipment" of the Underwriters' Laboratories. The panel box

shall not be less than 20" wide, 4.5" deep and of sufficient height to enclose the specified main and branch circuit breakers, buses, metering equipment and wire gutter. The panelboard enclosure shall be fabricated from code-gauge galvanized or galvanized-annealed steel without knockouts and with full front flange. The panel front shall be as shown on the plans and fabricated from cold rolled steel. Surface mounted panel boxes shall be finished with ANSI-61 light grey baked enamel. There shall be no screws projecting into the wiring raceways. The panelboard enclosure type shall be coordinated with the environment and location shown on the plans. Provide a NEMA 1 rated panelboard for installation within the switchboard.

- B. The front trim shall have full-length hinged outer door designed to expose the wiring raceways and breakers, when open. Another, inner hinged door shall expose breakers only, when open, making this a door-in-door construction. Both doors shall open to the right.
- C. Both doors shall be provided with concealed butt or piano hinges. A suitable latch, which can be operated without tools, shall be provided to properly hold the inner door closed. For doors 30 inches (765mm) high or less, a flush-type latch is satisfactory. For doors more than 30 inches (765) high, a vault-type handle shall be provided with a three-point latch that holds the door closed at the top and bottom. The outer door shall be secured with at least four (4) captured oval head machine screws.
- D. A sturdy metal frame, with a clear plastic cover, for an 8-1/2 inch x 11 inch panel schedule, shall be attached inside of the panel door with the RTV adhesive.
- E. Panel trim and doors, and surface mounted cabinets shall be thoroughly cleaned, given a rust-inhibiting treatment, and finished with ANSI-61 light grey baked enamel.
- F. All panelboards shall bear the Underwriters' Laboratories label.

2.05 EXCEPTIONS

- A. The bidders shall list all the exceptions taken from the specification with their quote. If no exceptions are listed with the bid, it is understood that the bidder shall meet all the requirements of this specification and applicable Codes and Standards.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Where surface mounted, provide suitable supports and rack all branch circuit conduits. All mounting attachments and connections shall be designed in conformance with the minimum lateral seismic force of 0.5g per the most current adopted version of the UBC.
- B. Height: Install top of trim 78 inches above finished floor, unless otherwise noted on drawings.

- C. Provide filler plates for unused spaces in panelboards.
- D. Provide typed or neatly hand printed 8-1/2x11-inch circuit directory for each panelboard, in the format as shown on the drawings. Revise directory to reflect circuiting changes required to balance phase loads.

3.02 QUALITY CONTROL

- A. Owner reserves the right to witness any of the following tests conducted by the contractor and shall be notified in advance of these tests. Test in accordance with contract documents.
- B. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Maintain proper phasing for multi-wire branch circuits.

3.03 FINAL SUBMITTALS

- A. After completion of the installation, wiring and testing, submit the following information within two weeks of the equipment acceptance.
 - 1. As-Built Panel Schedules.
 - 2. Copy of the certified test report described in Section 3.02.

3.04 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

END OF SECTION

SECTION 16481

MOTOR CONTROL CENTERS (MCC)

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish and install, ready to use, motor control centers for use as indicated on the Drawings and specified herein.
- B. Circuit breaker ratings, and modifications, shall be as indicated on the Drawings.
- C. MCP ratings, and modification, shall be as indicated on the Drawings.

1.02 SUBMITTALS

- A. The motor control centers shall meet the requirements of the latest edition of Standards for Industrial Control No. ICS published by the National Electrical Manufacturers Association. The following minimum information and drawings shall be submitted for review:
 - 1. Plan, front, side views and overall dimension of each motor control center.
 - 2. Weight.
 - 3. Internal wiring diagram of each plug-in unit.
 - 4. Internal wiring diagram of the motor control centers.
 - 5. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
 - 6. One-line and a schematic diagram for each motor control center.
 - 7. Bill of material list and Manufacturer's Product Data.
 - 8. Installation instructions.
 - 9. Manufacturer's certification that the following items are capable of interrupting and/or withstanding the specified short circuit condition:
 - a. Bus bar bracing
 - b. Feeder tap units
 - c. Starter units
- B. Product information shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- 1. Square D
- 2. Cutler Hammer
- 3. Allen Bradley

2.02 MOTOR CONTROL CENTERS (MCC)

- A. The motor control center fabricator shall be the manufacturer of the major components therein, such as circuit breakers and starters. Engineered motor control centers shall be by the component and housing manufacturer. The manufacturer shall comply with equipment specifications contained elsewhere in these Contract Documents.
- B. Each component, as well as the complete assembly, shall be constructed and tested in accordance with latest NEMA Standards for Industrial Control. The type of construction of the control centers shall be NEMA Class II, Type B. Lifting eyes shall be provided on each section to facilitate handling.
- C. Unit doors shall be mounted on the stationary structure and hinged on the side away from the vertical wireway. They shall be held closed with slotted thumbscrews.
- D. Unit doors shall have positive action linkage with disconnect operating mechanism. Mechanism shall be designed so that it can be locked in the OFF position with up to 3 padlocks. When the handle is not padlocked, it shall be possible to open the door by releasing the door interlock with a small tool. The control units shall be of the plug-in type. When doors are closed, the operating mechanism shall clearly indicate the ON or OFF position of the disconnect, and the door interlock mechanism shall engage. The disconnect operating mechanism shall be designed against inadvertent operation when the door is open. Each plug-in unit door shall be provided with a nameplate, specified elsewhere herein, that indicates the circuit number and circuit name. The nameplate shall be attached to the door with brass or stainless screws.
- E. It shall be possible to install up to 6 NEMA size one units in one vertical section. Units shall be completely enclosed with sheet steel. A small wireway shall be provided inside the unit, so all wiring can be laid in place without removing barriers or plates. Each vertical section that holds the units shall be rigidly formed of minimum 12 gauge, cold-rolled sheet steel. The vertical front-of-board-construction shall be supplied with minimum 20-inch depth.
- F. Continuous horizontal wiring troughs shall be provided at both top and bottom of each section. These troughs shall line up to form a continuous wireway for the full length of the MCC. A large continuous, full-height vertical wiring trough shall be provided in the right side of each section.
- G. All starter wiring, control, and power shall be terminated in terminal strips in this trough for size 2 and smaller starters. Size 3 and larger starters shall have control leads terminating on the terminal strips in the trough. Terminal strips shall be split-type to facilitate wiring connections without disconnecting factory or field conductors. Terminal strips shall be rated to accept conductor sizes as indicated on the Drawings.
- H. Bus bars shall be silver plated copper, and shall be of the ampacity indicated on the Drawings. Unit bus bar stabs shall insure high contact pressure. The vertical bus bars shall be effectively isolated from accidental contact by plastic insulating medium.

Horizontal bus shall be silver-plated at every joint. The entire vertical bus shall be silver-plated copper.

- I. Bus bar supports shall be of high impact strength, non-carbonizing insulating material mounted on padded steel brackets and shall provide adequate dielectric strength and creepage distance. The bus structure shall be capable of withstanding short circuit current in accordance with NEMA standards, and as indicated on the Drawings.
- J. Horizontal bus amperage rating shall be as indicated on the Drawings.
- K. Each section shall be equipped with horizontal ground bus that shall be continuous across the MCC.
- L. The MCCs shall be supplied as indicated on the Drawings, and as specified herein and in accordance with NEMA Standard Pub. IS 1.1, latest edition. The MCCs shall be enclosed in NEMA Type 1 gasketed industrial use enclosures, unless otherwise shown. NEMA 3R enclosures shall provide sufficient depth for air conditioning units to be mounted on the end of the structures. If the MCCs contain VFDs or Solid State Starters that require cooling, their respective sections shall be louvered top and bottom, and fans shall remove heat from within the sections.
- M. All metal surfaces and structural parts shall be given a phosphatizing, or equal, treatment prior to painting. The control centers shall then be given a gun-metal gray undercoat which is equal to zinc chromate. The exterior of the enclosure shall be finished in standard ANSI Grey.
- N. Spaces for future combination starters shall have all the hardware necessary so that a future plug-in control unit can be installed without having to modify the vertical sections. The number of spaces for future control units shall be as indicated on the Drawings.
- O. Devices, such as, but not limited to, starters, circuit breaker, relays, timers, conductors, shall conform to other sections of these Contract Documents.
- P. Provide customer metering instruments, as indicated on the Drawings. Unless otherwise indicated on the Drawings, metering units shall be electronic, capable of displaying volts line-to-line and line-to-neutral, and amps per phase.

PART 3 - EXECUTION

3.01 GENERAL

- A. The MCCs shall be erected in accordance with the recommendations of the manufacturer and with the details specified herein.
- B. Cables larger than No. 6 AWG, which hang from their vertical connections, shall be supported within 2 feet of the connection.

- C. The motor overload relays shall be provided and sized based on the actual full load amperes of the motor connected to the starter.
- D. The motor circuit protectors shall be adjusted to the lowest settings that do not cause false tripping.

3.02 TESTING

- A. Test in accordance with contract documents.

3.03 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16482

SOLID STATE MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Solid state motor controllers (SSMC) for use with NEMA Design "B" 460 VAC motors to reduce the current inrush as well as mechanical shocks that can result from starting or stopping a motor across the line.
2. This section pertains to stand-alone solid state motor controllers in addition to those provided as part of a Motor Control Center.
3. Provide SSMC fully assembled as part of a Motor Control Center or as a standalone controller, ready for field installation, testing, and startup.

1.02 SUBMITTALS

A. Submit the following:

1. Complete electrical data on the SSMC and all accessories.
2. Dimensional and weight information on the enclosure (if applicable).
3. Fully developed ladder style elementary diagrams complete with terminal and wire designations. Label or tag all control devices.
4. Comprehensive bill of material for all components used to assemble the finished product.
5. Anticipated heat load for sizing of building HVAC system.
6. Verification that unit is listed by an independent testing laboratory in accordance with Electric Industrial Control Equipment Specification UL508.
7. List of recommended spare parts for 1 year operation.

1.03 QUALITY ASSURANCE

- A. Final assembly to be provided with a UL508 label installed at the point of manufacturer.
- B. The manufacturer shall be a certified ISO 9002 facility.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Package unit to protect against shipping damage.
- B. Store unit in a clean, dry, controlled environment until scheduled installation.
- C. Handle units in accordance with manufacturer's recommendations and in such a manner as to prevent damage.
- D. Replace any unit damaged as a result of improper shipping, storage, or handling.

1.05 PROJECT/SITE CONDITIONS

- A. Unit shall be designed specifically for the environment into which it will be installed.
- B. Provide weather protection, space heating to prevent condensation, and cooling or ventilation as recommended by SSMC manufacturer.
- C. Provide sufficient clearance and housekeeping pads to allow air circulation and to prevent damage from standing water.

1.06 WARRANTY

- A. Provide a 1 year warranty on materials and workmanship from date of start up or 18 months from date of shipment.
- B. An optional extended warranty shall be available for up to an additional two years.

PART 2 - PRODUCT

2.01 MANUFACTURERS

- A. General Electric
- B. Cutler-Hammer

2.02 GENERAL DESCRIPTION

- A. Provided in a configuration suitable for panel mounting.
- B. Uses a thyristor bridge consisting of at least two SCRs per phase to control the starting and stopping of industry standard motors. A soft start/current limit will be obtained by a timed voltage ramp of the thyristors. The thyristors will be controlled in such a manner that a smooth and stable acceleration ramp is ensured, independent of motor load.
- C. Controlled by a microprocessor that continuously monitors the current and thyristor phasing of the starter.
- D. All soft start power ratings shall use the same control module.

2.03 RATINGS

- A. Designed to operate in an ambient temperature of 0° to 40°C.
- B. Storage temperature range shall be -25° to 70°C.
- C. Maximum relative humidity shall be 93% at 40°C, non-condensing.

- D. Designed to operate in attitudes up to 5650 feet above sea level. For higher altitudes, derate by 1.2% for each additional 330 feet.
- E. Capable of operation within -15% to +10% of nominal voltage rating and automatically adapt for 50 or 60 Hz.
- F. Capable of supplying 300% of rated full load current for 60 seconds at maximum ambient temperature.
- G. The SCRs shall have a minimum P.I.V. rating of 1400V. Lower rated SCRs with “protection” by MOVs will not be acceptable.

2.04 ADJUSTMENTS AND CONFIGURATIONS

- A. All dialog functions, display units, remote functions, terminal blocks, configuration switches and adjustment potentiometers shall be accessible on the front of the control module. Exposure to control circuit boards or electrical power devices during routine adjustments shall be prohibited.
- B. Dialog indication shall provide, as a minimum, the following conditions:
 - 1. Soft start ready for start
 - 2. Soft start starting/stopping motor
 - 3. Soft start running at full voltage
 - 4. Thermal pre-alarm condition
 - 5. Thermal fault
 - 6. Soft start internal fault
 - 7. Power supply fault
- C. Dip switches shall be used for configuring the soft start and will select:
 - 1. Manual or automatic reset
 - 2. Freewheel or controlled stopping
 - 3. Stop by deceleration ramp or DC injection braking
 - 4. Full voltage boost on start (on or off)
- D. Potentiometers or keypads shall be used for adjusting the operating parameters and will provide:
 - 1. Motor full load amps adjustable from 50 to 100% of the controller’s current rating.
 - 2. Current limitation on starting adjustable from 2 to 5 times rated motor current.
 - 3. Voltage ramp adjustable from 1 to 30 seconds.
 - 4. Deceleration ramp or DC injection time adjustable from 2 to 60 seconds.
- E. Output relays shall provide the following status indications:
 - 1. Fault trip or soft start: one form A and one form B minimum.
 - 2. Thermal pre-alarm: one form A and one form B or one form C minimum.
 - 3. End of start (voltage ramp complete and current below 130% motor FLA): one form A.
 - 4. Brake (for control of braking contactor if this function is specified): one form A.

- F. Relay functions listed above must be isolated with respect to common.

2.05 PROTECTION

- A. A microprocessor controlled thermal protection system shall be included which continuously calculates the temperature-rise of the motor and soft start and provides:
 - 1. An overload pre-alarm which indicates by relay contact that the motor has exceeded its rated temperature rise by 100%. This function shall be annunciated only without resulting in fault trip of the motor.
 - 2. A thermal fault condition which stops the motor if the temperature-rise exceeds 120% of the motor thermal capability.
 - 3. An analog electronic circuit with a time constant adjustable to the motor's thermal cooling time constant ensuring the memorization of the thermal state even after power supply disconnection or shorting out of the power semiconductors.
- B. The soft start shall have phase loss, phase unbalance and undervoltage protection.

2.06 CONTROL OPTIONS

- A. Provide lockable disconnecting means to isolate the SSMC from incoming power. Disconnect may be either fused or circuit breaker style as shown on the contract drawings.
- B. Provide lights, pushbuttons, selector switches, indicators, run time meters, and other accessories as shown on the contract documents. These accessories are to be full size, NEMA 4 rated, heavy duty type. Lights are to be 120 VAC, transformer style, LED, with push-to-test feature.
- C. Control relays are to be plug in style, 120 VAC, provided with DIN rail mounting sockets and shall have an indicating light to show when relay is energized. Contact sets to be rated at minimum 5 amps, 250 VAC.
- D. Provide a control power transformer, 480:120V, sized to accommodate all the control circuit requirements in addition to 25% spare capacity.
- E. The soft start shall accept control logic either by operator devices (push buttons, selector switches, etc.) wired directly into the unit or from external relay logic.
- F. Provide warning label in accordance with the NEC if power is available from more than one source.
- G. Provide nameplates identifying all panel mounted equipment and operator controls.

2.07 SHORTING CONTACTOR

- A. A microprocessor shall control the operation of the shorting contactor via an output relay.

- B. The shorting contactor shall close, shorting the thyristors after the motor current is below 130% of motor FLA and voltage is below nominal voltage (indicating the acceleration ramp is complete), and open on a stop command to allow a deceleration ramp or DC injection stop.
- C. Overload protection shall continue to protect the motor when shorting is used.

2.08 BRAKING CONTACTOR

- A. If required by contract drawings, a microprocessor shall control the operation of the braking contactor via an output relay.
- B. If an overload condition occurs during the injection brake period, braking shall continue as set. When braking is complete, restart shall be prohibited until the motor has cooled.

2.09 ISOLATION AND BYPASS CONTACTORS

- A. If required by contract drawings, provide NEMA rated three-pole isolation contactor to completely isolate the SSMC from the incoming power in the event of a shorted SCR or another defined fault condition.
- B. If required by contract drawings, provide NEMA rated three-pole reversing style contactor to both isolate the output of the SSMC as well as allow across-the-line starting of the motor.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Mount the SSMC in accordance with manufacturer's recommendations.
- B. Provide sufficient clearance for air circulation and operation of any vent fans or cooling equipment.
- C. Install conduit, pull and terminate all power and control conductors.

3.02 TESTING

- A. Test in accordance with contract documents.

3.03 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End Of Section

SECTION 16495

AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Automatic transfer switch shall be furnished and installed, as indicated on the Drawings, with full load current rating as indicated on the Drawings. The switch shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in a non-ventilated enclosure. Withstand current rating shall be as indicated on the Drawings.

1.02 SUBMITTALS

- A. Contractor shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with requirements of the Contract Documents.

PART 2 - PRODUCTS

2.01 AUTOMATIC TRANSFER SWITCH

- A. The automatic transfer switch shall be of the time delay neutral, open transition, break-before-make type. The automatic transfer switch shall have the following capabilities:
 - 1. Adjustable time delay for generator start
 - 2. Adjustable time delay transfer to generator
 - 3. Adjustable time delay in "off" position
 - 4. Adjustable time delay re-transfer to normal power
 - 5. Adjustable time delay for generator stop
 - 6. The switches shall be capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
- B. The normal and standby contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and standby positions without the use of hooks, latches, or magnets, and shall be silver alloy protected by arcing contacts, with magnetic blowouts on each pole. Parallel main contacts are not acceptable.
- C. The transfer switch shall be equipped with a manual operator that is designed to prevent injury to personnel if the electrical operator should become energized during manual transfer.
- D. The transfer switch, complete with all accessories, shall be listed by UL under Standard UL-1008.

- E. The transfer switch shall be ASCO or shall be supplied with the standby generator.
- F. The transfer switch operation shall be selectable by the Operator. In the Manual mode, the Operator shall be able to transfer the load to the generator using a selector, toggle, or pushbutton switch. In the Automatic mode, the internal logic shall sense loss or presence of utility power, and transfer the load to or from the generator.

2.02 ACCESSORIES

- A. The transfer switch shall be equipped with the following:
 - 1. Nominal 0.5 to 5 second time delay to override momentary normal source outages and delay all transfer and generator starting signals.
 - 2. An adjustable time delay with a minimum of 5 minutes for controlled timing of transfer of loads to standby power source to allow for adequate motor shutdown.
 - 3. Field adjustable 0 to 31 minutes time delay to retransfer to normal source with 5 minute unloaded running time of standby plant. A switch shall be provided to bypass this feature with transfer to normal source made manually. Time delay shall be nullified if standby power fails and normal power is available.
 - 4. Differential protection on 3 phases. Dropout and pickup.
 - 5. Test switch.
 - 6. Auxiliary contacts which close in normal position. Two sets of Form C contacts shall be provided.
 - 7. Auxiliary contacts which close in standby position. Two sets of Form C contacts shall be provided.
 - 8. Pilot lights: indicating normal and standby switch position.
 - 9. Manual and automatic selector switch.
 - 10. Manual and automatic pilot lights with push-to-test.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Transfer switch shall be installed, in accordance with the manufacturer's recommendations.

3.02 INSTALLATION TESTING

- A. When conducting temperature rise tests in accordance with UL-1008, the manufacturer shall include post-endurance temperature rise tests to verify the ability of the switches to carry full rated current after completing the overload and endurance tests.
- B. On completion of the installation, start-up shall be performed by a factory-trained service representative in the presence of the Owner and the Engineer.

3.03 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16622

STANDBY DIESEL ELECTRIC GENERATOR

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The outdoor standby electric generating system shall be rated for standby service and sized as shown on the Drawings.
- B. The Contractor shall be responsible for obtaining any required air quality permits on behalf of the Owner, posting all public notices, and shall include all associated fees in their bid, listed as separate line items in the schedule of values. The generator vendor shall provide the Contractor with the documentation required for permitting, showing published proof of EPA certification on the engine specified and furnished herein.

1.02 SUBMITTALS

- A. Submit product data in accordance with the Contract Documents.
- B. Submit shop drawings containing actual dimensions, complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated, and will properly function as a unit. Shop drawings shall show proposed layout, anchoring, support and appurtenances, including clearances for maintenance and operations. Shop drawings shall show details of piping connections for fuel.
- C. Submit a complete list of equipment and material, including manufacturer's specifications, performance charts, catalog cuts and installation instructions, and recommended spare parts list. Submit data for each different item of equipment specified, including but not limited to engine, generator, switchgear, automatic transfer switch, vibration isolators, radiator, and other components. The data shall include a complete list of parts and source of supply.
- D. Submit performance test reports in booklet form showing all field tests, and adjustments performed to prove compliance with specified criteria.
- E. Operation and maintenance (O&M) manuals shall describe the step-by-step procedure required for system start-up, operation and routine maintenance. The O&M manuals shall include troubleshooting and repair guidelines, as well as wiring diagrams of the system as installed.
- F. Miscellaneous:
 - 1. Manufacturer's kilowatts output curve and fuel consumption.

2. Manufacturer's transient response data of the complete engine generator set upon 50%, 75%, and 100% block loads at 1.0 pf. Data shall include maximum voltage dips, maximum frequency dips, and recovery time periods.
3. Engine altitude duration curve.
4. Generator motor starting curves showing the voltage dips versus starting KVA.
5. Prototype test certifications showing all components comply with specifications.
6. The following spare parts for the engine generator shall be supplied to the OWNER prior to acceptance of work.
 - a. Two sets of oil filters
 - b. Two sets of heavy duty air filters
 - c. One dozen spare lamps
 - d. Two fuses (for each control circuit)

1.03 MANUFACTURERS

- A. Generator set shall be manufactured by Generac, Onan, Caterpillar, or Cummins

PART 2 - PRODUCTS

2.01 ENGINE GENERATOR SET

- A. The provision of a standby electric generating system shall be rated for standby service as indicated on Drawings and as described in these Specifications, delivered at 0.8 power factor, 480 volts, three phase, four wire, 60 hertz, for ambient air temperature of 50 degrees C, and specifically rated for the operating altitude shown on the Drawings, without exceeding NEMA MG1 - temperature rise limits.
- B. The system shall be a package of:
 1. A diesel engine driven electric plant to provide standby electric power.
 2. Engine mounted control system.
 3. An automatic load transfer switch for switching of the load and control to provide automatic starting and stopping of the engine generator system.
 4. Mounted accessories as specified
 5. Integral fuel and exhaust systems.
 6. All other equipment as required to provide a complete and operable system.
- C. The engine-generator set and all its accessories shall be constructed for outdoor installation and operation all electrical components shall be housed in NEMA 3R enclosures.
- D. All materials, equipment, and parts comprising the units specified herein, shall be new and unused, or current manufacture and of the highest grade.
- E. The engine, generator and all major items of auxiliary equipment shall be manufactured in the U.S. by manufacturers currently engaged in the production of such equipment. The unit shall be factory assembled and tested by the engine manufacturer and shipped

to the job site by his authorized dealer having a parts and service facility in the area. The performance of the electric plant shall be certified by manufacturer as to the plant's full power rating, stability and voltage and frequency regulation, and field load tested at site.

- F. The units offered under these Contract Documents shall be covered by the manufacturer's standard warranty, or guarantee, on new machines, and shall be a minimum of two years after the date of substantial completion.

2.02 ENGINE

- A. The engine shall be water cooled in-line, or Vee-type compression ignition diesel, designed to operate on No. 2 fuel oil. Diesel engines requiring premium fuels will not be considered. The engine shall be equipped with fuel, lube oil, and intake air filters; lube oil coolers, fuel transfer pump, fuel priming pump, and gear driven water pump.
- B. The engine governor shall maintain frequency regulation not to exceed 1 percent from no load to full rated load.
- C. The unit shall be mounted on a structural steel sub-base and shall be provided with suitable vibration isolators.
- D. Safety shut-offs for high water temperature, low oil pressure, overspeed, and engine overcrank shall be provided. An engine-mounted radiator with blower type fan shall be sized to maintain safe operation at specified ambient temperature. The radiator shall be equipped for a duct adapter flange. Air flow restriction from the radiator shall not exceed 0.5 inch of water.
- E. The engine cooling system shall be filled with a solution of 30 percent ethylene glycol.
- F. Provide a Critical Grade type silencer as manufactured by Kittel, Maxim, or GT Exhaust Systems, including stainless steel flexible exhaust fitting, properly sized and installed, according to the manufacturer's recommendation. Mounting shall be provided as part of the generator set assembly. Silencer shall be mounted so that its weight is not supported by the engine. Exhaust pipe size shall be sufficient to ensure that measured exhaust back pressure does not exceed the maximum limitations specified by the generator set manufacturer. Noise attenuation shall limit the exhaust note to 85dBA within 15 feet of the exhaust stack.
- G. Exhaust piping shall have stainless steel automatic exhaust cap, and shall be coated with not less than 6 mils of inorganic zinc after sandblasting to "white metal".
- H. The fuel storage tank shall be a subbase type, with integral secondary containment, gauges, piping, fittings, and valves shall be supplied as part of the generator set. The fuel storage tank shall be aboveground and an integral part of the generator. The fuel tank shall be U.L. listed.

- I. The tank shall be provided with a level gauge in the primary tank, and leak detection in the secondary tank capable of producing low level and leakage alarm.
- J. The tank shall be of sufficient capacity to run the generator set at full load for 12 hours.
- K. The level gauges shall be Liquidometer industrial type as manufactured by Hersey Products Company, Petro-Meter Company, or equal.
- L. An engine-mounted fuel filter, fuel pressure gauge, and engine fuel priming pump shall be provided.
- M. A DC electric starting system with positive engagement drive shall be furnished.
- N. Fully automatic generator set start-stop controls in the generator control panel shall be provided. Controls shall provide two auxiliary contacts for activating accessory items. Controls shall include a 30 second cranking cycle limit with lockout. (Three 10 second cranks or a single 30 second crank.)
- O. A unit mounted thermal circulation type water heater shall be furnished to maintain engine jacket water to 90 degrees F in an ambient temperature of zero degrees F. The heater shall be single phase, 60 hertz, and 120/240 volts. Heater shall be Chromalox, General Electric, or equal.
- P. A lead-acid storage battery set of the heavy-duty diesel starting type shall be provided. The battery set shall be of sufficient capacity to provide for 1-1/2 minutes total cranking time without recharging and shall be rated no less than 220 amp-hours. A battery rack and necessary cables and clamps shall be provided as part of the generator set.
- Q. A current limiting battery charger shall be furnished to automatically recharge the batteries. The charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressers, DC ammeter, DC voltmeter and fused AC input. Amperage output shall be no less than 10 amperes.

2.03 GENERATOR

- A. The generator shall be a 4-pole or 6-pole revolving field type with static exciter and magnetic amplifier or SCR voltage regulator. No commutator or commutator brushes shall be allowed. Class F insulation shall be used on the stator and rotor, and both shall be further protected with 100 percent epoxy impregnation and an overcoat of resilient insulating material to reduce possible fungus and/or abrasive deterioration. The starter shall be directly connected to the engine flywheel housing, and the rotor shall be driven through a semi-flexible driving flange to insure permanent alignment. Voltage regulation shall be within plus or minus 2 percent of rated voltage, from no load to full-load. The instantaneous voltage dip shall be less than 15 percent of rated voltage when full load and rated power factor is applied to the generator. Recovery to stable operation shall occur within 5 seconds. Stable or steady-state operation is defined as

operation with terminal voltage remaining constant within plus or minus one percent of rated voltage. A rheostat shall provide a minimum of plus or minus 5 percent voltage adjustment from rated value. Temperature rise at full-load determined by resistance shall be within rating as defined by NEMA MG-1.

- B. The specified standby kW shall be for continuous electrical service during interruption of the normal utility source.
- C. These ratings must be substantiated by manufacturer's standard published curves. Special ratings or maximum ratings are not acceptable.
- D. A generator mounted vibration isolated 14 gauge steel control panel shall be provided.
- E. Control panel shall be microprocessor-based, and shall provide the following features:
 - 1. Voltmeter, 3-1/2 inch, 2 percent accuracy
 - 2. Ammeter, 3-1/2 inch, 2 percent accuracy
 - 3. Voltmeter/Ammeter phase selector switch
 - 4. Frequency meter, 3-1/2 inch, dial type
 - 5. Automatic starting controls
 - 6. Panel illumination lights and switch
 - 7. Voltage level adjustment rheostat
 - 8. Engine oil pressure gauge
 - 9. Engine water temperature gauge
 - 10. Dry contacts for remote alarms wired to terminal strips for the following:
 - a. Run status
 - b. Trouble alarm
 - c. Fault alarm
 - 11. Fault indicators for low oil pressure, high water temperature, overspeed, and overcrank
 - 12. Four position function switch marked AUTO, MANUAL, OFF/RESET, and STOP
 - 13. Battery charge rate ammeter if not furnished on separate charger
 - 14. Running time meter
- F. A generator mounted main line molded case circuit breaker shall be installed as a load circuit interrupting and protection device. It shall operate both manually for normal switching function and automatically during overload and short circuit conditions.
- G. Generator exciter field circuit breakers do not meet the above electrical standards and are unacceptable for line protection.
- H. Provide a sign at the service entrance equipment indicating type and location of standby power generator per NEC.

2.04 PANELBOARD

- A. The generator system shall be equipped with a 120/240 volt, single phase, 50 amps minimum distribution panelboard. Higher amperage rated panelboards shall be provided if required by the system. The panelboard shall be UL67 listed. Buses shall be copper.
- B. The panelboard shall be mounted where fully accessible. The panelboard enclosures shall be NEMA 3R unless installed inside the generator system's weatherproof housing. The minimum interrupting capacity of any device shall be 10,000 minimum unless indicated otherwise on Drawings.
- C. All devices requiring power inside the generator system shall be prewired to the panelboard in accordance with NEC requirements. Provide grounding per NEC, and Section 16170 of the Specifications.
- D. Panelboards shall be as manufactured by Square D, Cutler Hammer, or Siemens.

2.05 WEATHERPROOF SOUND ATTENUATING ENCLOSURE

- A. Provide a sound attenuating weatherproof enclosure for the engine, and associated components.
 - 1. Enclosure shall have fully gasketed doors for access to all portions of the generator that required any maintenance. All doors to have rain molding above door opening, stainless steel hinges and a two point latch to allow the doors to be completely removed. Handles to be the key locking type.
 - 2. Enclosure roof, walls and doors shall contain ½ inch deep support ribs with 16 gauge minimum exterior steel with interior sound attenuating insulation. Insulation shall consist of minimum #6 density wool held in place with a perforated liner.
 - 3. Provide fixed louvers with a screened cover over air openings sized as required for proper air flow.
 - 4. The enclosure shall have a steel base channel constructed to drop over the generator set with anchor boltholes for fastening to a concrete slab.
 - 5. Maximum sound levels emitted from the generator set shall not exceed the requirements of all local governing authorities or 65 dB at 7m (21 feet) from the perimeter wall, whichever is the most stringent.
 - 6. Provide 100 amp electrical distribution panel wired to generator set accessories with interior light package.
 - 7. Provide a stainless steel exhaust flex.
 - 8. Provide a roof mounted critical silencer, tail pipe, rain cap.
- B. All seams shall be caulked with a sealer prior to painting. Paint exterior surfaces of equipment with two coats of acceptable UV, oil, and heat-resistant paint, applied after surfaces have been thoroughly cleaned and prepared with suitable priming coat.

PART 3 - EXECUTION

3.01 FACTORY TESTS

- A. Before the equipment is installed, a factory certified test log of the generator set showing a minimum of $\frac{3}{4}$ hour testing with $\frac{1}{2}$ hour at 100 percent rated load, continuously, shall be submitted to the ENGINEER.

3.02 FIELD TESTS

- A. Test in accordance with contract documents.

3.03 INSTALLATION

- A. The generating system shall be installed as indicated on the Drawings, per manufacturer's recommendations and shall meet all applicable codes and regulations.

3.04 START-UP

- A. On completion of the installation, start-up shall be performed by a factory-trained dealer service representative.
- B. This generating system shall be full-load tested at site in the presence of the ENGINEER for a period of 8 hours, with supplier providing necessary resistive load banks. Any defects which become evident during this test shall be corrected by the CONTRACTOR at his own expense.
- C. After installation the tank shall be filled with No. 2 fuel oil. The tank shall be refilled after the 8-hour on-site test.

3.05 GROUNDING

- A. Provide grounding as shown on the Drawings, and as per NEC.

3.06 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 16904

VARIABLE FREQUENCY DRIVES – LOW VOLTAGE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Variable Frequency Drive (VFD) systems rated 480 VAC or lower.

1.02 VFD FEATURES

A. The VFDs shall be provided with the following features:

1. Fused control circuit transformer.
2. Provision for 4 to 20 mA input speed reference signal.
3. Electrically isolated auxiliary contacts for ready, running, and trouble status.
4. Adjustable minimum/maximum frequency limits.
5. Independent timed linear acceleration and deceleration.
6. Adjustable motor slip compensation based on motor current.
7. Terminal blocks for control and signal wires entering and leaving the controller.
8. Output transistors shall be insulated gate bipolar transistors (IGBT) type, or Darlington pair.
9. Current limit.
10. Programmable automatic restart.
11. 4 to 20 mA output signal proportional to VFD output frequency.
12. Digital keypad for configuration, programming, local control, and monitoring.
13. Microprocessor-based control for system logic sequencing functions.
14. VFD shall have a minimum 12-pulse input circuit designed to reduce harmonic distortion.

1.03 FUNCTIONAL REQUIREMENTS

- A. **SUPPLY POWER:** The VFD shall operate continuously with supply power of 460 volts plus or minus 10 percent, 60 hertz plus or minus 3 percent. The VFD shall remain on line and operate without damage to either the VFD or its connected load during a supply power variation of plus 50 percent lasting for a period of up to 0.01 seconds and minus 100 percent lasting for a period of up to 0.5 seconds.
- B. **AMBIENT CONDITIONS:** The VFDs shall operate continuously as specified in an ambient temperature of 0 to +40 degrees C and an ambient humidity of 0 to 90 percent, non-condensing. Provide air conditioning as required to maintain the VFD manufacturers' maximum ambient temperature rating.
- C. **LOAD:** The VFD system shall be capable of 110% continuous current overload. Variable torque inverters shall be capable of delivering 120 percent of the specified load

for up to 60 seconds, and constant torque inverters shall deliver 150 percent overload current for 120 seconds.

- D. **POWER FACTOR:** Displacement power factor shall be not less than 0.95 at rated full speed and load. Overall power factor, including harmonic distortion, shall be 0.85, or greater. Contractor shall provide power factor correction components as necessary to meet this requirement.
- E. **EFFICIENCY:** Efficiency of VFD systems shall be at least 96 percent at 60 hertz output driving the specified maximum load.
- F. **FREQUENCY AND VOLTAGE REGULATION:** VFD output frequency shall be regulated to within 0.6 hertz of the frequency set point. VFD output voltage shall be regulated to within ± 1.0 percent of that value which will produce minimum motor heating at any operating frequency within the specified range.
- G. **FREQUENCY RANGE:** VFD shall be capable of continuous operation with the specified load at any frequency between 0.1 hertz and 60 hertz.
- H. **SPACE:** VFD system size shall not exceed the size allotments specified on the Drawings, nor shall any portion of the VFD system exceed a height of 90 inches. VFD system shall be front accessible and shall not require rear access. The VFD equipment shall be suitable for mounting directly against the wall without any clearance for ventilation or other purposes. VFD units shall be arranged as required for entry of incoming line cables and as required for entry of load cables.
- I. **AMBIENT NOISE:** Free field noise generated by the VFD shall not exceed 85 dB at 3 feet out from any point on the VFD cabinet under any normal operating condition.
- J. VFD shall operate at an elevation of 5650 feet above sea level.

1.04 PROTECTION AND ANNUNCIATION

- A. **OVERCURRENT PROTECTION:** The VFD system shall provide electronic current limit at 150 percent of motor nameplate current. Current limit shall be accurate to within 1.0 percent and shall smoothly limit motor speed at whatever value is necessary to limit motor current to that value.
- B. The VFD shall also provide motor running overcurrent protection in compliance with NFPA 70.
- C. **SHORT CIRCUIT PROTECTION:** The VFD shall be fully protected against load faults. Bolted faults, phase to phase, or phase to ground shall not damage the unit. Any impedance or other current limiting necessary to meet this requirement shall be provided as part of the VFD system, and any losses caused by current limiting devices shall be included in efficiency calculation for the VFD system.

- D. LINE VOLTAGE: The VFD shall be protected against high and low line voltage on one or more phases.
- E. INTERNAL FAULTS: The VFD shall incorporate an internal fault monitoring system to detect malfunctions. This system shall be designed to protect the VFD from transient and sustained faults, and to limit damage that may be caused by these faults.
- F. OVERTEMPERATURE: Overtemperature circuitry shall shut down the VFD upon overheating, and display an overtemperature alarm, or message.
- G. DIAGNOSTICS: The VFD shall be provided with a fault diagnostics system that indicates the cause of any shutdown. The system shall store faults in memory and discard the oldest faults as new ones fill the memory. Faults shall be accessible via a digital keypad, also used for local control and programming.

1.05 EXTERNAL CONTROL AND MONITORING

- A. SPEED REFERENCE: The VFD shall accept a 4 to 20 milliampere direct current speed reference signal. Speed reference input shall be galvanically isolated and input resistance shall not exceed 250 ohms.
- B. READY SIGNAL: The VFD shall provide a contact closure that indicates that the controller line power supply is within acceptable tolerances, the control circuits are normal, and there are no internal or external fault conditions that have not been reset. Presence of this signal indicates that the controller should start normally.
- C. RUNNING SIGNAL: The VFD shall provide a contact closure which indicates that the controller is running.
- D. SYSTEM TROUBLE: Isolated normally open contacts for remote fault annunciation shall be provided and wired to terminal blocks, which shall be labeled and identified. Contact shall close under fault conditions. Fault conditions that drive the outputs shall be selectable from the digital keypad.
- E. The VFD control circuitry shall shutdown the VFD if the motor overheats. Motor winding temperature switches, or RTDs, shall be connected if provided by the motor manufacturer.

1.06 QUALITY ASSURANCE

- A. This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
IEEE 519-1992	Guide for Harmonic Control in Electric Power Systems

NEMA 250-85	Enclosures for Industrial Control and Systems
NEMA ICS 2-83	Industrial Control Devices, Controllers and Assemblies
NEMA ICS 3-83	Industrial Systems
NFPA 70-87	National Electrical Code (NEC)
Underwriters Laboratories	UL 508

- B. The VFD shall comply with the applicable requirements of NEMA ICS 3 and additional standards referenced by ICS 3.
- C. The VFDs specified in this section shall be the product of a single vendor. The Contractor shall assign unit responsibility for the adjustable frequency drives in this section. The Contractor shall submit letters of certification with the shop Drawings from the VFD manufacturer, the motor manufacturer, and the driven equipment manufacturer stating that they have reviewed each application and that the combination will satisfy the application duties required, for the actual motor sizes required, regardless of deviations from the scheduled "nominal horsepower".
- D. VFD manufacturing facility shall be ISO 9001 certified.

1.07 SUBMITTALS

- A. The following information shall be provided in accordance with the Contract Documents:
 - 1. Catalog and technical data.
 - 2. Outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.
 - 3. External connection wiring diagram showing function and identification of all terminals requiring field connections.
 - 4. Line harmonic distortion calculations and filter design if applicable.
 - 5. Component fabrication Drawings consisting of detailed circuit schematics, printed circuit board Drawings, and chassis layouts for all electrical and electronic components.
 - 6. Manufacturer's certification that VFD can withstand fault conditions specified in paragraph 16904-1.04.
 - 7. Manufacturer's certification that VFD can withstand environmental conditions specified in paragraph 16904-1.04.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. The VFDs shall be manufactured by Baker Hughes – Centrilift, Cutler Hammer, or Square D.

- B. AC reactors shall be TCI, MIRUS, Powersmiths, or equal.

2.02 ENCLOSURES

- A. Enclosures shall be as shown on the Drawings, with force ventilated gasketed enclosures. UL approved Class 1 filters shall be provided on ventilation openings. Cabinets shall be fabricated from 14 gauge minimum thickness sheet steel. Cabinet shall be provided with an interior frame or otherwise formed so as to provide a rigid structure. Doors shall be hung on removable-pin hinges and equipped with vault-type latch capable of accepting a 3/8-inch-shackle padlock. Three-point latch hardware shall be provided. Door width shall not exceed 30 inches.

2.03 INVERTER

- A. A door interlocked power disconnecting means shall be provided to protect the inverter against internal faults and as a backup for external load faults. Load faults shall normally be cleared by the inverter assembly.
- B. Harmonic filtering shall be provided on each VFD to reduce total harmonic distortion (THD) of the voltage and current power source. Total voltage and current harmonic distortion, including contribution of notching, and with all VFDs in operation shall not exceed the limits set forth for a general system in IEEE 519-1992, Tables 10.2 and 10.3. The point of common coupling (PCC) is defined herein as the circuit breakers feeding each VFD, or where each VFD connects to the bus.
- C. AC reactor coils in output circuitry of the VFD shall be provided to limit inductive switching surges such that the measured RMS voltage at the motor terminations does not exceed 480 VAC line to line.
- D. Provide EMI/RFI filtering to eliminate radio interference between 10KHZ and 30MHZ.

2.04 CONTROL DEVICES

- A. The following control devices shall be front mounted on the VFD enclosure:
 - 1. Digital keypad.
 - 2. Manual/remote speed control selector switch.
 - 3. VFD run light.
 - 4. Inverter ready light.
 - 5. Inverter fault light
- B. Control devices shall be as specified herein. Indicating lamps shall be high intensity colored LED type with clear lenses.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

- A. Each VFD shall be installed by the Contractor and commissioned by a trained technician in accordance with the manufacturer's specifications and the Contract Documents. The installation shall be certified in writing by the manufacturer's representative. Submit written documentation to the Engineer for review within seven days of commissioning.

3.02 TESTING

- A. Test in accordance with contract documents.

3.03 TRAINING

- A. Provide four (4) hours of VFD training for the Owner's Operations and Maintenance Staff. Training shall be certified on forms provided in the Contract Documents. Training shall cover VFD theory of operation, features and functions available, normal operation, troubleshooting, and routine maintenance. The Contractor shall submit a syllabus for the training session for approval, within 3 weeks of conducting the class. Provide each attendee with a class syllabus detailing each topic to be discussed.

3.04 SPARE PARTS

- A. The following spare parts shall be supplied with each type, or frame size, of VFD:
 - 1. Three sets of all replaceable fuses
 - 2. One of each color pilot light

3.05 WARRANTY

- A. Refer to ACWWA Electrical and Instrumentation Design Standards for warranty information.

End of Section

SECTION 17111
FLOAT SWITCHES

PART 1 - GENERAL

1.01 SCOPE

- A. This section includes furnishing all float switches as indicated on the drawings and specified herein.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer prior to installation:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 BALL TYPE FLOAT WITH INTEGRAL SWITCH AND ATTACHED CABLE.

- A. Float switch shall be direct acting and consist of a 316 type stainless steel housing, mounting clamp, a flexible three-conductor cable with a synthetic rubber jacket and a mercury switch. The float housing shall be a sphere of at least 4 1/2 inches in diameter.
- B. The switch shall be embedded in a metal housing inside the float. The cable shall be 3/C #14, "SO" TYPE with 105 strands per conductor, made specifically for underwater use and heavy flexing service.
- C. The switch shall be connected to two of the three conductors of the cable. The third conductor shall be an internal ground and shall be colored green. The switch shall have a 20 ampere rating at 115 volts AC.

- D. An additional synthetic rubber jacket shall act as a hinge between the float and where the cable is held by the stationary clamp. This clamp shall be stainless steel with an adapting fitting and two yokes for mounting on a vertical 1-inch pipe.
- E. A liquid rise of 1 inch from the reset position shall operate the float switch, and reset shall occur when the liquid level drops to 1 inch. Operating temperature shall be 0 degrees F to + 180 degrees F.
- F. Weight and buoyancy shall be such that contaminants like a cake of grease will not result in the float switch changing operating level more than 1 inch.
- G. A cast aluminum, NEMA 4 junction box shall be supplied for termination of the float cable(s), to allow conventional wiring and conduit to be run from the junction box to a control panel. It shall have terminal blocks for the required number of circuits and shall accept sealed fittings furnished with the float switch.
- H. Float switches shall be as manufactured by US Filter Model 9G-EF, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified and as shown on the drawings. Contractor shall coordinate with Mechanical and Structural for optimum location of float switches.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications.

End of Section

SECTION 17120

PRESSURE TRANSMITTERS

PART 1 - GENERAL

1.01 SCOPE

- A. This section includes furnishing Pressure Transmitters as shown on the Drawings and specified herein.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer prior to installation:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. Pressure transmitter manufacturers shall be Endress & Hauser, Ashcroft, Setra or Rosemount.

PART 2 - PRODUCTS

2.01 PRESSURE TRANSMITTER

- A. Provide pressure transmitters with 1/2 inch NPT process connection, block and bleed valve, and local LCD indicator scaled in engineering units.
- B. Transmitters shall be of a two-wire type, 24 VDC powered, producing a 4 to 20 mA output proportional to the calibrated pressure range of the instrument. Transmitters shall be capable of driving a 500 ohm loop load.

- C. Instrument accuracy shall be within plus or minus 0.5 percent of span, and a 0.2 percent repeatability. Dead band shall be within 0.1 percent of span.
- D. Transmitters shall have external zero and span adjustment for field calibration. Instrument enclosure shall be NEMA 4, with 316 stainless steel wetted parts.

EXECUTION

2.02 INSTALLATION

- A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations, and as shown on the Drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

2.03 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

End of Section

SECTION 17121

PRESSURE SWITCHES

PART 1 GENERAL

1.01 SCOPE

- A. This section covers Pressure Switches and Differential Pressure Switches as shown on the Drawings.
- B. Refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for and guarantee performance of the equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the equipment.
- B. Reference standards shall be the latest edition, including addenda, supplements and revision. Applicable reference publications include the following:

NEC
NEMA

1.03 SUBMITTALS

- A. Submit product information cut sheets containing manufacturer's specifications, Operations and Maintenance data, instrument enclosure type, installation location, and process pressure range to be supplied. Indicate product part number in full.
- B. Provide submittals in accordance with the Contract Documents.

PART 2 PRODUCTS

2.01 PRESSURE SWITCHES

- A. Pressure switches shall be capable of dual control with independent set points and adjustable deadbands. Differential pressure switches shall be capable of single control with adjustable set points and adjustable deadband. Switches shall be snap action, single-pole, and double-throw switching elements with an electrical rating of at least 10 amperes at 120 VAC. Pressure switches shall be enclosed in a NEMA 4 or weatherproof housing.

- B. Operating pressures and set points shall be determined in the field, unless otherwise indicated on the Drawings.
- C. Set points shall be fully adjustable and shall be in the middle of the working range. Set point adjustments shall be made with adjustment screws or thumbwheels. Accuracy shall be plus or minus one percent of adjustable range.
- D. For pressures up to 150 PSIG pressure sensing element shall be of the diaphragm or bourdon tube type, and shall have a proof pressure of at least twice the maximum working pressure. For pressures above 150 PSIG, sensing element shall be bourdon tube type. Diaphragms or bourdon tubes shall be stainless steel.
- E. Pressure switches shall be installed with individual ball valves for isolation. Valve material shall be compatible with the process piping and process fluid. In addition, process piping up to the sensor shall be insulated to protect against freezing.
- F. Pressure switches shall be as manufactured by United Electric or Mercoid Controls DA Series.
- G. Differential pressure switches shall be as manufactured by United Electric or Mercoid Controls DPA Series.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified and shown on the drawings. Contractor shall coordinate with Mechanical and Piping to insure proper connection to piping and/or other mechanical equipment.

3.02 ACCEPTANCE

- A. As a condition precedent to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17122

LEVEL TRANSMITTERS - PRESSURE TYPE

PART 1 - GENERAL

1.01 SCOPE

- A. This section includes furnishing Level Transmitters as shown on the Drawings and specified herein.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. Level transmitter manufacturers shall be Rosemount, Foxboro, or ABB.

PART 2 - PRODUCTS

2.01 LEVEL TRANSMITTER

- A. Transmitters shall be of a two-wire type, 24 VDC powered by the signal loop, producing a 4 to 20 mA output proportional to the calibrated pressure range of the instrument. Transmitters shall be capable of driving a 500 ohm loop load.
- B. Instrument accuracy shall be within plus or minus 0.5 percent of span, and a 0.2 percent repeatability. Dead band shall be within 0.1 percent of span.

PART 3 - EXECUTION

A. INSTALLATION

- B. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations, and as shown on the Drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.
- C. In areas prone to freezing, wrap all wetted parts of the instrument and piping with insulating material. Provide access to bleed valves and pipe fittings.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

End of Section

SECTION 17123

ULTRASONIC LEVEL TRANSMITTER

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the Ultrasonic Level Transmitters and Controllers to be provided where indicated on the Drawings.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 ULTRASONIC LEVEL CONTROLLER

- A. The ultrasonic level controller system shall be comprised of a transmitter in a NEMA 4X housing, an ultrasonic transducer, and cabling. The system shall be of the non-contact type for continuous measurement and control of liquid and solid levels.
- B. The transmitter shall include a front panel mounted, 4 digit LCD indicator, scaleable in engineering units. The transmitter shall provide a 4-20 mA DC analog output signal which is proportional to level. The unit shall also have 5 form 'C' SPDT relays assignable for level control, totalizing, sampling, and alarming. The LCD shall provide messages for loss of echo, and cabling trouble. The transmitter shall be designed to operate from -20 degrees C to +50 degrees C.

- C. The transducer shall be encapsulated in chemical and corrosion resistant material, such as Kynar, Teflon, or TEFZEL, and be capable of operating from -40 degrees C to +73 degrees C. The unit shall be ambient temperature compensated. The transducer shall be compatible with the level range as indicated on the Drawings, and shall operate with up to 1200 feet of separation from the transmitter.
- D. The transducer shall be capable of measuring a span of up to 33 feet. The span and range shall be set in the field. Accuracy shall be +/-0.25 percent of range.
- E. The system shall operate on 120 VAC, and shall be Endress & Hauser, Siemens Milltronics HydroRanger, or equal.
- F. Differential level controllers, where indicated on the Drawings, shall be Siemens Milltronics MultiRanger Plus, or equal.

2.02 ULTRASONIC LEVEL TRANSMITTER

- A. Where ultrasonic measurement is indicated on the Drawings, but relay control is not required, and the measurement span is less than 16 feet, Flowline or Endress Hauser, Prosonic shall be used.
- B. Power requirement shall be 24 VDC, and a 2-wire shielded cable with 600-volt insulation, and 16 AWG conductors with a tinned drain wire shall be provided.
- C. The instrument shall have a measurement range of 0.8 to 16.4 feet. Accuracy in air shall be 0.25% of range with built-in temperature compensation. Operating temperature shall be -20 to +60 degrees C.
- D. Output shall be 4-20 mA into 750 ohms. A status relay contact shall close on loss of echo, internal failure, or loss of power to the instrument.
- E. All mounting hardware shall be 316 stainless steel, and the instrument enclosure shall be rated NEMA 4.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings. The Contractor shall coordinate the installation with the other trades, to insure proper installation of the transducer, transmitter, and associated conduit and cables.
- B. The Contractor shall calibrate the instruments to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local, or remote monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

3.03 SPARE PARTS

- A. Provide the Owner with a list of the manufacturers' recommended spare parts.

End of Section

SECTION 17124

SUBMERSIBLE LEVEL TRANSMITTER

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the Submersible Level Transmitters to be provided where indicated on the Drawings.
- B. Refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY

- A. Equipment to be furnished under this section shall be the products of companies regularly engaged in the design and manufacture of this type of equipment. Manufacturers shall assume responsibility for, and guarantee performance of, equipment furnished. However, this shall not be construed as relieving the Contractor from their responsibility for the proper installation and functioning of the equipment.
- B. Reference standards. Standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:

NEC
NEMA

1.03 SUBMITTALS

- A. Submit product information cut sheets containing manufacturer's specifications, Operations and Maintenance data, instrument enclosure type, installation location, and process pressure range to be supplied. Indicate product part number in full.
- B. Provide submittals in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 SUBMERSIBLE LEVEL TRANSMITTER

- A. The submersible level transmitter system shall be designed for total submersion, and shall have the following features:
 - 1. Accuracy of +/-0.1% of full scale.
 - 2. Titanium construction.
 - 3. Two-wire, 4 mA output at zero pressure, 20 mA output at full range pressure.
 - 4. Operating pressure ranges from 1 psi to 900 psi, as required by the application.

5. Overpressure rating shall be 4 times the operating pressure range from 1 to 5 psi, and 2 times the range for 10 psi and above.
6. Pressure transducer shall be of the integrated silicon strain gauge bridge type.
7. Transmitter supply voltage shall be 9-30 VDC.
8. Operating temperature shall be -20 to +60 degrees C.
9. Transmitter shall be provided with sufficient cable length to reach terminations at junction box shown on the Drawings. Supply and install instrumentation cable from junction box to RTU.

B. Submersible level transmitter shall be Dynotek, Slimline PTX series.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings. The Contractor shall coordinate the installation with the other trades, to insure proper installation of the transmitter, and associated conduit and cables.
- B. The instrument shall be factory calibrated to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local, or remote monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17134
FLOW SWITCHES

PART 1 - GENERAL

1.01 SCOPE

- A. This section covers flow switches to be furnished as indicated on the Drawings.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance, of equipment furnished. However, this shall not be construed as relieving the Contractor from their responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 FLOW SWITCHES

- A. Flow switches for pump discharge monitoring shall be thermal dispersion type, made of stainless steel, and shall give a no-flow signal when the flow drops below the set actuating flow rate. The flow switch enclosure shall meet NEMA 4 standards. The switch contact output shall be SPDT rated at 4 amps. Flow switches shall be Magnetrol, Thermatel or equal.
- B. Eyewash and shower flow switches shall be stainless steel, installed in the potable waterline, and shall indicate eyewash or shower operation.
- C. Flow switches for pump seal water lines shall actuate at 0.04 gpm to provide an indication of seal water flow to the pump. The lower housing of the switch body shall be brass, and shall be leakproof. The snap switch shall be magnetically actuated. The machined tee flow section, and other wetted parts, shall be stainless steel. An adjustable bypass valve shall set the trip point of the switch. Pipe connections shall be ½ inch NPT. Flow switch shall be Dwyer/Anderson Low Flow Model V6, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed as shown on Drawings.

3.02 GUARANTEE

- A. Contractor shall fully guarantee all work under this section for a period of one year from date of final acceptance by the owner against faulty workmanship and failure or malfunction of materials and/or equipment due to faulty or imperfect workmanship. This guarantee shall be given in writing to the owner at the time of issuing final certificate. Work, materials or equipment found to be defective within this period shall be replaced without cost to the owner.

3.03 ACCEPTANCE

- A. As a condition precedent to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17136

DIRECT DRIVE PROPELLER FLOWMETER

PART 1 - GENERAL

1.01 SCOPE

- A. This section includes furnishing a propeller-type flowmeter as indicated on the Drawings.
- B. Equipment listed for this section includes propeller flowmeter and mechanical digital totalizer mounted on meter head.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 DIRECT DRIVE PROPELLER FLOWMETER WITH MECHANICAL DIGITAL TOTALIZER

- A. The flowmeter shall be designed to operate continuously at any flow rate within the rated range. Meter accuracy shall be $\pm 2\%$ of rate at any flow from the minimum rating to 150% of the maximum rating. The meter shall be wet flow calibrated against a primary standard accurate to $\pm 0.25\%$ or better traceable to the U.S. National Bureau of Standards. Two certified copies of the calibrations taken at or near minimum flow rating, at mid-range and at the highest flow rate within the range attainable by the test facility shall be furnished to the engineer.
- B. The meter head shall be mounted on a flanged connection for ease of removal from the pipe for inspection or service. The meter head shall consist of a cast iron or steel cover

plate, bronze or cast iron gear box, stainless steel Delrin or Hard rubber wetted working parts and polyethylene propeller. The drive mechanism shall be by means of stainless steel gears and shafting. Meter heads which utilize flexible cable drives between the propeller and the readout device will not be accepted. The meter head shall be equipped with a 6-digit straight-reading totalizer protected by an all metal register box and cover with locking hasp.

- C. 2" to 4" meter heads shall be furnished with cast iron tubes lined with stainless steel at the metering section and AWWA flanges. The tubes shall be protected by the manufacturer's standard protective coating. 6" to 36" meter heads shall be furnished with both saddles and straightening vanes or with flanged tubes with integral straightening vanes. The 6" to 36" tubes with straightening vanes shall be fabricated of carbon steel with ANSI flanges. The tubes and straightening vanes shall be lined with a 10 mil minimum coating of neoprene with the outside of the tube protected by the manufacturer's standard protective coating or lined and coated with a 4 mil thick coating of polyurethane. 42" to 72" meter heads shall be furnished with saddles and straightening vanes.
- D. Flow transmitter shall provide a 4 to 20 mA output, and be powered by 24 VDC.
- E. The meters shall be McCrometer, Water Specialties or Sensus Model 101/102, sized per data from drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed as shown on drawings. Contractor shall choose flowmeter, saddle and flange according to materials indicated on applicable drawings and documents.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications.

End of Section

SECTION 17137

MAGNETIC FLOWMETERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the Magnetic Flowmeters to be provided where indicated on the Drawings. The flowmeters shall consist of two parts with manufacturer supplied interconnecting wiring, the field installed flow element and the flow indicating transmitter.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 MAGNETIC FLOWMETERS:

- A. Acceptable Manufacturers:
 - 1. Endress & Hauser
 - 2. Siemens
 - 3. Rosemount
- B. Materials:
 - 1. All mounting hardware shall be 316 stainless steel, the instrument enclosure shall be rated NEMA 4X, the flow sensor liner shall be Polyurethane lined, and the electrode material shall be 316 stainless steel.

C. Design and fabrication

1. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate.
2. Provide flanged end connections per ANSI B16 rated for piping system operating and test conditions.
3. Operating pressure: 100 psi.
4. Operating temperature: 122 Deg F.
5. Grounding requirements:
 - a. Nonmetallic or lined pipe:
 - 1) Inlet and outlet grounding rings of same material as electrode.
 - b. Conductive piping:
 - 1) Conductive path between the meter and the piping flanges.
6. Provide cable between magnetic flowmeter and transmitter.
7. Pulsed DC magnetic field excitation.
8. Automatic zero
9. Adjustable low flow cutoff.
10. 16-character alphanumeric display shall indicate user-defined flow units and total flow. All menu advice and commands shall be viewed on this display.
11. Minimum signal lock (empty tube zero) to prevent false measurement when tube is empty.
12. Accuracy:
 - a. +/- 0.5 percent of rate above 1 fps.
 - b. +/- 0.01 fps below 1.0 fps.
 - c. 4-20 mA DC isolated output into maximum 800 ohms.
 - d. Scaled frequency output, 24 VDC.
 - e. Power supply: 117 V +/- 10 percent, 60 HZ.
 - f. Meter operable as specified in liquids with 5.0 micromho/cm or more conductivity.
13. Electrodes shall be self-cleaning.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings. The Contractor shall coordinate the installation with the other trades, to insure proper installation of the flow element, transmitter, and associated conduit and cables.
- B. The Contractor shall calibrate the instruments to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

3.03 SPARE PARTS

- A. Provide the Owner with a list of the manufacturers' recommended spare parts.

End of Section

SECTION 17150

LIMIT AND POSITION SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes
 - 1. Position switches used to detect security intrusion.
- B. Related Sections
 - 1. General Conditions for testing, adjusting and balancing of systems.

1.02 SUBMITTALS

- A. In accordance with the Contract Documents.
- B. Product Data
 - 1. Product information brochures, catalog cut sheets, other product literature containing manufacturer's specifications, sizes, ratings, enclosure type and details, conditions-of-use, and fully developed part numbers.
- C. Reference standards shall be the latest edition, including addenda, supplements and revision. Applicable reference publications include the following:
 - NEC
 - NEMA
- D. Quality Assurance/Control
 - 1. Manufacturer's instructions for use.

1.03 QUALITY ASSURANCE

- A. Manufacturer must be regularly engaged in the design and manufacture of this type of equipment and shall assume responsibility for and guarantee performance of the equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- 1. Cutler Hammer
- 2. Square D

2.02 GENERAL

- A. Heavy duty, industrial grade units with NEMA rated housings compatible with installation location and environmental conditions. Enclosures to be NEMA 4X unless noted otherwise or provided as part of a packaged system.
- B. Electrical contact sets configured as shown on drawings and rated for 5 amps at 250 volts minimum. Electrical connections maximum #12 AWG copper wire and ½” conduit.
- C. Sensing elements must have provisions for field mechanical adjustment.

2.03 LIMIT SWITCHES - MECHANICAL

- A. Combination switch housing and position sensing lever coordinated with mechanical equipment whose position is to be sensed. Lever sensing arm to be rated for 10,000 mechanical operations.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install and connect as specified and shown on the drawings.
- B. Adjust position sensing elements for reliable and repeatable operation.
- C. Coordinate with Mechanical and other trades to insure proper connection to mechanical or other equipment.

3.02 ACCEPTANCE

- A. Certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17320

CHLORINE RESIDUAL ANALYZER

PART 1 GENERAL

1.01 SCOPE

- A. This section includes furnishing and installing Chlorine Analyzers in the locations indicated on the Drawings and specified herein.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. Chlorine Analyzers shall be manufactured by Hach Analytical Model CL17.

PART 2 PRODUCTS

2.01 CHLORINE ANALYZERS

- A. The analyzer shall use colorimetric DPD chemistry to continuously monitor water for free or total residual chlorine.
- B. The analyzer shall have a sensor input with a 4-20 mA output that can be independently programmed. Two fully programmable alarm relays shall also be included.
- C. The analyzer shall have a LCD 3 digit measurement readout.
- D. The analyzer shall be housed in a NEMA 4X enclosure and shall operate on 115 VAC.

- E. The ambient temperature range will be 41 to 104 deg. F.
- F. Provide mounting hardware and spare parts as recommended by the manufacturer and approved by the OWNER.

2.02 CHLORINE SENSORS

- A. The sensor shall measure the continuous level of total chlorine.
- B. The sensor shall have a measuring range of 0 to 5 ppm (mg/L).
- C. Provide mounting hardware and spare parts as recommended by the manufacturer and approved by the OWNER.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Analyzer and element shall be mounted in a NEMA 4X, wall mount enclosure.
- B. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations, and as shown on the Drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.
- C. The Contractor shall calibrate the instruments to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local, or remote monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

END OF SECTION

SECTION 17330

TEMPERATURE TRANSMITTERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section includes furnishing Temperature Transmitters and Temperature Elements as shown on the Plans and specified herein.
- B. Refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the CONTRACTOR from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the CONTRACTOR shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. Temperature transmitter manufacturers shall be United Electric Controls, Measurement Technologies Limited, Rosemount, or Weed. Temperature element manufacturers shall be Measurement Technologies Limited, Weed, or Watlow.

PART 2 - PRODUCTS

2.01 TEMPERATURE TRANSMITTER

- A. Provide temperature transmitters with 1/2 inch NPT or optional cable gland element connection, and local indicator scaled in engineering units.
- B. Transmitters shall be of a two-wire type, 24 VDC powered, producing a 4 to 20 mA output proportional to the calibrated temperature range of the instrument. Transmitters shall be capable of driving a 600 ohm loop load.

- C. Instrument accuracy shall be within plus or minus 0.5 percent of span, and a 0.2 percent repeatability. Dead band shall be within 0.1 percent of span.
- D. Transmitters shall have external zero and span adjustment for field calibration. Instrument enclosure shall be NEMA 4 (minimum) and NEMA 4X and 7 if required by the area classification, as shown on the plan drawings.

2.02 TEMPERATURE ELEMENTS

- A. Resistance Temperature Detectors (RTD): RTDs shall be 100 ohm platinum, 3-wire, with a temperature coefficient of 0.00385 ohm/ohm-°C.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations, and as shown on the Plans. CONTRACTOR shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the CONTRACTOR shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

End of Section

SECTION 17410
AUTOMATIC DIALER

PART 1 - GENERAL

1.01 SCOPE

- A. This section covers the automatic dialer to voice annunciate alarm conditions over the telephone lines.
- B. Refer to requirements of general conditions for testing and adjusting system.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.
- B. Reference standards. Standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:
NEC
NEMA

1.03 SUBMITTALS

- A. Products shall be submitted to the Engineer:
 - 1. Manufacturer's complete model and part number, product specifications, and installation details.
 - 2. Detail electrical wiring diagrams showing component designation, and rating.
 - 3. Operations and maintenance manuals shall be provided for review, prior to Final Acceptance.

PART 2 - PRODUCTS

2.01 AUTOMATIC DIALER

- A. Furnish the number of output channels as required on the drawings. Each channel shall monitor a normally closed input contact. Upon alarm, the automatic dialer shall dial, over standard dial-up telephone line, the telephone number of designated personnel. When the phone call is answered, the automatic dialer shall identify which alarm condition has occurred, and its location. If the phone call is unanswered, the automatic dialer shall cycle indefinitely through the programmed telephone numbers, until the alarm condition is acknowledged.

- B. The 16 telephone numbers shall be programmable using an integrally mounted keypad. The dialer shall be capable of dialing 24 digits.
- C. The dialer shall have provision to accept incoming calls. The dialer shall, during an incoming call, report the status of its monitored points to the caller.
- D. The dialer shall be powered by 115 volts, 60 hertz, and dialer shall contain its own integrally mounted and wired battery backup. The battery shall be able to operate the dialer for 24 hours during power failure.
- E. The messages transmitted by the dialer shall be electronically recorded, or voice synthesized.
- F. The dialer shall be tested and guaranteed for performance in ambient temperatures 0 to 50 degrees C.
- G. The dialer shall be equipped with alarm channels as indicated on the P&ID Drawings and the schematic diagrams.
- H. Unless specifically indicated otherwise on the Drawings, the automatic dialer shall be enclosed in a NEMA 12 enclosure (if installed indoors) and NEMA 4X enclosure (if installed outdoors or in a corrosive area).
- I. The automatic dialer shall be a Verbatim, Chatterbox or Guardit model, by Raco Manufacturing Company,

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified herein, indicated on the Drawings, and per manufacturer's recommendations.
- B. The Contractor shall program the automatic dialer with the messages and phone numbers provided by the Owner.
- C. The Contractor shall test and verify all alarms with the Owner.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17420

PH SENSOR AND ANALYZER

PART 1 - GENERAL

1.01 SCOPE

- A. This section contains specifications for pH Sensors and Analyzers. Refer to the Drawings and provide the devices as indicated.
- B. Refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. pH Analyzers shall be manufactured by Endress & Hauser.
- B. pH Sensors shall be manufactured by Endress & Hauser.

PART 2 - PRODUCTS

2.01 PH ANALYZER

- A. The analyzer shall be microprocessor-based and accept a conventional analog electrode sensor input, a conventional combination electrode, or an electrode pair. The analyzer shall come with sensor mating fittings, communication cables, process mounting equipment and other necessary accessories to form a complete pH measurement system once a separate and appropriate sensor has been selected.

- B. The analyzer shall have diagnostics for a live check of sensor blocking or failure, sensor glass breakage, and a neutralization controller to handle rapid solution changes.
- C. The analyzer shall have a graphical dot matrix LCD display with LED backlighting. The main display character height shall be 1/2 inch (13mm). Auxiliary information character height shall be 1/8 inch (3 mm).
- D. The analyzer main display shall indicate pH. Optionally (by menu selection) displayed auxiliary information shall include process temperature, the pH sensor's mA input, the pH sensor's percentage of scale input mA, the pH sensor's mV input, relay status, diagnostic warnings, or error messages.
- E. The pH analyzer shall have two pH calibration methods: a) Known: Measuring in two calibration solutions of known pH value. b) Slope: Entering data for the slope and zero point.
- F. The user shall have the ability to lock and unlock the analyzer's faceplate keyboard.
- G. The analyzer shall have diagnostic display for error messages (including scrolling error codes for fail and warn alarm conditions), calibration records, sensor statistics for the first and last three calibrations, logbook, analyzer hardware tests, device description, and factory assistance.
- H. The analyzer shall automatically retain calibration records, including the type of calibration performed, and important electrode statistics such as zero, and slope.
- I. The analyzer shall have self-check functions for all memory chips, the keypad, and display pixels.
- J. The analyzer shall have two sets of isolated analog outputs. Each output set shall be 4-20 mA. Each output set can be assigned to represent the measured pH, or temperature. Output 2 can provide the normal proportional output, or a special dedicated non-proportional alarm signal (selectable for 4 mA or 20 mA only). pH or temperature values can be entered to define the endpoints at which the minimum and maximum output values are desired.
- K. The analyzer shall be powered by 120VAC, and shall be Endress+Hauser, Liquisys Model CPM253.

2.02 PH SENSOR

- A. The pH sensor shall be of Differential Electrode Technique design using two electrodes to compare the process value to a stable internal reference standard buffer solution. The standard electrode shall have non-flowing and fouling-resistant characteristics.
- B. The sensor shall have a sterilizable dirt-repellant PTFE ring diaphragm on the electrode to prevent blocking and assure sensor stability and accuracy.

- C. The sensor shall have a double junction system of the metal lead to offer better protection from the electrode poisons.
- D. The electrode of the sensor shall be pressure proof up to 16 bar and can be applied at temperatures up to 135°C.
- E. The sensor shall be Endress+Hauser, Orbisint Model CPS11 for pH measurement.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications.

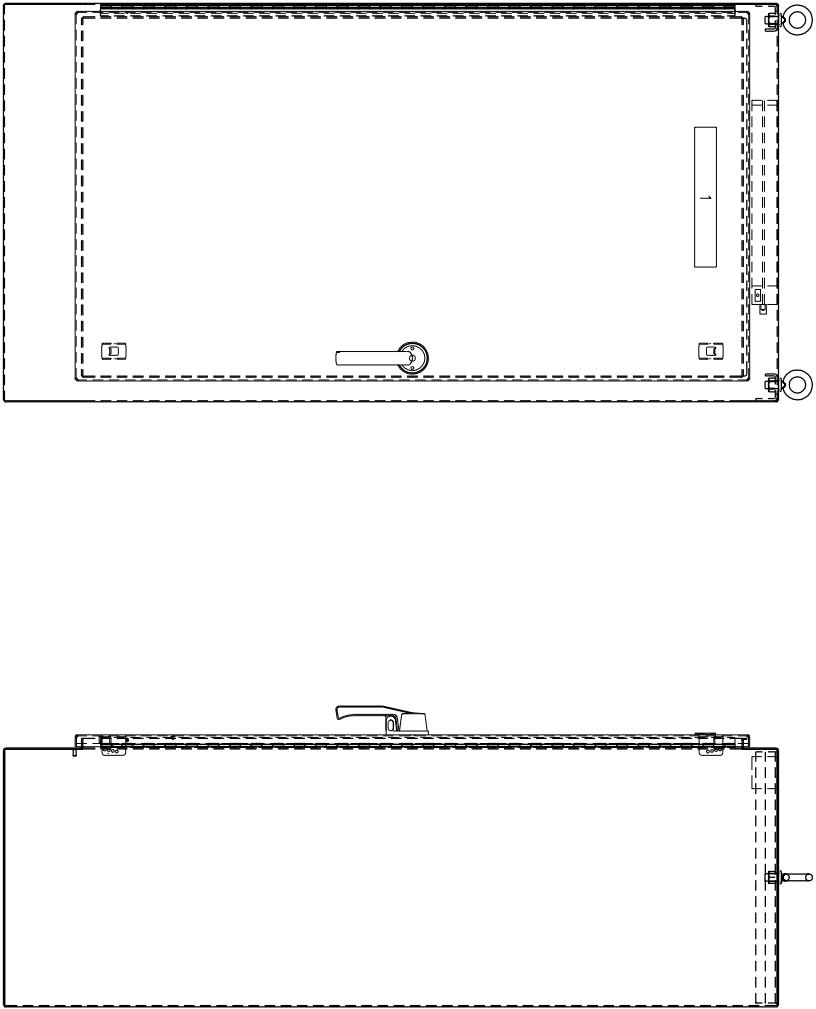
3.03 WARRANTY

- A. The equipment listed in this section shall have a one year warranty from the manufacturer.

End of Section

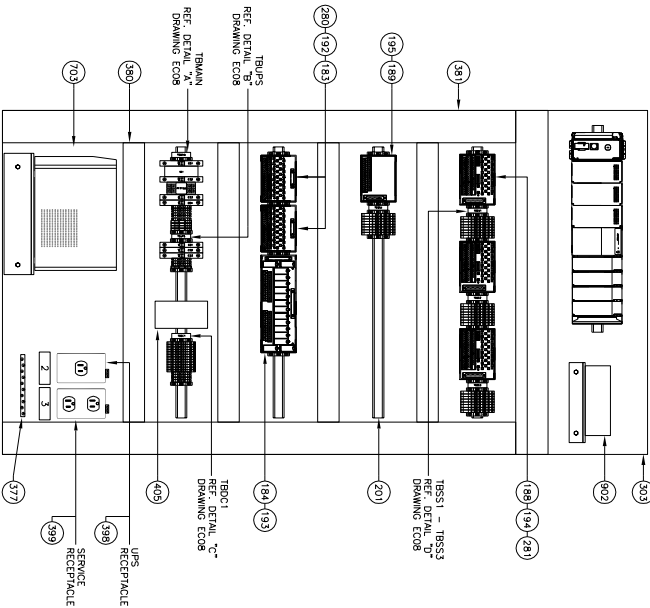
QTY	ITEM #	MANUFACTURER	PART NUMBER	DESCRIPTION
1	.01	ALLENBRADLEY	1789L36E	PROCESSOR, COMPACTLOGIX
1	.02	ALLENBRADLEY	1789-P44	POWER SUPPLY, COMPACTLOGIX 24VDC INPUT VOLTAGE, 4A @5VDC, 2A @24VDC
2	.110	ALLENBRADLEY	1789-Q16	I/O MODULE, COMPACTLOGIX DC DIGITAL INPUT, 24VDC, 16-CH PROVIDED WITH SCREW CLAMP STYLE RTB
1	.112	ALLENBRADLEY	1789-Q16	I/O MODULE, COMPACTLOGIX DC DIGITAL OUTPUT, 24VDC, 16-CH PROVIDED W/ SCREW CLAMP STYLE RTB
3	.115	ALLENBRADLEY	1789-F8	I/O MODULE, COMPACTLOGIX DC ANALOG INPUT, 24VDC, 8-CH PROVIDED W/ SCREW CLAMP STYLE RTB
1	.116	ALLENBRADLEY	1789-Q8C	I/O MODULE, COMPACTLOGIX DC ANALOG OUTPUT, 24VDC, 8-CH PROVIDED W/ SCREW CLAMP STYLE RTB
1	.118	ALLENBRADLEY	1789-EOR	END CAP, COMPACTLOGIX 168T1 SIDE
2	.63	ALLENBRADLEY	1492-FM20F-F24A-2	DIGITAL INPUT INTERFACE MODULE, 20-PIN FUSIBLE W/ BFTs, FOR 1789-Q16
1	.64	ALLENBRADLEY	1492-AM20A-6R	DIGITAL OUTPUT INTERFACE MODULE, 20-PIN MASTER W/ (16) 24VDC RELAYS, FOR 1789-Q16
3	.68	ALLENBRADLEY	1492-AIFM8-F-5	ANALOG INPUT INTERFACE MODULE, 8-CH, FUSIBLE, FOR 1789-F8
1	.69	ALLENBRADLEY	1492-AIFM8-F-5	ANALOG OUTPUT INTERFACE MODULE, 8-CH, FUSIBLE, FOR 1789-F8C
2	.92	ALLENBRADLEY	1492-CA-B025B-69	PRE-WIRED CABLES FOR DIGITAL I/O FIMs, 20 CONDUCTORS, 22 AWG, W/ PRE-WIRED RTB @ I/O MODULE END, FOR 1789-Q16
1	.93	ALLENBRADLEY	1492-CA-B025B-69	PRE-WIRED CABLES FOR DIGITAL I/O FIMs, 20 CONDUCTORS, 22 AWG, W/ PRE-WIRED RTB @ I/O MODULE END, FOR 1789-Q16
3	.94	ALLENBRADLEY	1492-CA-B010B-D89	PRE-WIRED CABLES FOR ANALOG I/O FIMs, 16-PIN D-SHELL, W/ PRE-WIRED RTB @ I/O MODULE END, FOR 1789-F8
1	.95	ALLENBRADLEY	1492-CA-B025B-69	PRE-WIRED CABLES FOR ANALOG I/O FIMs, 16-PIN D-SHELL, W/ PRE-WIRED RTB @ I/O MODULE END, FOR 1789-F8C
AR	.201	ALLENBRADLEY	1492-OR6	TERMINAL MOUNTING RAIL, 16-PAIR, ALUMINUM
24	.202	ALLENBRADLEY	1492-EA-35	END ANCHOR
7	.210	ALLENBRADLEY	1492-GA-35	TERMINAL BLOCK, GROUP MARKING CARRIER
18	.215	ALLENBRADLEY	1492-J4	TERMINAL BLOCK, SINGLE CIRCUIT, 600V, GRAY
12	.219	ALLENBRADLEY	1492-D3P	TERMINAL BLOCK, DOUBLE LEVEL, W/ PLUGGABLE TOP LEVEL
3	.221	ALLENBRADLEY	1492-J24	TERMINAL BLOCK, SINGLE CIRCUIT, GROUNDING
12	.223	ALLENBRADLEY	1492-FM24	FUSE PLUG INSERT W/ BFT, 1038VACDC WORKING VOLTAGE, 10A MAX @ 250V, PROVIDE FAST BLOW FUSES AS REQUIRED
2	.231	WEIDMULLER	9926251002	CIRCUIT BREAKER, 2A
1	.232	WEIDMULLER	9926251007	CIRCUIT BREAKER, 1A
2	.234	WEIDMULLER	9926251015	CIRCUIT BREAKER, 20A
1	.235	WEIDMULLER	9926251020	CIRCUIT BREAKER, 15A
32	.280	ANY	ANY	250V, 16A, 5mmx20mm GLASS FUSES FOR PART NO. 1492-FM20F-F24A-2
24	.281	ANY	ANY	250V, 16A, 5mmx20mm GLASS FUSES FOR PART NO. 1492-AIFM8-F-5
12	.282	ANY	ANY	250V, 5mmx20mm FAST BLOW GLASS FUSES (SIZE AS PER INDICATED ON DRAWING)
1	.201	HOFFMAN	A729324S-PT	ENCLOSURE, NEMA TYPE 4, SINGLE DOOR, FREE STANDING, 72"H X 37"W X 24"D
1	.203	HOFFMAN	A72934F1	SUBPANEL, WHITE, (60"H x 32"W)
1	.213	HOFFMAN	A-LF16D24	24" FLUORESCENT LIGHTING FIXTURE W/ DOOR SWITCH
1	.257	CUSTOM	N/A	CABLE, RS-232 BETWEEN PROCESSOR AND RADIO
1	.258	BELDEN	837	CABLE, COAXIAL, RG-413 (OR EQUAL) WITH APPROPRIATE CONNECTORS, (LENGTH AS REQUIRED)
1	.277	ANY	ANY	GROUNDING BAR
AR	.280	PANOUT	F24ALG8_C2A66	2 X 4 PLASTIC WIRING DUCT TYPE "E", W/COVER STYLE "C"
AR	.281	PANOUT	F24ALG8_C3A66	3 X 4 PLASTIC WIRING DUCT TYPE "E", W/COVER STYLE "C"
1	.288	HUBBELL	HBL3A811	SIMPLEX RECEPTACLE, 1/0RN, 125V/20A, W/BOX AND BRUSHED ALUMINUM COVER (HUBBELL P/N #A9)
1	.299	HUBBELL	HBL3A823	DUPLEX RECEPTACLE, 1/0RN, 125V/20A, W/BOX AND BRUSHED ALUMINUM COVER (HUBBELL P/N #A9)
1	.405	PULS	OS10-241	POWER SUPPLY, 24VDC, 240W, W/ INTEGRAL STA-TUS-FAULT RELAY
1	.408	IDEC	RH2B-UL-ACT2V	RELAY, 120VAC COIL, DPDT W/ INDICATOR
1	.421	IDEC	SH2B-46C	DPDT RELAY SOCKET, DIN RAIL MOUNT, FINGERSAFE
1	.450	MIL SURGE TECHNOLOGIES	MA160D/151	120/240 VAC, 15A, SURGE SUPPRESSOR AND FILTER
32	.451	PHOENIX CONTACT	2881186	SURGE SUPPRESSOR
4	.452	PHOENIX CONTACT	2884994	END CAP FOR SURGE SUPPRESSOR
1	.203	POWERWARE	PW5115-600	UPS, 120VAC, 500 VA, MINIMUM 30 MIN. RUNTIME OF COMPLETE RTU OPERATIONS POWER
1	.811	POLYPHASER	IS-50N-C2	BROADBAND COAXIAL SURGE PROTECTOR, BLK/HEAD MOUNT
3	.853	THIES MICROWAVE SYSTEMS	EZ-400-AMC	MALE CONNECTOR
1	.854	THIES MICROWAVE SYSTEMS	GK-5400T1	ANTENNA LEAD GROUNDING KIT FOR LMR-400
AR	.855	THIES MICROWAVE SYSTEMS	LMR-400B8	ANTENNA CABLE, .50 OHM COAXIAL, WATER TIGHT, LENGTH AS REQUIRED
1	.902	FREEMOVE	FOR-115RC	INDUSTRIAL SPREAD SPECTRUM RADIO
1	.951	KATHREIN - SCALA	TV-900	ANTENNA, YAGI, 100d GAIN, WIN-TYPE CONNECTORS & LIGHTNING ARRESTER
0	.959	HOFFMAN	A-TENMO	TEMPERATURE CONTROL SWITCH (THERMOSTAT), N.O. CONTACTS
0	.999	WEIDMULLER	9926251001	CIRCUIT BREAKER, 1A
0	.999	CUSTOM	N/A	METAL SHELF FOR RADIO
0	.999	MICROWAVE DATA SYSTEMS	TRANSMET-900	RADIO TRANSCEIVER, SPREAD SPECTRUM, 15M BAND (902-928MHz), WITH NETWORK WIDE DIAGNOSTIC PACKAGE
0	.999	BELDEN	7929A	CABLE, ETHERNET 4 PR, 24 AWG, CAT 5E, (LENGTH AS REQUIRED)
0	.999	TESSCO	16526	IN-CONNECTOR TO SURGE PROTECTOR
0	.999	DIGIKEY	ACX107-ND	TNC PLUG CONNECTOR FOR RG 8213 CABLE
0	.999	ALLENBRADLEY	271P-110CA41	PANELVIEW PLUS 1000 COLOR W/ TOUCH SCREEN, ETHERNET I/P COM., & RS-232 PORT, 120VAC POWER
0	.999	ALLENBRADLEY	1492-J03	TERMINAL BLOCK, DOUBLE LEVEL
0	.999	HOFFMAN	A72923F-4	SWING-OUT PANEL, PALE PANEL, 30.68" X 31"
0	.999	HOFFMAN	A-RANDK	SWING-OUT PANEL KIT
0	.999	HOFFMAN	CR39616G688	CR SERIES COMPACT AIR CONDITIONER, 115VAC, 4000 BTUHR W/ OUTDOOR PACKAGE & NEMA 4X
0	.999	HOFFMAN	302VSS-16C	VERBATIM AUTODIALER, 16 CHANNEL, 120VAC

A
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 BILL OF MATERIALS



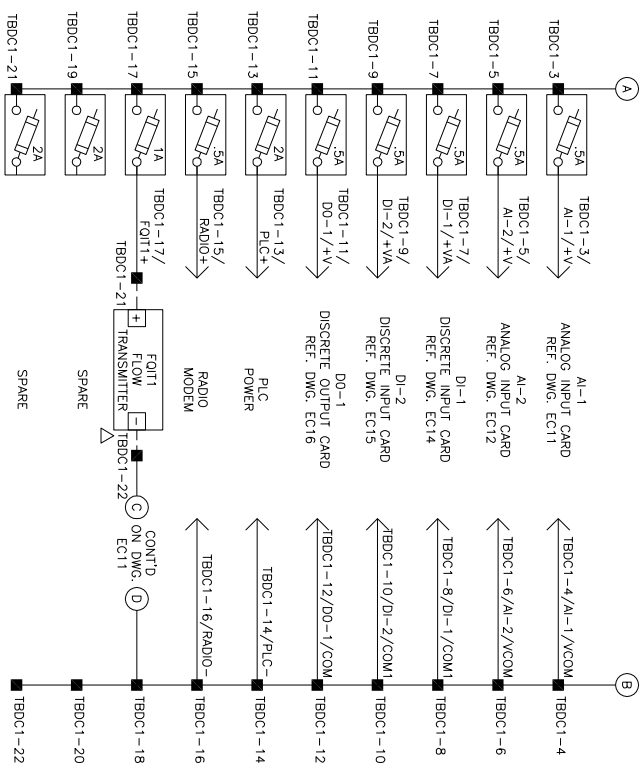
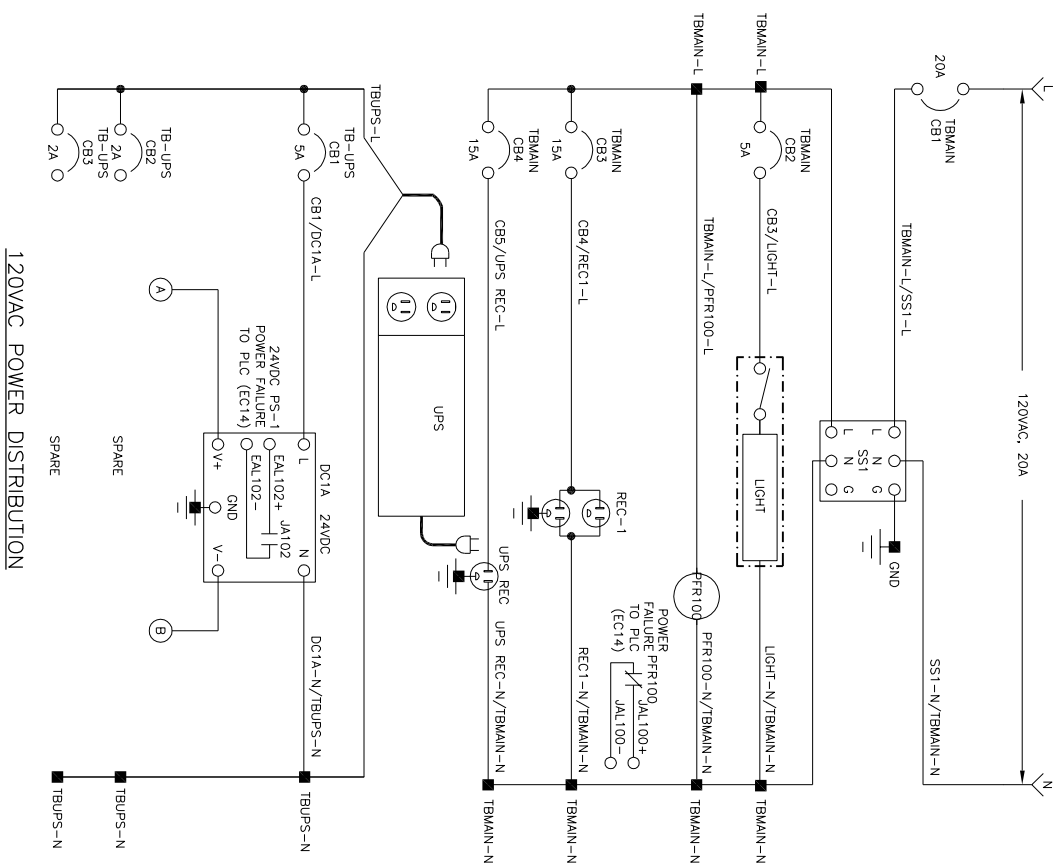
B
 ~
 RTU ENCLOSURE FRONT

C
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 RTU ENCLOSURE SIDE



D
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 SUBPANEL LAYOUT

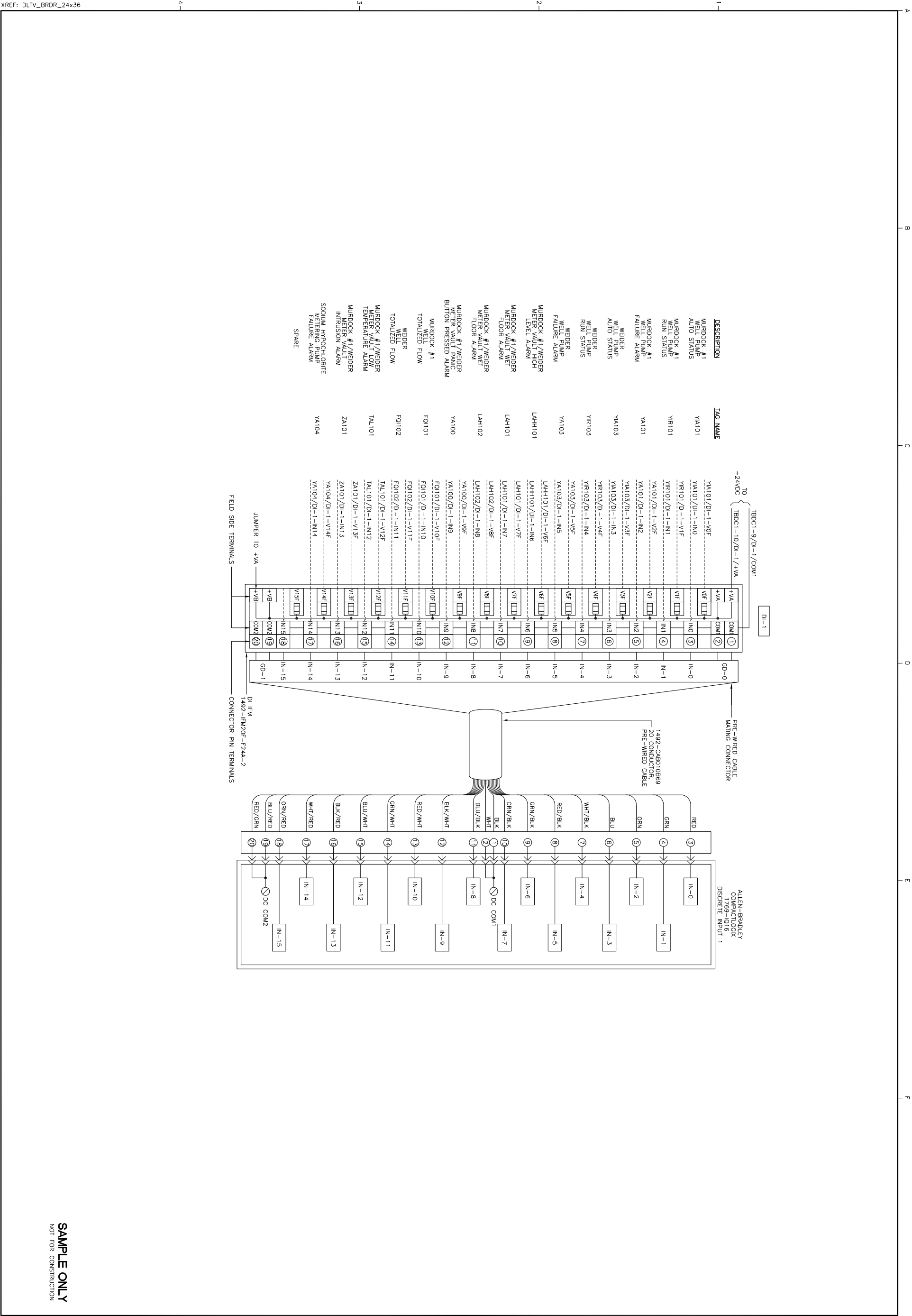
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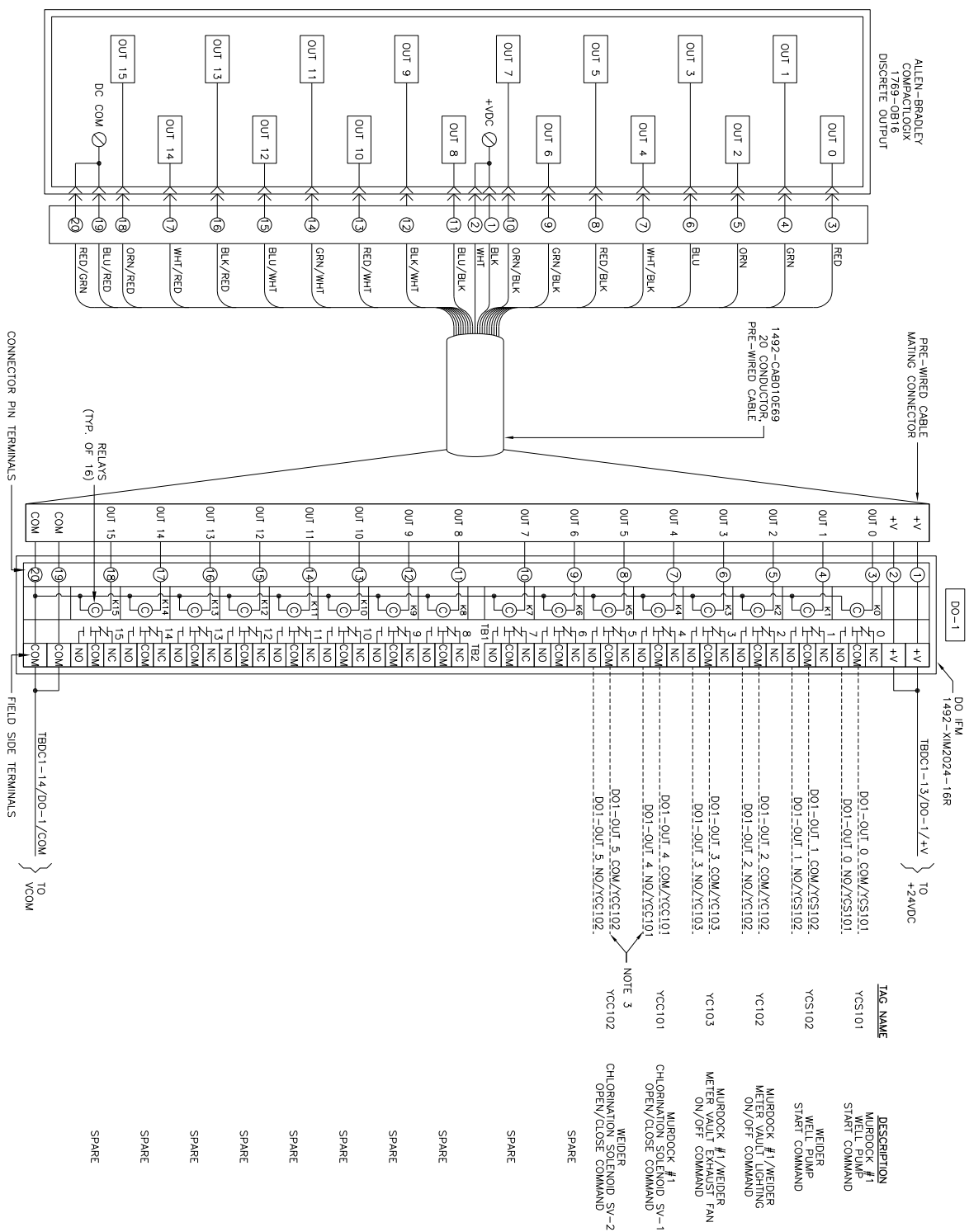


24VDC POWER DISTRIBUTION

120VAC POWER DISTRIBUTION

SAMPLE ONLY
NOT FOR CONSTRUCTION





SAMPLE ONLY
NOT FOR CONSTRUCTION

A		B		C		D		E		F			
SCHEMATIC DIAGRAM SYMBOLS				POWER SINGLE LINE DIAGRAM SYMBOLS				ELECTRICAL ABBREVIATIONS					
	CONTROL RELAY		2 POSITION SELECTOR SWITCH POSITION LEGEND: X=CLOSED O=OPEN		JUNCTION BOX WITH BLOCK OR LUGS		CIRCUIT BREAKER SHOWN WITH TRIP RATING AND NUMBER OF POLES	A	ADJUSTABLE FREQUENCY DRIVE	J/B	JUNCTION BOX	P/NL	PANEL
	TIME DELAY RELAY		3 POSITION SELECTOR SWITCH HAND - OFF - AUTO POSITION LEGEND: X=CLOSED O=OPEN		CONDUIT SEALOFF		MOTOR CIRCUIT PROTECTOR WITH TRIP RATING AND NUMBER OF POLES	A/B	ABOVE FINISHED FLOOR	L, LO	LOCAL AREA NETWORK	P/B	POWER PULLBOX
	ALARM RELAY		NORMALLY CLOSED PUSH BUTTON		LTC CONNECTION		DISCONNECT SWITCH SHOWN WITH RATING AND NUMBER OF POLES	A/C	AMPS INTERRUPTING CAPACITY	L/C	LOCAL CONTROL	P/G	POUNDS PER GALLON
	ELAPSED TIME METER		LOCKOUT STOP PUSH BUTTON		MC CONNECTION		MOTOR MANAGEMENT RELAY	A/C	CHLORINE	L/C	LOCAL CONTROL	P/H	POUNDS PER HOUR
	MOTOR STARTER OR CONTACTOR COIL		NORMALLY OPEN PUSH BUTTON		BOND TO METALLIC WATER PIPE		SOLID STATE STARTER	A/S	AIR SUPPLY	L/C	LOCAL OFF-STOP	P/M	POUNDS PER MIN
	PHOTO CELL		EMERGENCY STOP PUSH BUTTON (MAINTAINED)		UTILITY METER		VARIABLE FREQUENCY DRIVE	A/T	AUTOMATIC TRANSFER SWITCH	L/S	LEVEL (i.e., FLOOD) SWITCH	P/P	PRESSURE
	BEACON ALARM LIGHT LETTER INDICATES COLOR R=RED, A=AMBER, B=BLUE, G=GREEN		DISCONNECT SWITCH SHOWN WITH RATING AND NUMBER OF POLES		MOTOR NUMBER DESIGNATES NEMA HORSEPOWER SIZE		HARMONIC FILTER	A/C	CONTROL	L/C	LOCAL CONTROL	P/S	POUNDS PER SQUARE INCH
	PILOT LIGHT LETTER INDICATES COLOR R=RED, A=AMBER, B=BLUE, G=GREEN		LIMIT OR POSITION SWITCH		ELECTRONIC OVERLOAD RELAY		GROUND CONNECTION	A/C	CLOCKWISE	L/C	LOCAL CONTROL	P/S	POUNDS PER SQUARE INCH
	OUTPUT DV/DI FILTER		PRESSURE SWITCH HIGH		FUSE		FUSEBLOCK OR FUSEBLOCK	A/C	CLOCKWISE	L/C	LOCAL CONTROL	P/S	POUNDS PER SQUARE INCH
	HEATING ELEMENT		PRESSURE SWITCH LOW		AMPs		GROUND CONNECTION	A/C	CLOCKWISE	L/C	LOCAL CONTROL	P/S	POUNDS PER SQUARE INCH
	TRANSFORMER		FLOW SWITCH	SITE PLAN SYMBOLS									
	CURRENT TRANSFORMER		LEVEL FLOAT SWITCH		TELEPHONE OUTLET		FIELD DEVICE	ELECTRICAL LINETYPES				GENERAL NOTES	
	GROUND CONNECTION		TIMER RELAY CONTACT INSTANTANEOUS CLOSE TIME DELAY OPEN		SINGLE POLE SWITCH		GROUND ROD	EXPOSED CONDUIT				1. THE COMPLETED INSTALLATION SHALL COMPLY WITH LATEST REVISION OF APPLICABLE FEDERAL, STATE, AND LOCAL CODES, ORDINANCES, AND REGULATIONS. THE CONTRACTOR SHALL OBTAIN NECESSARY PERMITS AND INSPECTIONS REQUIRED BY THE AUTHORITIES HAVING JURISDICTION. ALL WORK SHALL BE COMPLETED IN A NEAT, WORKMANLIKE MANNER IN ACCORDANCE WITH THE LATEST MECA STANDARDS OF INSTALLATION UNDER COMPETENT SUPERVISION. INSTALL GROUNDING PER NEC.	
	GENERATOR		TIMER RELAY CONTACT NORMALLY OPEN TIME DELAY CLOSE		3 WAY SWITCH		DUPLEX RECEPTACLE	EXISTING EXPOSED CONDUIT				2. VISIT THE SITE PRIOR TO BIDDING TO BECOME FAMILIAR WITH EXISTING CONDITIONS AND OTHER FACTORS, WHICH MAY AFFECT THE EXECUTION OF THE WORK. INCLUDE ALL RELATED COSTS IN THE INITIAL BID PROPOSAL.	
	HORN		TEMPERATURE SWITCH		4-WAY SWITCH		ANTENNA MAST	UNDERGROUND CONDUIT				3. THE CONTRACTOR SHALL COORDINATE WORK WITH THE UTILITIES PROVIDING SERVICES ON THIS PROJECT, AND SHALL COMPLY WITH ALL THEIR INSTALLATION REQUIREMENTS.	
	FULL VOLTAGE NON-REVERSING (FVNR) MOTOR STARTER OR DESIGNATES NEMA SIZE		FUSE		MANUAL MOTOR STARTER		CONDUIT SEALOFF	EXISTING UNDERGROUND CONDUIT				4. ALL MATERIALS SHALL BE NEW AND OF THE BEST QUALITY, MANUFACTURED IN ACCORDANCE WITH THE LATEST REVISION OF NEMA, ANSI, UL, OR OTHER APPLICABLE STANDARDS. THE USE OF MANUFACTURERS' NAMES, MODELS, AND NUMBERS IS INTENDED TO ESTABLISH STYLE, QUALITY, APPEARANCE, USEFULNESS, AND BID PRICE.	
	NORMALLY OPEN CONTACT		FUSEHOLDER OR FUSEBLOCK		SPECIAL PURPOSE OR WELDING OUTLET		DISCONNECT SWITCH	BRAVE COPPER GROUND CONDUCTOR				5. PROTECT ALL ELECTRICAL MATERIAL AND EQUIPMENT INSTALLED AGAINST DAMAGE BY OTHER TRADING CONDITIONS OR ANY UNREASONABLE CAUTIONS. EQUIPMENT DAMAGED DURING SHIPPING OR CONSTRUCTION, PRIOR TO ACCEPTANCE BY THE ENGINEER OR THE OWNER, WILL BE REJECTED AS DEFECTIVE.	
	NORMALLY CLOSED CONTACT		THERMAL OVERLOAD RELAY		SMOKE DETECTOR		MOTOR	EXISTING OR FUTURE				6. LEAVE THE SITE CLEAN. REMOVE ALL DEBRIS, EMPTY CARTONS, TOOLS, CONDUIT, WIRE SCRAPS AND ALL MISCELLANEOUS SPARE EQUIPMENT AND MATERIALS USED IN THE WORK. DURING CONSTRUCTION, ALL COMPONENTS SHALL BE FREE OF DUST, GRIT AND FOREIGN MATERIALS. LEAVE NEW ELECTRICAL ACCEPTANCE OF WORK. PROTECT PAINT AND FINISHES SHALL BE TOUCHED UP OR REPAINTED WITH MATCHING COLOR PAINT AND FINISH.	
	RTU OR PLC CONTACT		TERMINAL BLOCK		THERMOSTAT	CIRCUIT SCHEDULE LEGEND						7. CIRCUIT CONDUCTORS #6 AWG OR SMALLER SHALL BE THHN STRANDED COPPER. #4 AWG THROUGH #2 AWG SHALL BE XHHW STRANDED COPPER. #1 AWG OR LARGER SHALL BE XHHW-2 STRANDED COPPER. MINIMUM POWER CONDUCTOR SIZE SHALL BE #12 AWG WITH #12 AWG GROUND.	
	DEVICE LOCATED AT REMOTE LOCATION		CONDUIT SEALOFF	CIRCUIT SCHEDULE LEGEND								8. UNDERGROUND CONDUITS SHALL BE SCHEDULE 40 PVC. MINIMUM CONDUIT DEPTH SHALL BE 24 INCHES. MINIMUM UNDERGROUND CONDUIT SIZE SHALL BE 1 INCH.	
	CONDUIT SEALOFF		SIGNAL TERMINAL NODE	CIRCUIT SCHEDULE LEGEND								9. CONDUITS SHALL BE MARKED AT EACH END WITH MATCHING NUMBERED BRASS TAGS. SPARE CONDUITS SHALL HAVE A PULL STRING INSTALLED, SECURED, AND CAPPED.	
	SIGNAL TERMINAL NODE		CONDUIT SEALOFF	CIRCUIT SCHEDULE LEGEND								10. EXPOSED CONDUITS SHALL BE GALVANIZED RIGID STEEL (GRS). MINIMUM SIZE 3/4 INCH, UNLESS OTHERWISE NOTED ON THE PLANS.	
	CONDUIT SEALOFF		SIGNAL TERMINAL NODE	CIRCUIT SCHEDULE LEGEND								11. SAFETY SWITCHES, ELECTRICAL DISTRIBUTION EQUIPMENT, CONTROL PANELS, AND OTHER ELECTRICAL DEVICES SHALL BE UL LISTED, AND RATED FOR HEAVY DUTY SERVICE.	
	SIGNAL TERMINAL NODE		CONDUIT SEALOFF	CIRCUIT SCHEDULE LEGEND								12. WIRING DEVICES SHALL BE SPECIFICATION GRADE.	
	CONDUIT SEALOFF		SIGNAL TERMINAL NODE	CIRCUIT SCHEDULE LEGEND								13. THE CONTRACTOR IS RESPONSIBLE FOR MANAGING, SCHEDULING, AND COORDINATING ALL WORK. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND INSPECTIONS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING ACCURATE SHOP AND RECORD DRAWINGS, AND O&M MANUALS SHALL BE SUBMITTED PRIOR TO FINAL ACCEPTANCE OF THE WORK.	
	SIGNAL TERMINAL NODE		CONDUIT SEALOFF	CIRCUIT SCHEDULE LEGEND								14. TYPICAL DETAILS SHALL APPLY IN ALL CASES, WHETHER SPECIFICALLY REFERRED TO OR NOT.	
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ELECTRICAL AND INSTRUMENTATION
DESIGN STANDARDS

ELECTRICAL NOTES AND SYMBOLS

DLT&V

SYSTEMS ENGINEERING

3550 N. CENTRAL AVE, STE. 1900
PHOENIX, AZ 85012 (602) 266-4658

Rev'd

By

Date

Job No.
1467.03.100

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CIRCUIT DESCRIPTION	KVA	HP	FLA
MOTOR LOADS			
PUMP NO.1	100.0	124.0	
PUMP NO.2	100.0	124.0	
NONMOTOR LOADS			
SINGLE PHASE TRANSFORMER	15.0		31.3
SUBTOTAL			279.3
+ 25% OF LARGEST MOTOR			31.0
TOTAL AMPS @ 480V/3 PHASE			310.3
SERVICE SIZE (AMPS)			600.0



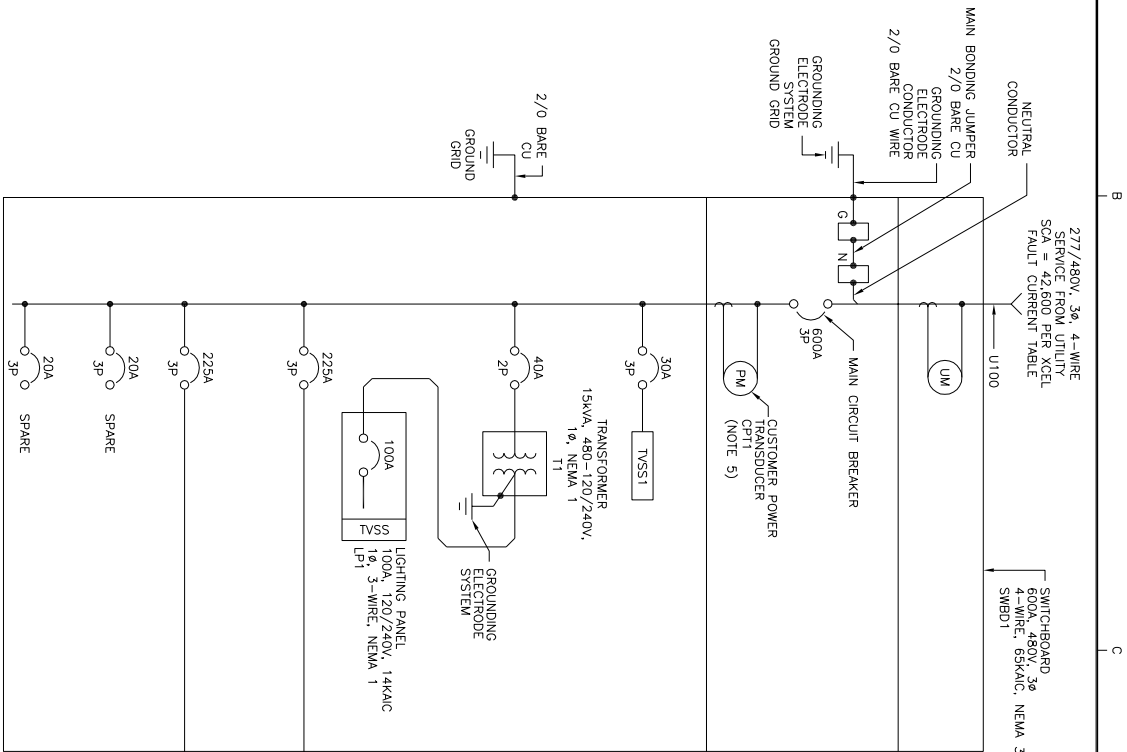
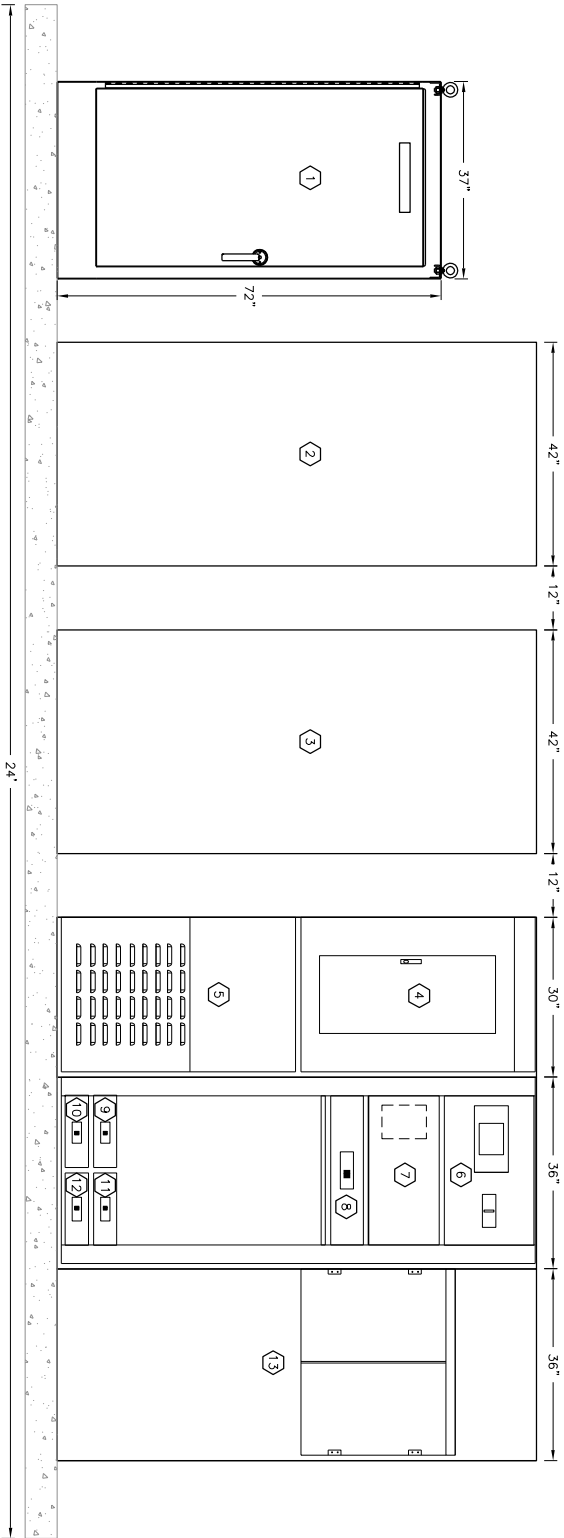
DEFINITIONS	FORMULAS
ISC = SHORT CIRCUIT CURRENT (AMPS)	3 PH: $f = \frac{1,732 \times L \times I_{sc}}{N \times C \times V \times L_{L}}$
N = NUMBER OF CONDUCTORS/PHASE	
L = LENGTH OF CONDUCTOR (FEET)	1 PH: $f = \frac{2 \times L \times I_{sc}}{N \times C \times V \times L_{L}}$
C = CONSTANT FROM TABLE OF "C"	
I _{sc} = AVAILABLE SHORT-CIRCUIT AMPS	
V _{L-L} = LINE TO LINE VOLTAGE (VOLTS)	
V _P = PRIMARY VOLTAGE	
S = SECONDARY VOLTAGE	1 PH XFMR: $f = \frac{I_{sc} \times V \times \% Z}{100,000 \times KVA}$
%Z = TRANSFORMER % IMPEDANCE	

ISC(1)

$$f = \frac{1,732 \times 12 \times 42,600}{1 \times 11423 \times 480} = 0.1615$$
$$M = \frac{1}{1 + 0.1615} = 0.861$$
$$ISC(1) = 42,600 \times 0.861 = 36,679 \text{ A}$$



ITEM	CONTENTS
1	RTU
2	WIEDER WELL PUMP VFD
3	MARDOCK #1 WELL PUMP VFD
4	LIGHTING PANEL
5	TRANSFORMER
6	TVSS
7	CUSTOMER POWER TRANSUDCER
8	MAIN BREAKER
9	SPARE
10	SPARE
11	MARDOCK #1 WELL PUMP BREAKER
12	WIEDER WELL PUMP BREAKER
13	INCOMING SECTION/UTILITY METERING



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ELECTRICAL AND INSTRUMENTATION
DESIGN STANDARDS
SINGLE LINE DIAGRAM

Scale	NONE
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PANEL TAG NO. LP 1										NEMA TYPE MOUNTING 1/SURFACE									
LOCATION INSIDE SWITCHBOARD 1										MAIN DEVICE 100A MCB									
BUS AMPACITY 100A										AIC RATING 14K									
VOLTS, PHASE, WIRE 240 V/1-PHASE/3-WIRE										FED FROM TRANSFORMER T1									
REMARKS										ACCESSORIES TVSS									
LOAD VA										LOAD VA									
PHASE A	PHASE B	LOAD DESCRIPTION	WIRE SIZE	DEMAND	BKR	BKR NO.	BKR	DEMAND	WIRE SIZE	LOAD DESCRIPTION	PHASE A	PHASE B							
234	100	EXHAUST FAN	#12	1.25	20/1	1	2	20/1	1.00	#12	300	540							
		LIGHT POLE FIXTURE	#12	1.25	20/1	3	4	20/1	1.00	#12									
1150		SLUMP PUMP	#12	1.25	20/1	5	6	20/1	1.25	#12	500								
	2400	ELECTRIC HEATER	#10	1.00	30/1	7	8	20/1				0							
800		VAULT LIGHTS	#12	1.25	20/1	9	10	20/1	1.25	#12		20							
	0	SPARE			20/1	11	12	20/1				0							
0		SPARE			20/1	13	14	20/1				0							
	0	SPARE			20/1	15	16	20/1				0							
0		SPARE			20/1	17	18	20/1				0							
2184	2500	CONNECTED VA											820	540					
2730	2525	DEMAND VA											950	540					
* Each branch circuit phase conductors shall have an equipment grounding conductor sized per N.E.C. Article 250																			
TOTAL PANEL CONNECTED LOAD										VA		AMPS		TOTAL CONNECTED VA - PER PHASE					
TOTAL PANEL DEMAND LOAD										6044		25.18		TOTAL DEMAND VA - PER PHASE					
PANEL DEMAND FACTOR										112%		28.10		TOTAL DEMAND PHASE AMPS					
														30.7 25.5					

A

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PANEL SCHEDULE

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