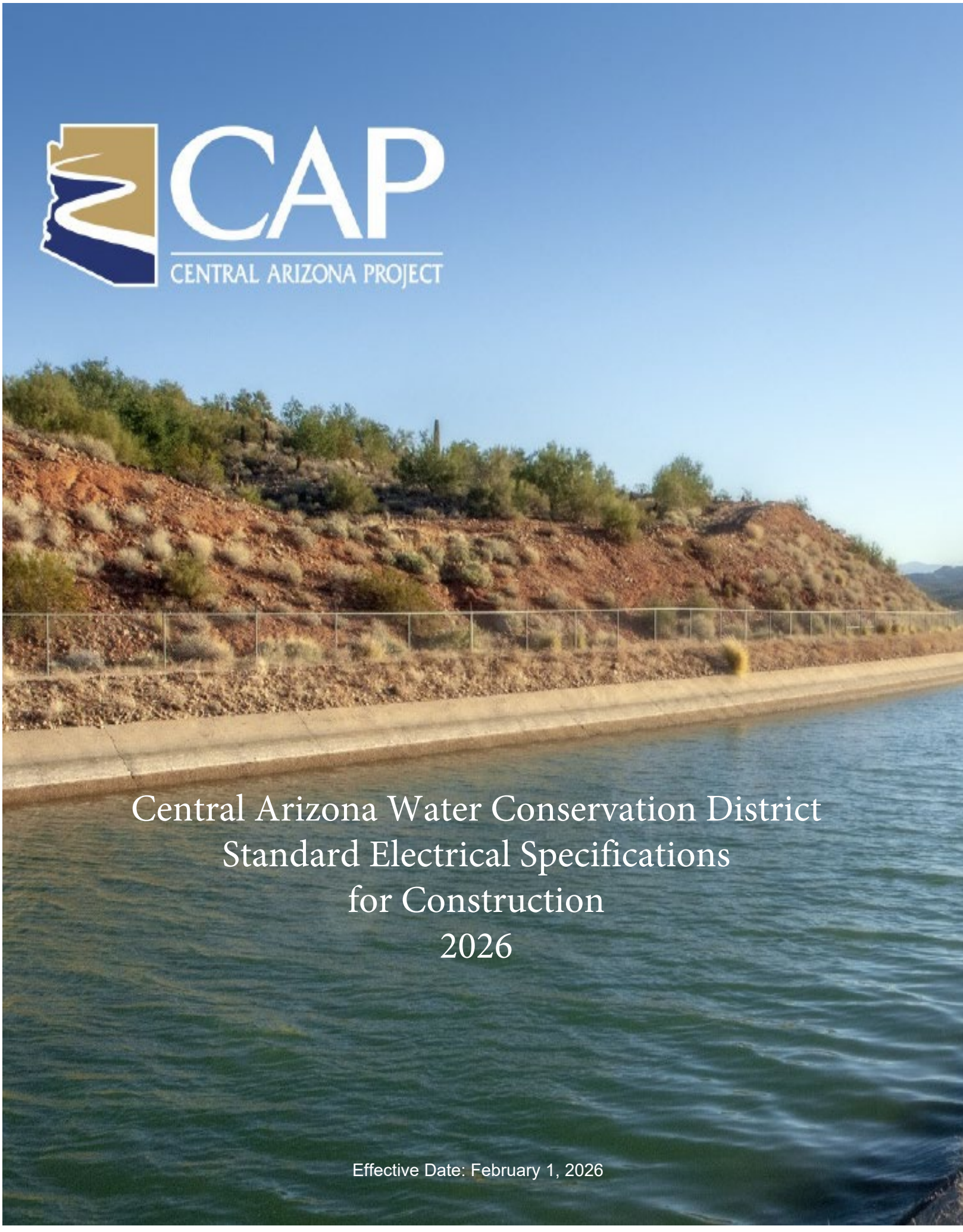


Central Arizona Water Conservation District
Standard Electrical Specifications
for Construction
2026

Effective Date: February 1, 2026

Table of Contents

SECTION 260010 – STANDARDS FOR DEVELOPMENT OF ELECTRICAL POWER AND CONTROLS PLANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, Special Provisions and Design Scope of Services for this project.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this Section.

1.2 SUMMARY

A. This Section includes standard procedures and instructions for the development of CAWCD Power and Control plans when the Contractor is required to provide design services as part of the Contract. This Section applies to design plans that will integrate into existing CAWCD drawings and for new drawings. Specific topics covered in this Section include:

1. Standard Electrical Symbols
2. Nomenclature and Numbering
3. Devices
4. Piping and Instrumentation (P&ID) Diagram Development
5. Schematic Diagram Development
6. Wiring Diagram Development

1.3 DEFINITIONS

A. The term “panel” in this section is interchangeable with the term “enclosure” and is defined as any enclosure with more than two electrical devices.

1.4 REFERENCES

A. C37.2-2008 - IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

B. NEMA Standards Publication ICS 19-2002 (R2007) Diagrams, Device Designations, and Symbols for Industrial Control and Systems

C. ANSI/ISA-5.1-2009 Instrumentation Symbols and Identification

D. NFPA70 National Electrical Code

E. USBR Design Standards NO.5 – Field Installation Procedures – Electrical Standards for Equipment Installation

PART 2 - PRODUCTS - **NOT USED**

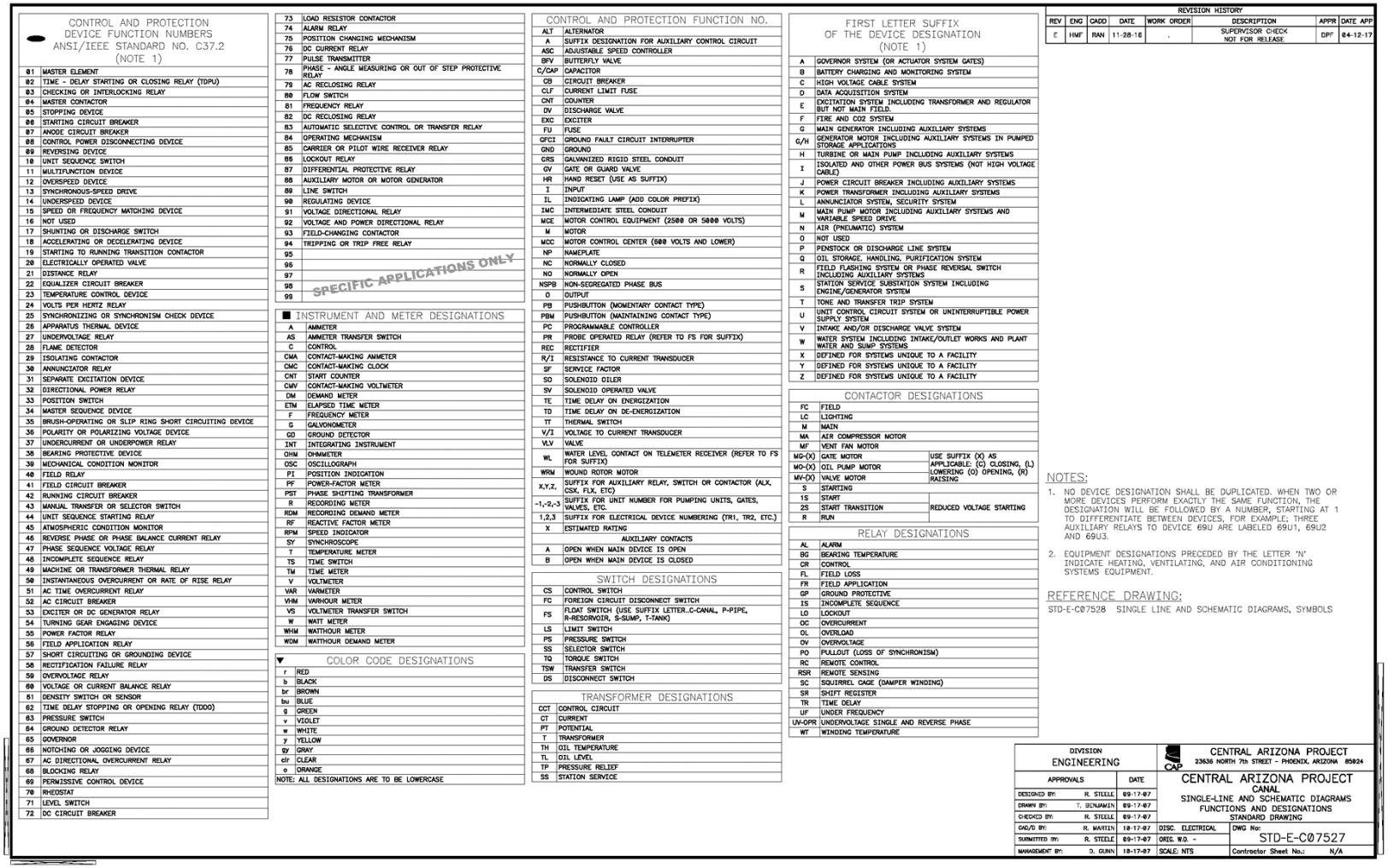
PART 3 - EXECUTION

3.1 STANDARD ELECTRICAL SYMBOLS

A. CAWCD will provide standard electrical symbol drawings in .dwg format. All symbols will be individual blocks that can be copied and used in the design plans. Attributes are incorporated in the blocks as needed for assigning size, name, rating, or other designations. If the design requires the use of a symbol not included in the standard drawings, the Contractor's designer shall create the new symbol to meet all CAWCD block requirements.

1. Functions and Acronym Definitions

a. CAWCD utilizes the ANSI/IEEE Standard device function numbers for control and protection. Device function numbers and acronym definitions are included in the reference drawing STD-E-C07527 FUNCTIONS AND DESIGNATIONS (Figure 1). This standard drawing includes tables for instrumentation and metering, control and protection, transformers, switches, contacts, relays, and conductor color acronyms to be used. The device function numbers and acronyms are used to create a unique device designation. No device function shall be duplicated. When two or more devices perform the same function, a number starting at one (1) will follow the designation. For example, three auxiliary relays to device 469U are labeled 469U1, 469U2, and 469U3.



CONTROL AND PROTECTION DEVICE FUNCTION NUMBERS ANSI/IEEE STANDARD NO. C37.2 (NOTE 1)

01	MASTER ELEMENT
02	TIME - DELAY STARTING OR CLOSING RELAY (TDPU)
03	CHECKING OR INTERLOCKING RELAY
04	MASTER CONTACTOR
05	STOPPING DEVICE
06	STARTING CIRCUIT BREAKER
07	ANODE CIRCUIT BREAKER
08	CONTROL POWER DISCONNECTING DEVICE
09	REVERSING DEVICE
10	UNIT SEQUENCE SWITCH
11	MULTIFUNCTION DEVICE
12	OVERSPEED DEVICE
13	SYNCHRONOUS-SPEED DRIVE
14	UNDERSPEED DEVICE
15	SPEED OR FREQUENCY MATCHING DEVICE
16	NOT USED
17	SHUNTING OR DISCHARGE SWITCH
18	ACCELERATING OR DECELERATING DEVICE
19	STARTING TO RUNNING TRANSITION CONTACTOR
20	ELECTRICALLY OPERATED VALVE
21	DISTANCE RELAY
22	EQUALIZER CIRCUIT BREAKER
23	TEMPERATURE CONTROL DEVICE
24	VOLTS PER HERTZ RELAY
25	SYNCHRONIZING OR SYNCHRONISM CHECK DEVICE
26	APPARATUS THERMAL DEVICE
27	UNDERVOLTAGE RELAY
28	FLAME DETECTOR
29	ISOLATING CONTACTOR
30	ANNUNCIATOR RELAY
31	SEPARATE EXCITATION DEVICE
32	DIRECTIONAL POWER RELAY
33	POSITION SWITCH
34	MASTER SEQUENCE DEVICE
35	BRUSH-OPERATING OR SLIP RING SHORT CIRCUITING DEVICE
36	POLARITY OR POLARIZING VOLTAGE DEVICE
37	UNDERCURRENT OR UNDERPOWER RELAY
38	BEARING PROTECTIVE DEVICE
39	MECHANICAL CONDITION MONITOR
40	FIELD RELAY
41	FIELD CIRCUIT BREAKER
42	RUNNING CIRCUIT BREAKER
43	MANUAL TRANSFER OR SELECTOR SWITCH
44	UNIT SEQUENCE STARTING RELAY
45	ATMOSPHERIC CONDITION MONITOR
46	REVERSE PHASE OR PHASE BALANCE CURRENT RELAY
47	PHASE SEQUENCE VOLTAGE RELAY
48	INCOMPLETE SEQUENCE RELAY
49	MACHINE OR TRANSFORMER THERMAL RELAY
50	INSTANTANEOUS OVERCURRENT OR RATE OF RISE RELAY
51	AC TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER
53	EXCITER OR DC GENERATOR RELAY
54	TURNING GEAR ENGAGING DEVICE
55	POWER FACTOR RELAY
56	FIELD APPLICATION RELAY
57	SHORT CIRCUITING OR GROUNDING DEVICE
58	RECTIFICATION FAILURE RELAY
59	OVERVOLTAGE RELAY
60	VOLTAGE OR CURRENT BALANCE RELAY
61	DENSITY SWITCH OR SENSOR
62	TIME DELAY STOPPING OR OPENING RELAY (TDDO)
63	PRESSURE SWITCH
64	GROUND DETECTOR RELAY
65	GOVERNOR
66	NOTCHING OR JOGGING DEVICE
67	AC DIRECTIONAL OVERCURRENT RELAY
68	BLOCKING RELAY
69	PERMISSIVE CONTROL DEVICE
70	RHEOSTAT
71	LEVEL SWITCH
72	DC CIRCUIT BREAKER
73	LOAD RESISTOR CONTACTOR
74	ALARM RELAY
75	POSITION CHANGING MECHANISM
76	DC CURRENT RELAY
77	PULSE TRANSMITTER
78	PHASE - ANGLE MEASURING OR OUT OF STEP PROTECTIVE RELAY
79	AC RECLOSING RELAY
80	FLOW SWITCH
81	FREQUENCY RELAY
82	DC RECLOSING RELAY
83	AUTOMATIC SELECTIVE CONTROL OR TRANSFER RELAY
84	OPERATING MECHANISM
85	CARRIER OR PILOT WIRE RECEIVER RELAY
86	LOCKOUT RELAY
87	DIFFERENTIAL PROTECTIVE RELAY
88	AUXILIARY MOTOR OR MOTOR GENERATOR
89	LINE SWITCH
90	REGULATING DEVICE
91	VOLTAGE DIRECTIONAL RELAY
92	VOLTAGE AND POWER DIRECTIONAL RELAY
93	FIELD-CHANGING CONTACTOR
94	TRIPPING OR TRIP FREE RELAY
95	
96	
97	
98	
99	

SPECIFIC APPLICATIONS ONLY

INSTRUMENT AND METER DESIGNATIONS

A	AMMETER
AS	AMMETER TRANSFER SWITCH
C	CONTROL
CMA	CONTACT-MAKING AMMETER
CMC	CONTACT-MAKING CLOCK
CNT	START COUNTER
CMV	CONTACT-MAKING VOLTMETER
DM	DEMAND METER
ETM	ELAPSED TIME METER
F	FREQUENCY METER
G	GALVONOMETER
GD	GROUND DETECTOR
INT	INTEGRATING INSTRUMENT
OHM	OHMMETER
OSC	OSCILLOGRAPH
PI	POSITION INDICATION
PF	POWER-FACTOR METER
PST	PHASE SHIFTING TRANSFORMER
R	RECORDING METER
RDM	RECORDING DEMAND METER
RF	REACTIVE FACTOR METER
RPM	SPEED INDICATOR
SY	SYNCHROSCOPE
T	TEMPERATURE METER
TS	TIME SWITCH
TM	TIME METER
V	VOLTMETER
VAR	VARMETER
VHM	VARHOUR METER
VS	VOLTMETER TRANSFER SWITCH
W	WATT METER
WHM	WATTHOUR METER
WDM	WATTHOUR DEMAND METER

COLOR CODE DESIGNATIONS

r	RED
b	BLACK
br	BROWN
bu	BLUE
g	GREEN
v	VIOLET
w	WHITE
y	YELLOW
gy	GRAY
clr	CLEAR
o	ORANGE

NOTE: ALL DESIGNATIONS ARE TO BE LOWERCASE

CONTROL AND PROTECTION FUNCTION NO.

ALT	ALTERNATOR
A	SUFFIX DESIGNATION FOR AUXILIARY CONTROL CIRCUIT
ASC	ADJUSTABLE SPEED CONTROLLER
BFV	BUTTERFLY VALVE
C/CAP	CAPACITOR
CB	CIRCUIT BREAKER
CLF	CURRENT LIMIT FUSE
CNT	COUNTER
DV	DISCHARGE VALVE
EXC	EXCITER
FU	FUSE
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GND	GROUND
GRS	GALVANIZED RIGID STEEL CONDUIT
GV	GATE OR GUARD VALVE
HR	HAND RESET (USE AS SUFFIX)
I	INPUT
IL	INDICATING LAMP (ADD COLOR PREFIX)
IMC	INTERMEDIATE STEEL CONDUIT
MCC	MOTOR CONTROL EQUIPMENT (2500 OR 5000 VOLTS)
M	MOTOR
MCC	MOTOR CONTROL CENTER (600 VOLTS AND LOWER)
NP	NAMEPLATE
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NSPB	NON-SEGREGATED PHASE BUS
O	OUTPUT
PB	PUSHBUTTON (MOMENTARY CONTACT TYPE)
PBM	PUSHBUTTON (MAINTAINING CONTACT TYPE)
PC	PROGRAMMABLE CONTROLLER
PIR	PROBE OPERATED RELAY (REFER TO FS FOR SUFFIX)
REC	RECTIFIER
R/I	RESISTANCE TO CURRENT TRANSDUCER
SF	SERVICE FACTOR
SO	SOLENOID OILER
SV	SOLENOID OPERATED VALVE
TE	TIME DELAY ON ENERGIZATION
TD	TIME DELAY ON DE-ENERGIZATION
TT	THERMAL SWITCH
V/I	VOLTAGE TO CURRENT TRANSDUCER
VLV	VALVE
WL	WATER LEVEL CONTACT ON TELEMETER RECEIVER (REFER TO FS FOR SUFFIX)
WRM	WOUND ROTOR MOTOR
X,Y,Z,	SUFFIX FOR AUXILIARY RELAY, SWITCH OR CONTACTOR (ALX, CSX, FLX, ETC)
-1,-2,-3	SUFFIX FOR UNIT NUMBER FOR PUMPING UNITS, GATES, VALVES, ETC.
1,2,3	SUFFIX FOR ELECTRICAL DEVICE NUMBERING (TR1, TR2, ETC.)
X	ESTIMATED RATING
	AUXILIARY CONTACTS
A	OPEN WHEN MAIN DEVICE IS OPEN
B	OPEN WHEN MAIN DEVICE IS CLOSED

SWITCH DESIGNATIONS

CS	CONTROL SWITCH
FC	FOREIGN CIRCUIT DISCONNECT SWITCH
FS	FLOAT SWITCH (USE SUFFIX LETTER..C-CANAL, P-PIPE, R-RESORVOIR, S-SUMP, T-TANK)
LS	LIMIT SWITCH
PS	PRESSURE SWITCH
SS	SELECTOR SWITCH
TQ	TORQUE SWITCH
TSW	TRANSFER SWITCH
DS	DISCONNECT SWITCH

TRANSFORMER DESIGNATIONS

CCT	CONTROL CIRCUIT
CT	CURRENT
PT	POTENTIAL
T	TRANSFORMER
TH	OIL TEMPERATURE
TL	OIL LEVEL
TP	PRESSURE RELIEF
SS	STATION SERVICE

FIRST LETTER SUFFIX OF THE DEVICE DESIGNATION (NOTE 1)

A	GOVERNOR SYSTEM (OR ACTUATOR SYSTEM GATES)
B	BATTERY CHARGING AND MONITORING SYSTEM
C	HIGH VOLTAGE CABLE SYSTEM
D	DATA ACQUISITION SYSTEM
E	EXCITATION SYSTEM INCLUDING TRANSFORMER AND REGULATOR BUT NOT MAIN FIELD.
F	FIRE AND CO2 SYSTEM
G	MAIN GENERATOR INCLUDING AUXILIARY SYSTEMS
G/H	GENERATOR MOTOR INCLUDING AUXILIARY SYSTEMS IN PUMPED STORAGE APPLICATIONS
H	TURBINE OR MAIN PUMP INCLUDING AUXILIARY SYSTEMS
I	ISOLATED AND OTHER POWER BUS SYSTEMS (NOT HIGH VOLTAGE CABLE)
J	POWER CIRCUIT BREAKER INCLUDING AUXILIARY SYSTEMS
K	POWER TRANSFORMER INCLUDING AUXILIARY SYSTEMS
L	ANNUNCIATOR SYSTEM, SECURITY SYSTEM
M	MAIN PUMP MOTOR INCLUDING AUXILIARY SYSTEMS AND VARIABLE SPEED DRIVE
N	AIR (PNEUMATIC) SYSTEM
O	NOT USED
P	PENSTOCK OR DISCHARGE LINE SYSTEM
Q	OIL STORAGE, HANDLING, PURIFICATION SYSTEM
R	FIELD FLASHING SYSTEM OR PHASE REVERSAL SWITCH INCLUDING AUXILIARY SYSTEMS
S	STATION SERVICE SUBSTATION SYSTEM INCLUDING ENGINE/GENERATOR SYSTEM
T	TONE AND TRANSFER TRIP SYSTEM
U	UNIT CONTROL CIRCUIT SYSTEM OR UNINTERRUPTIBLE POWER SUPPLY SYSTEM
V	INTAKE AND/OR DISCHARGE VALVE SYSTEM
W	WATER SYSTEM INCLUDING INTAKE/OUTLET WORKS AND PLANT WATER AND SUMP SYSTEMS
X	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY
Y	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY
Z	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY

CONTACTOR DESIGNATIONS

FC	FIELD	
LC	LIGHTING	
M	MAIN	
MA	AIR COMPRESSOR MOTOR	
MF	VENT FAN MOTOR	
MG-(X)	GATE MOTOR	USE SUFFIX (X) AS APPLICABLE: (C) CLOSING, (L) LOWERING (O) OPENING, (R) RAISING
MO-(X)	OIL PUMP MOTOR	
MV-(X)	VALVE MOTOR	
S	STARTING	
1S	START	
2S	START TRANSITION	REDUCED VOLTAGE STARTING
R	RUN	

RELAY DESIGNATIONS

AL	ALARM
BG	BEARING TEMPERATURE
CR	CONTROL
FL	FIELD LOSS
FR	FIELD APPLICATION
GP	GROUND PROTECTIVE
IS	INCOMPLETE SEQUENCE
LO	LOCKOUT
OC	OVERCURRENT
OL	OVERLOAD
OV	OVERVOLTAGE
PO	PULLOUT (LOSS OF SYNCHRONISM)
RC	REMOTE CONTROL
RSR	REMOTE SENSING
SC	SQUIRREL CAGE (DAMPER WINDING)
SR	SHIFT REGISTER
TR	TIME DELAY
UF	UNDER FREQUENCY
UV-OPR	UNDERVOLTAGE SINGLE AND REVERSE PHASE
WT	WINDING TEMPERATURE

REVISION HISTORY

REV	ENG	CADD	DATE	WORK ORDER	DESCRIPTION	APPR	DATE APP
E	HMF	RAN	11-28-16	.	SUPERVISOR CHECK NOT FOR RELEASE	DPF	04-12-17

NOTES:

1. NO DEVICE DESIGNATION SHALL BE DUPLICATED. WHEN TWO OR MORE DEVICES PERFORM EXACTLY THE SAME FUNCTION, THE DESIGNATION WILL BE FOLLOWED BY A NUMBER, STARTING AT 1 TO DIFFERENTIATE BETWEEN DEVICES, FOR EXAMPLE; THREE AUXILIARY RELAYS TO DEVICE 69U ARE LABELED 69U1, 69U2 AND 69U3.
2. EQUIPMENT DESIGNATIONS PRECEDED BY THE LETTER 'N' INDICATE HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS EQUIPMENT.

REFERENCE DRAWING:

STD-E-C07528 SINGLE LINE AND SCHEMATIC DIAGRAMS, SYMBOLS

DIVISION	ENGINEERING	CENTRAL ARIZONA PROJECT	23636 NORTH 7th STREET - PHOENIX, ARIZONA 85024
APPROVALS	DATE	CENTRAL ARIZONA PROJECT CANAL	
DESIGNED BY: R. STEELE	09-17-07	SINGLE-LINE AND SCHEMATIC DIAGRAMS FUNCTIONS AND DESIGNATIONS STANDARD DRAWING	
DRAWN BY: T. BENJAMIN	09-17-07		
CHECKED BY: R. STEELE	09-17-07		
CAD/D BY: R. MARTIN	10-17-07	DISC. ELECTRICAL	DWG No: STD-E-C07527
SUBMITTED BY: R. STEELE	09-17-07	ORIG. W.O. -	
MANAGEMENT BY: D. GUNN	10-17-07	SCALE: NTS	Contractor Sheet No.: N/A

Figure 1 – STD – E-C07527 FUNCTIONS AND DESIGNATION

2. Single-line and Schematic Diagram Symbols

   a. Graphical symbols used for single-line and schematic diagrams are included in the reference drawing STD-E-C07528 SINGLE-LINE AND SCHEMATIC DIAGRAMS SYMBOLS (Figure 2). NEMA Standards ICS 19-2002 diagram symbols shall be used for symbols not included in the standard drawing.
   b. Contacts in control circuits are shown in the de-energized position. Liquid level switches are shown with the liquid container empty. Vacuum and pressure switches are shown at ambient pressure. Temperature switches are shown at ambient temperature. Where polarity marks are used, the (+) sign is positive and the (–) sign is negative.
   c. Make wire connection with a solid dot connection. Wires that do not connect are allowed to cross with no solid dot.

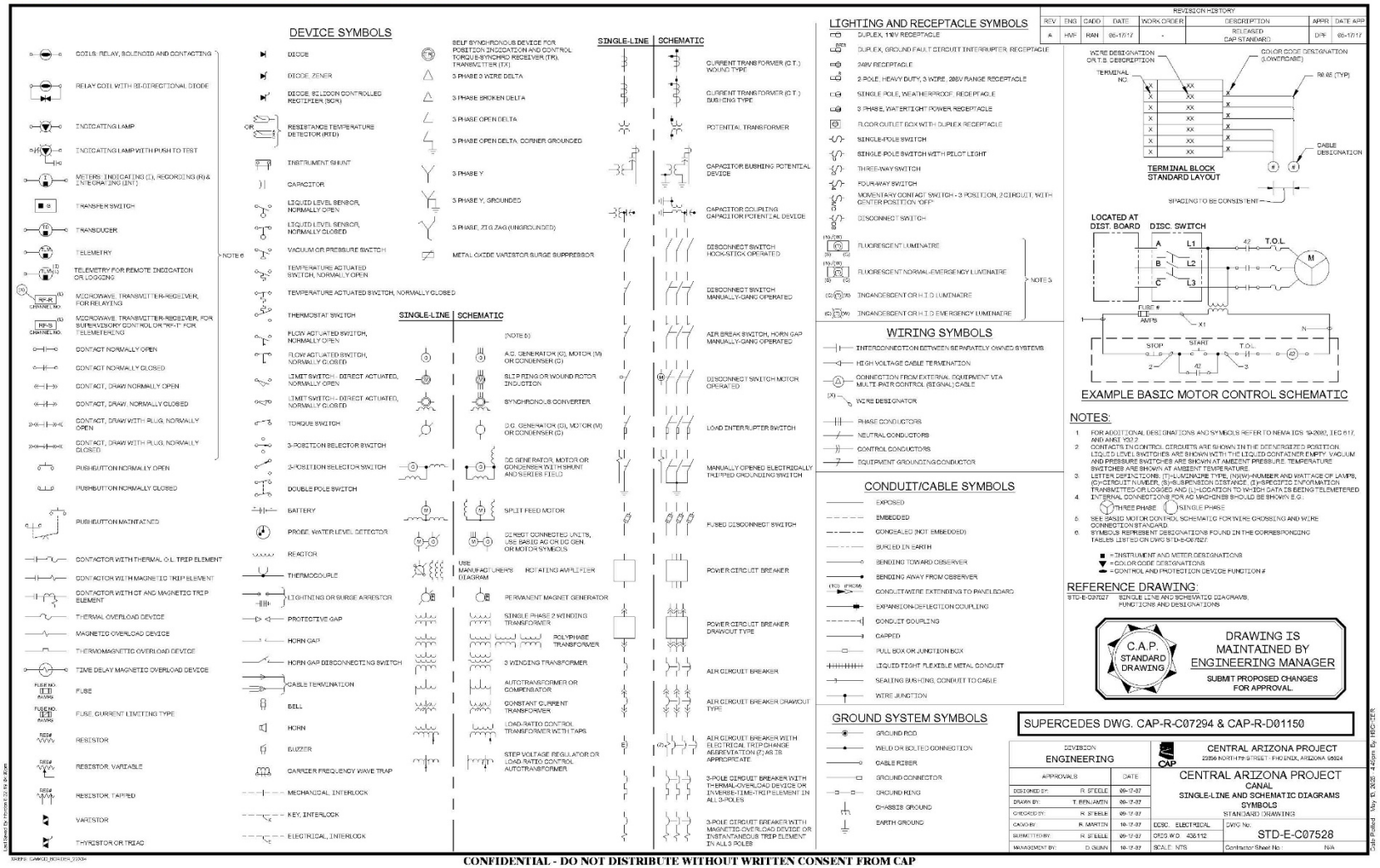


Figure 2 – STD-E-C07528 SINGLE LINE AND SCHEMATIC DIAGRAMS SYMBOLS

3. Instrumentation Legend and Symbols

   a. The most common legends and symbols used to depict measurement and control instrumentation, and control devices and functions are shown in standard drawing STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOLS (Figure 3). This standard drawing is used to develop Conceptual Design plans such as a Process Flow Diagram (PFD) and Construction Design Piping and Instrumentation Diagram (P&ID). If the control system requires a designation or symbol not shown on the standard drawing, use the ANSI/ISA-5.1-2009 Standard.

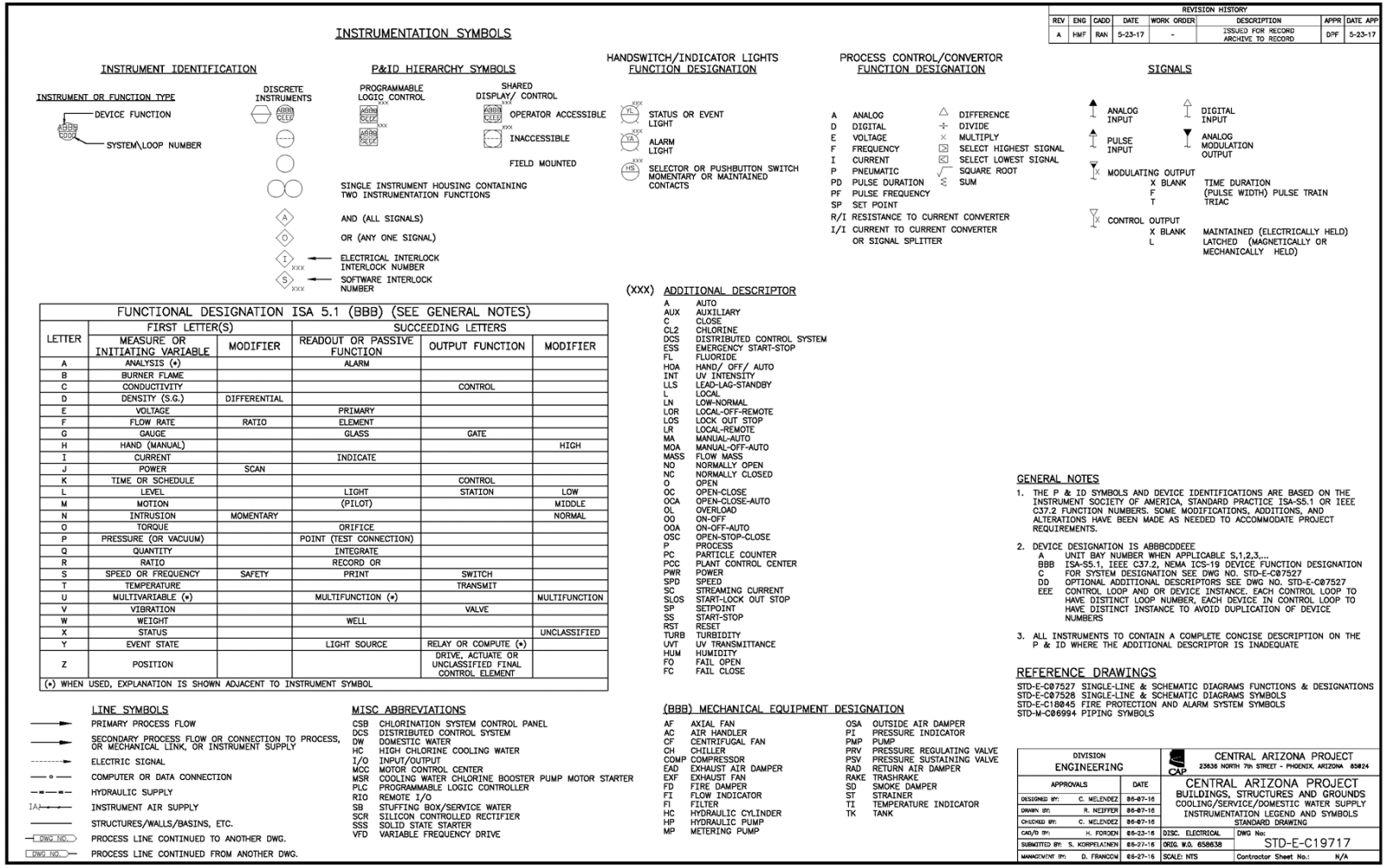


Figure 3 – STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOLS

3.2 NOMENCLATURE AND NUMBERING

A. Electrical Equipment List

1. Electrical equipment is designated by a group of three symbols and includes type of equipment, physical location and differentiation of equipment of the same type in the same location.

    a. The first symbol in an equipment designation is a single capital letter and represents the type of equipment according to Table 1 - KEY LIST FOR EQUIPMENT SYMBOLS.

Symbol	Type of Equipment
A	Actuator, turbine governor
B	Battery, DC distribution board, charger
C	Control board, high voltage cable
D	Station service switchgear, distribution board (except for lighting and HVAC), unit substation rated less than 600V
E	Static exciter, junction box, pull box, trench
F	Fuses, fused disconnect switch, fire and carbon dioxide equipment
G	Generator
H	Hydraulic board, turbine or main pump
I	Not used
J	Power circuit breaker (above 600V)
K	Transformer (except lighting), reactor, regulator, or metering equipment
L	Lighting System Equipment
M	Motor controller, pump, valve board
N	HVAC system equipment
O	Not used
P	(Reserved)
Q	Current transformer, oil storage or handling equipment
R	Cable rack
S	Motor-generator sets
T	Telephone and communication
U	AC power switchgear above 600V
W	Bus disconnect switch, phase reversal switch
X	Bypass switch
Y	Line or selector disconnect switch
Z	Grounding switch

Table 1 – KEY LIST FOR EQUIPMENT SYMBOLS

b. The second symbol in an equipment designation represents the physical location of the equipment. It is a capital letter (or letters) or a number according to Table 2 - KEY LIST FOR LOCATION SYMBOLS.

SYMBOL	LOCATION
A	(Reserved)
B	Separate warehouse or storage building
C	Control Bay
D	Dam – general (Do not use this symbol if E, F, or G are used)
E	Dam – right side
F	Dam – center or spillway section
G	Dam – left side
H	Service building
I	(Reserved)
J	Separate outlet works – primary, upper, or right side
K	Separate outlet works – primary, lower, or left side
L	(Reserved)
M	Machine or workshop in location other than service bay
N	(Reserved)
O	(Reserved)
P	Pumping plant
Q	Separate oil house
R	(Reserved)
S	Service bay
T	Separate spillway on right side
U	Separate spillway on left side
W	230 kV Switchyard
X,Y	115 kV Switchyard
Z	Switchyard
1	Main Unit Bay Number 1
2	Main Unit Bay Number 2
3	Main Unit Bay Number 3
4	Main Unit Bay Number 4
5	Main Unit Bay Number 5
6	Main Unit Bay Number 6
7	Main Unit Bay Number 7
8	Main Unit Bay Number 8
9	Main Unit Bay Number 9
10	Main Unit Bay Number 10

Table 2 – KEY LIST FOR LOCATION SYMBOLS

c. The third symbol in an equipment designation is a capital letter, starting from A, used to differentiate between pieces of equipment of the same type and in the same location.

2. As an example, consider an electrical control panel for Unit No. 2 in a Pumping Plant. Assume that this panel is in the same bay as Unit No. 2. The designation for this control panel is as follows. The first symbol always represents the type of equipment from the KEY LIST OF EQUIPMENT SYMBOLS. The symbol “C” represents control or terminal boards. Therefore, “C” is the first symbol of the designation. The next symbol represents the physical location from the KEY LIST FOR LOCATION SYMBOLS. The number “2” represent the location of Main Unit Bay No. 2. Therefore, it is the second symbol. Assuming that there are no other control panels in the Main Unit Bay No. 2, the third symbol is a differentiation letter “A”. The complete designation is “C2A”.

Type of Equipment	Location	Differentiation
C	2	A

3. If the design requires the addition of a new control panel in the location of the Main Unit Bay No. 3, regardless of the elevation within the Pumping Plant, its designation would be C2B.
4. CAWCD Engineer will assign panel designations and update the Electrical Equipment Designation List to ensure that panel designations remain unique within the plant.

B. Cables and Conduits List

1. Cable and conduit for power, control, and lighting systems are designated in a similar manner. Refer to Table 3 – ROUTING LIST for an example.
2. Cables and conduits are designated in two parts separated by a dash. The first part consists of the equipment designation, as determined by 3.2.A.2 above, (plus a panel or compartment number, if this equipment has more than one panel or compartment). The second part consists of the designation of the equipment at the other end of the cable or conduit, (plus a panel or compartment number if necessary). This represents a “From – To” designation, such as H1A–M1A.
3. In addition, control cable designation is preceded by a numeral consecutively numbering the cables extending from the same piece of equipment or from each panel or cubicle of equipment. The numerals for cables from the next panel start again with 1. For example, if three cables extend from H1A and enter M1A at the other end, they are designated as 1H1A–M1A, 2H1A–M1A, and 3H1A–M1A.

4. The circuit number will precede the designation for power cables and conduits. For example, 4DSA-M1A is the fourth power circuit exiting the “A” power distribution board, located in the Service Bay.
5. All conduit designations are preceded by the nominal diameter of the conduit in inches separated from the rest of the conduit designation by a dash. In the example above, if all three cables are located within a 3-inch diameter conduit, the conduit designation is 3-1H1A-M1A.
6. When conduits enter and terminate at an undesignated junction or terminal point and then continue as two or more conduits as a branch, each branch is designated with the designation of the original conduit plus a suffix (lower case letter). Each suffix is to be consecutive. All branches of the original conduit are to be designated in this manner regardless of the number of branches or number of undesignated junctions and/or terminal points associated with the original conduit. For example, the main or original conduit is designated 1"-2BSA and each branch is designated the same as the main conduit with the addition of a suffix as 3/4"-2BSAa, for the first branch out of the junction box, 3/4"-2BSAb for the second branch, etc.
7. Control and/or power cable installed in the branch conduit described previously is also designated by adding a suffix (lower case letter) to the designation of the original cable.
8. In the event the conduit enters a trench under a switchboard, the designation of the conduit should not show the panel number. The omission of the panel number is desired because the physical termination of the conduit may not be at the location of the panel with which it is to be associated.
9. In some instances, where the equipment at the terminal end is not designated, a cable or conduit designation has no second part or intervening dash.
10. Designations of conduits for lighting consist only of the designation of the panelboard at which the conduits originate preceded by a number. The number will be different for each conduit 1”-2LDCA.

Conductors and Cables						Conduit/Routing			
Cable Designation	No. of Cond.	Size of Cond.	Ins. Volts	Ins. Type	Purpose	Est. Lth.	Conduit Size	Conduit Type	Conduit Designation
1C1A-M1B	5/C	#16	600		A.C. Control	70 ft.	1-1/2	GRC	1-1/2-1C1A-M1B
5D3A-M1B	3-1/C	#12	600	XHHW-2	A.C. Power	120 ft.	3/4	GRC	¾-5D3A-M1B

Table 3 – ROUTING LIST (EXAMPLE)

3.3 DEVICES

A. Panel Components

1. It is common to mount devices such as relays, terminal blocks, power supplies, signal conditioners, Programmable Logic Controllers, etc. on panels within an electrical enclosure. Devices mounted on panels inside control cabinets are identified with a two-letter designation by their location on the panel in a row, column format. Groups of terminal blocks are identified by a single letter (A though C in Figure 4). Individual terminal blocks within a grouping are identified by a number. Therefore, if group A has 12 terminal blocks, they are individually referred to as A1, A2…A12. All Device Location designations are unique on a panel.

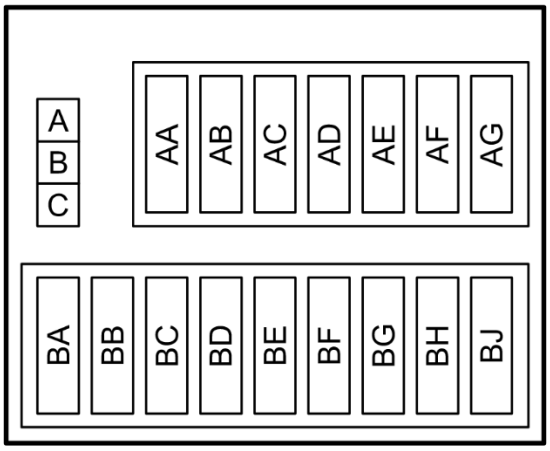


Figure 4 – PANEL LAYOUT WITH DEVICE LOCATION

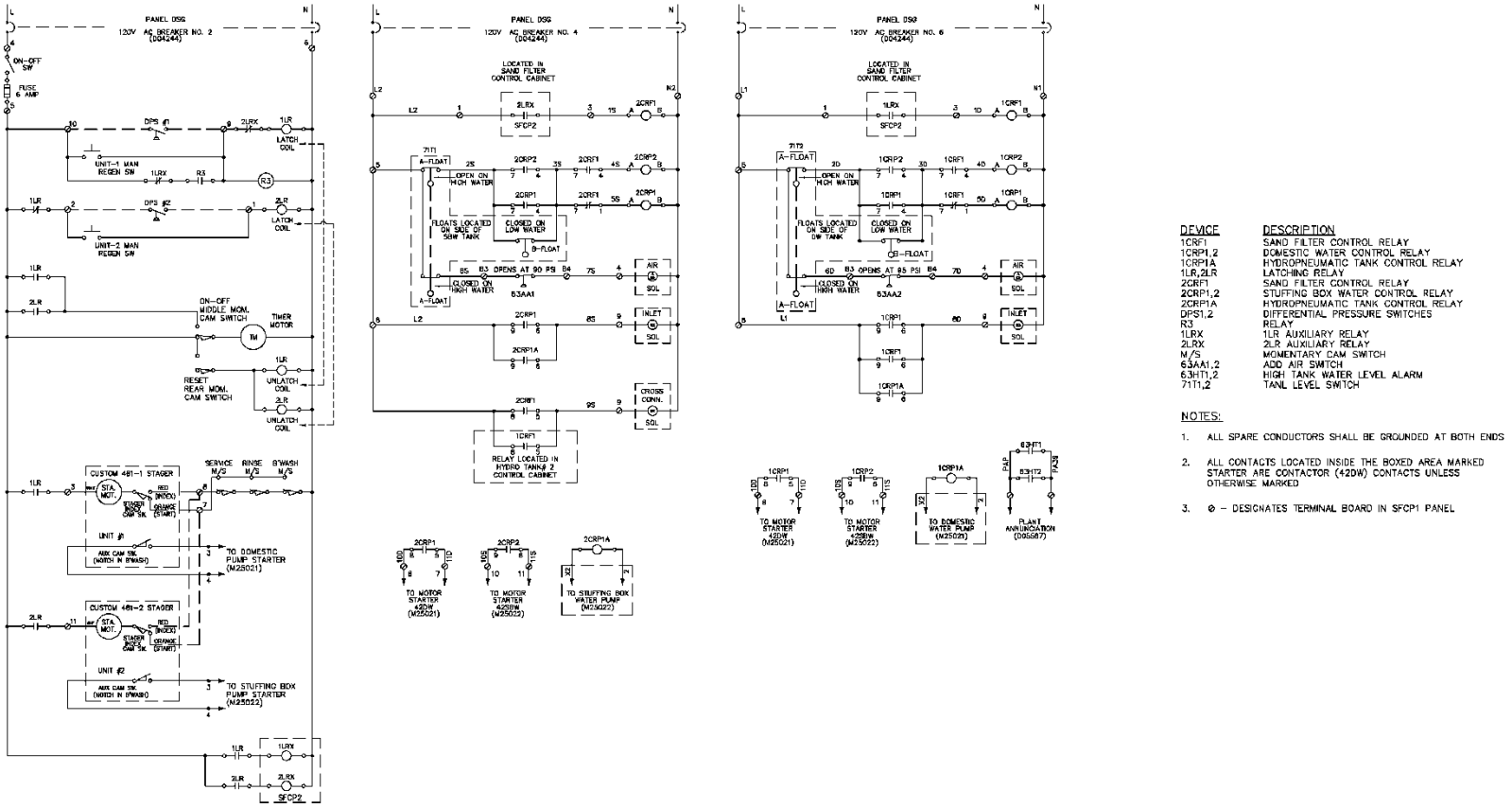
3.4 PIPING AND INSTRUMENTATION (P&ID) DIAGRAM DEVELOPMENT

A. P&IDs are Piping and Instrumentation Drawings although they are sometimes referred to as Process and Instrumentation Drawings due to their use in defining control processes. P&IDs are classified by CAWCD as Electrical drawings though they may fall under Mechanical or Electrical Instrumentation and Control requirements, depending upon the project. Contractor/designer shall adhere to the ANSI/ISA 5.1-2009 Instrumentation Symbols and Identification standard which is illustrated in Figure 3 - STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOL.

3.5 SCHEMATIC DIAGRAM DEVELOPMENT

A. The purpose of the schematic diagram is to provide a representation of all the circuit elements and how their function relates to each other to control the process. The schematic shall include the main circuit and all auxiliary circuits for control, signaling, annunciation, and protection. A schematic diagram must be developed for all circuits that include a controlling device beyond a circuit breaker or fuse. The circuit representation must be shown with sufficient detail to explain local- and remote-control functions.

B. The following information in this article provides details of each element of a schematic diagram. An example of a complete schematic diagram meeting CAWCD requirements is shown in Figure 5 – SCHEMATIC DIAGRAM (EXAMPLE).



DEVICE	DESCRIPTION
1CRF1	SAND FILTER CONTROL RELAY
1CRP1,2	DOMESTIC WATER CONTROL RELAY
1CRP1A	HYDROPNEUMATIC TANK CONTROL RELAY
1LR,2LR	LATCHING RELAY
2CRF1	SAND FILTER CONTROL RELAY
2CRP1,2	STUFFING BOX WATER CONTROL RELAY
2CRP1A	HYDROPNEUMATIC TANK CONTROL RELAY
DPS1,2	DIFFERENTIAL PRESSURE SWITCHES
R3	RELAY
1LRX	1LR AUXILIARY RELAY
2LRX	2LR AUXILIARY RELAY
M/S	MOMENTARY CAM SWITCH
63AA1,2	ADD AIR SWITCH
63HT1,2	HIGH TANK WATER LEVEL ALARM
7IT1,2	TANK LEVEL SWITCH

NOTES:

1. ALL SPARE CONDUCTORS SHALL BE GROUNDED AT BOTH ENDS
2. ALL CONTACTS LOCATED INSIDE THE BOXED AREA MARKED STARTER ARE CONTACTOR (42DW) CONTACTS UNLESS OTHERWISE MARKED
3. Ø – DESIGNATES TERMINAL BOARD IN SFCP1 PANEL

Figure 5 – SCHEMATIC DIAGRAM EXAMPLE

1. Device Designation

   a. The device designation is descriptive of the function of the device and is unique within the system. Device function numbers and acronym definitions are included in Figure 1 - STD-E-C07527 FUNCTIONS AND DESIGNATIONS. CAWCD utilizes C37.2-2008 ANSI/IEEE Standard for device function numbers in control and protection.

   b. Figures 6 and 7 illustrate device symbols, terminal blocks, and wire designations for horizontal and vertical applications respectively.

   c. The example in Figure 12 – RELAY IN A WIRING DIAGRAM (callout 2) would represent the first time delay relay used on a Fire System control. From Figure 1 - STD-E-C07527 FUNCTIONS AND DESIGNATIONS:

      1) 02F1 = (02) TIME-DELAY RELAY + (F) FIRE AND CO2 SYSTEM + (1) First numeric Identifier.

   d. A second time delay relay located in the same enclosure and associated with the fire control system would have the device designation 02F2.

Figure 6 – DEVICE SYMBOLS, TERMINAL BLOCKS, AND WIRE DESIGNATION (HORIZONTAL)

   e. When multiple pumping units have similar control or protection systems, they often have devices with similar functions. In this instance, the unit number will be used as the unique identifier. The unique identifier (Unit Number) may be a prefix or suffix to the device designation. For example, the device designation 233DVC or 33DVC2 may be used for a limit switch that is triggered when the discharge valve is closed on unit number 2. Refer to the existing plant drawings to determine which method to use.

2. Device Symbol

   a. The CAWCD standard device symbols are included in Figure 2 - STD-E-C07528 SINGLE-LINE AND SCHEMATIC DIAGRAMS SYMBOLS. Each device shall include a unique device

designation. The device designation is shown above a horizontally placed symbol or to either side of a vertically placed symbol.

b. As applicable, use a word or letter to describe the function of a device, such as “STOP”, “START”, “R” for remote, or “L” for local. The function description is shown below a horizontally placed symbol or to either side of a vertically placed symbol.

c. If the device is physically located in a different enclosure than listed on the drawing title block, the location enclosure designation shall be shown in parenthesis. The enclosure designation shall be shown below a horizontally placed symbol or to either side of a vertically placed symbol.

d. The device terminal connections are represented by small hollow circles at either side.

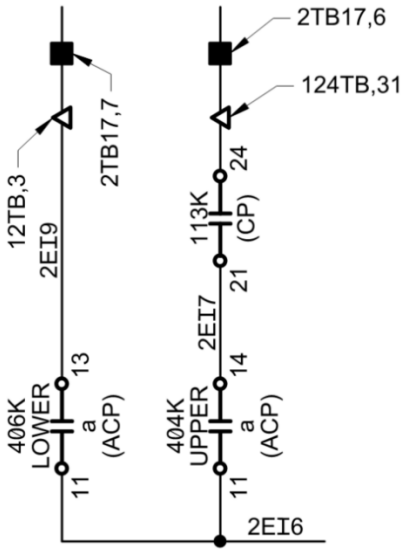


Figure 7 – DEVICE SYMBOLS, TERMICAL BLOCKS, AND WIRE DESIGNATION (VERTICAL)

3. Terminal Blocks

a. The terminal block graphic is a unique geometric shape that also represents the enclosure location of the terminal. The terminal block designation and number must match the wiring diagram. A legend shall be included in each sheet with the geometric shape and text, which denotes the terminal block enclosure as shown in Figure 8 – TERMINAL BLOCK LEGEND.

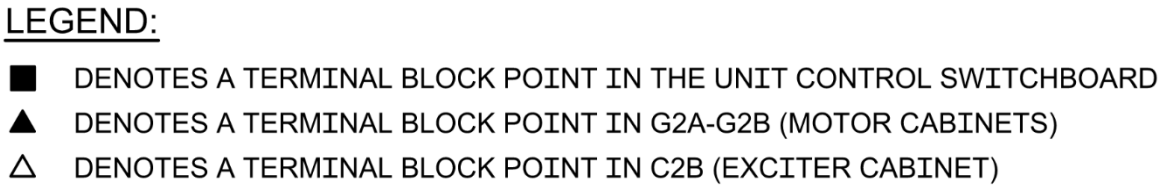


Figure 8 – TERMINAL BLOCK LEGEND

4. Coils and Contacts

a. Each coil must have the associated contact developed. The preferred method is to show the contacts on the same sheet as the coil. If the sheet does not have available space, a separate sheet may be used to show the contact development.

b. Contacts are shown in the de-energized state. All contacts must be shown, even if they are spare or not used. The contact development shall include the coil designation, de-energized state, terminal numbers, wire designation, purpose, and reference drawing. The reference drawing is the drawing in which the contact can be located. CAWCD drawings do not use rung numbers to reference the location of the contact. The reference drawing number is used and shown in parenthesis. If the contact is on the same sheet as the coil, use (THIS DWG) instead of the drawing number. See Figure 9 – RELAY AND COIL CONTACTS and Figure 10 – TIMER AND COIL CONTACTS for relay coil and timer coil, respectively.

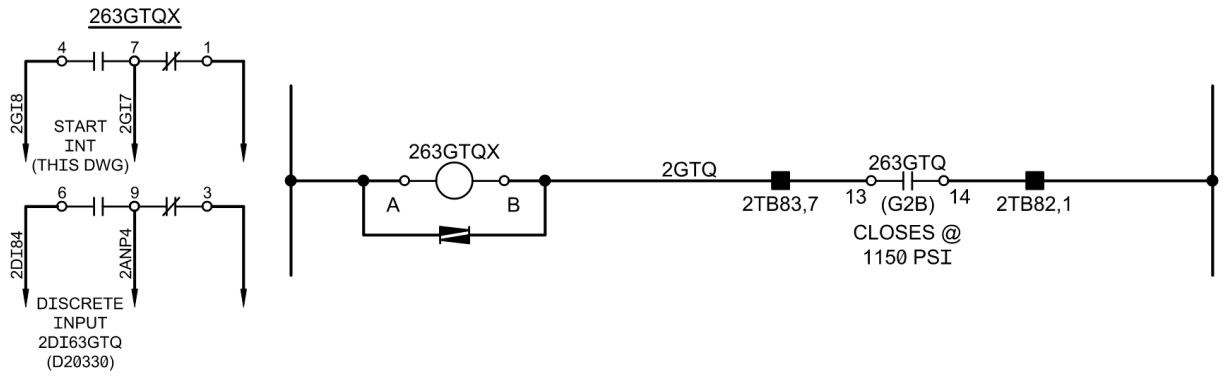


Figure 9 – RELAY AND COIL CONTACTS

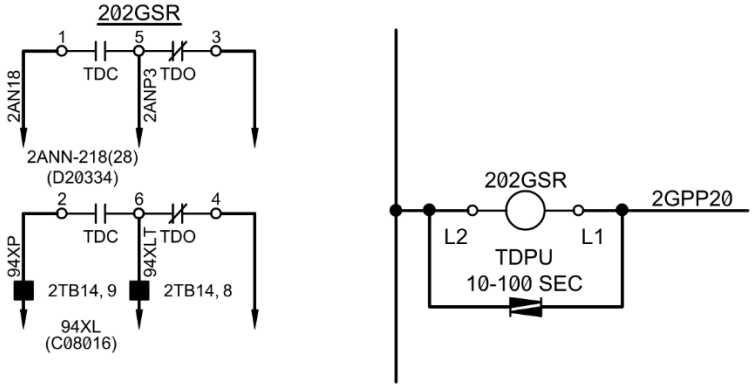


Figure 10 – TIMER AND COIL CONTACTS

5. Device Designations and Functions Table

a. Each sheet shall contain a device names and function table as shown in Table 4 – DEVICE DESIGNATIONS AND FUNCTIONS TABLE. The table must include:

1) The device designation (Number) assigned using Figure 1 - STD-E-C07527 FUNCTIONS AND DESIGNATIONS.
2) The manufacturer’s OEM number, if applicable.
3) Description of the device function

DEVICE	LOC.	DESCRIPTION	MFR & TYPE	DWG.
01CS1	CSA14F	UNIT START/STOP CONTROL SWITCH	WEST W-2	THIS DWG.
01X1	CSA14RX	UNIT NORMAL SHUTDOWN AUX. RELAY	WEST MG-6	THIS DWG.
02CL1	CSA14RX	UNIT CHL. ADMISSION TIMING RELAY	AGST. 7012PCX	THIS DWG.
03ST1	CSA14FX	UNIT STARTING INTERLOCK CHECKING RELAY		
03SD1	CSA14RX	UNIT SHUTDOWN SEQ. CHECKING RELAY	AGST. 7012PBX	THIS DWG.
04-1	CSA14RX	UNIT MASTER START RELAY	WEST MG-6	THIS DWG.
04A1	CSA14RX	UNIT AUX. START/STOP RELAY	WEST MG-6	THIS DWG.
04A1X	M1A	AUXILIARY RELAY TO 04A1		
05R1	CSA14RX	UNIT EMERGENCY SHTDN. RELAY	WEST MG-6	THIS DWG.
14MD1	M1A	UNIT MOTION DETECTOR		
31E1	C1A	BASLER DECS-250E RELAY NO. 7 (EXCITER READY TO START)		C23219
27SX1	CSA1RX	AUX. RELAY TO STATION SERVICE UNDERVOLTAGE RELAY	WEST MG-6	
27/47BXD	CSA8RX	BUS UNDER VOLTAGE / REVERSE PHASE AUX. RELAY	WEST MG-6	D05193
33DVC1	M1B	DISCHARGE VALVE LIMIT SWITCHES		
52E	C1A	EXCITER CABINET MOLDED CASE SWITCH (CB1)	BASLER ELECTRIC	D05346
43CS1	CSA14F	UNIT LOCAL/SUPV. CONTROL SWITCH	WEST W-2	THIS DWG.
48DVC1	M1B	DISCH. VALVE INCOMPLETE CLOSING RELAY		
43DV1	M1B	DISCHARGE VLV LOCAL/REMOTE SWITCH		
43CW1	CSA14RX	UNIT COOLING WATER SELECTOR SWITCH		
43HQ1		UNIT HIGH PRESS. LUBE OIL PUMP SELECTOR SWITCH		
52-1	U5A	UNIT POWER CIRCUIT BREAKER		
52EX	C1A	EXCITER CABINET MOLDED CASE SWITCH AUXILIARY (CB1X)	BASLER ELECTRIC	D05380
62SD1	CSA14RX	UNIT SHUTDOWN SEQ. TIME DELAY RELAY	AGST. 7012PFX	THIS DWG.
62SD1X	CSA14RX	AUX. RELAY FOR 62SD1	WEST SG	THIS DWG.
63CWN1	M1A	NORM. COOLING WATER PRESS. SWITCH		
63PSWN1	H1A	PUMP STUFFING BOX NORM. COOLING WATER PRESS. SWITCH		
63TBQ1		MOTOR HIGH PSI LUBE OIL-NORM. PRESSURE SWITCH		
71LBQH/LX1	M1A	MOTOR LOWER GUIDE BRG. OIL LEVEL AUXILIARY RELAY		
71PGQH1	H1A	PUMP GUIDE BRG. OIL LEVEL SWITCHES		
71PGQL1	H1A	PUMP GUIDE BRG. OIL LEVEL SWITCHES		
71TBQH/LX1	M1A	MOTOR THRUST BRG. OIL LEVEL SWITCHES AUXILIARY RELAY		
86-1	CSA14R	UNIT SHTDN. & LOCKOUT RELAY	WEST WL-2	D05178
86VFR	CSA8R	RIGHT HALF PLANT SHTDN. LOCKOUT RELAY	WEST WL-2	D05190
89N-CL1	C1A	NORMAL LINE ISOLATING DISC. AUX. SWITCH	WEST MG-6	D05178
94SX1	CSA14RX	UNIT EMER. SHTDN. AUX. TRIPPING RELAY		
BD-1	CSA14FX	BLOCKING DIODE		
R	CSA14F	UNIT STARTING INTERLOCK CIRCUIT READY INDICATING LIGHT		
R5	RTU	UNIT SUPV. START/STOP RELAY		
RTS-VFR	CSA8R	TEST SWITCH DEVICE 86VFR UNITS 1-5	WEST FT-1	
SVCW1	P1A	UNIT COOLING WATER SOLENOID		
SVCLA1	P1A	CHLORINE APPLICATION SOLENOID		
SVSB1	P1A	PUMP STUFFING BOX WATER SOLENOID	WEST EZC	THIS DWG.
DISSW	PLC/RTU	PLC OUTPUT DISCONNECT SWITCH		

Table 4 – EXAMPLE DEVICE DESIGNATIONS AND FUNCTIONS TABLE

6. Wire Designations (Name)

a. Wire designations shall always be unique within the system. The wire designation does not change across terminal block connections. Wire designations only change across a control device. Several unique alpha and/or numeric wire designations may be required to complete a circuit.

b. The CAWCD standard is to use descriptive wire designations. For example, in Figure 6 – DEVICE SYMBOLS, TERMINAL BLOCKS, AND WIRE DESIGNATION (HORIZONTAL), the wire from terminal block 2TB22,1 and terminal 8, on normal contact from device 233GBX2, is 2GI6. This is the sixth wire on the unit control circuit for Unit #2 generator interlock.

   2GI6 = (2) Unit Number + (G) Generator + (I) Interlock + (6) sixth wire.

c. The next wire in the same circuit may be a designation as 2GI7 and continue to increase by one.

   2GI7 = (2) Unit Number + (G) Generator + (I) Interlock + (7) seventh wire

d. An alphabetic character can be used only after a numeric character to differentiate wires in a circuit.

   2GI7A = (2) Unit Number + (G) Generator + (I) Interlock + (7) seventh wire + (A) section

e. When multiple pumping units have similar control or protection systems, they often have similar wire designations, except for a first identifier. The first identifier, in this example, is the unit number.

   2GI6 = (2) Unit # 2 Control + (G) Generator + (I) Interlock + (6) sixth wire

   3GI6 = (3) Unit # 3 Control + (G) Generator + (I) Interlock + (6) sixth wire

3.6 WIRING DIAGRAM DEVELOPMENT

A. The wiring diagram is a graphical representation of the physical layout and wiring of the electrical enclosure. The wiring diagram must have the devices arranged on the drawing as they are physically located within the enclosure. On the wiring diagram, place devices mounted on a door as installed with the door open and viewed from the rear. Wiring diagrams must include the device location, device designation, wire designation, wire color, wire destination, wire tags and terminal identification as referenced in this specification. Design plans must show the complete circuit wiring diagram changes, even if the circuit is shown in multiple drawings. The following information in this article provides

details of each element of a WIRING diagram. An example of a complete wiring diagram meeting CAWCD requirements is shown in Figure 11 – WIRING DIAGRAM (EXAMPLE).

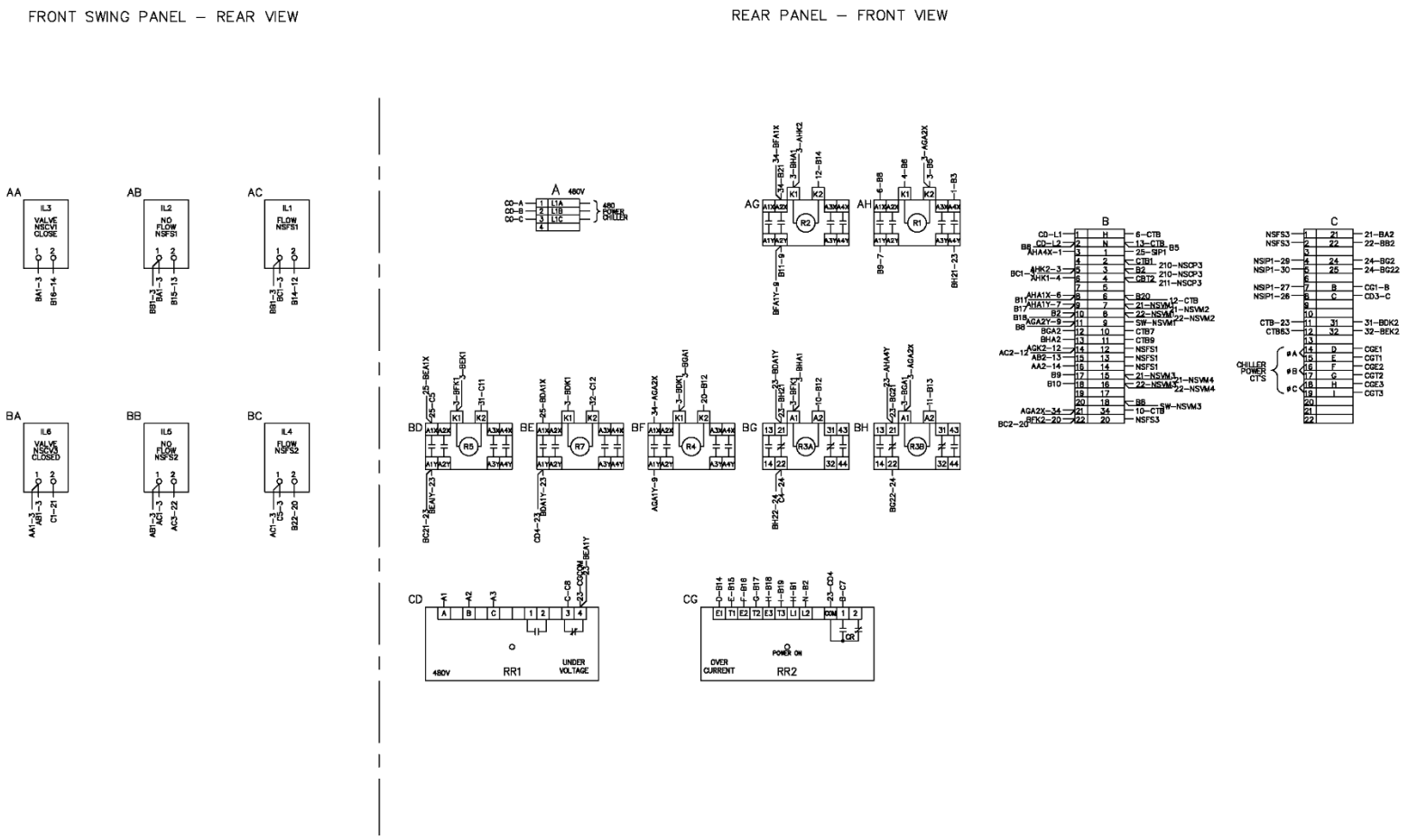


FIGURE 11 – WIRING DIAGRAM EXAMPLE

1. Device Location

    a. The placement of the device in a panel determines the device location designation. The enclosure is segmented into a grid of alphabetic rows and columns. Begin the grid on the top-left corner. The rows start at the top with the letter “A”. The columns start at the far left with the letter “A”. The same applies to devices mounted on a door or side panel. Show devices mounted on the door viewed from the back, with the door open.
    b. The example in Figure 12 – RELAY IN A WIRING DIAGRAM (callout 1) represents a relay in row “B”, column “D”. It is in the second row of devices and the fourth column from the left.

2. Terminal Block Designation

    a. The terminal block designation is a single, underlined letter as shown as the letter A in Figure 15 - TERMINAL BLOCK IN A WIRING DIAGRAM (callout 1). The letter is shown on the top of vertically stacked blocks and at the far left of horizontally stacked blocks. Designate the first terminal block as “A” and increase alphabetically throughout the enclosure. The block terminal numbers will always begin at number one and increase numerically until the end of the block. For example, terminal block “C” is the third block in the enclosure. The first terminal number will be the number one, regardless of the quantity of terminals that are in terminal blocks “A” or “B”.
    b. In some cases, the original equipment manufacturer may have used a non-standard terminal block designation. This non-standard terminal block is shown under the established standard letter designation as shown in Figure 15 - TERMINAL BLOCK IN A WIRING DIAGRAM (2TB1). The fourth terminal in Figure 15 is referenced as A4 or 2TB1,4.

3. Wire Destination

    a. In a wiring diagram, use wire destinations to allow for an extension reference to the same wire in the drawing. The wire destination details where the other end of the wire terminates. This is often required to prevent lines from crowding the drawing. A wire destination includes several parts. Refer to Figure 13 – SWITCH IN A WIRING DIAGRAM. A proper wire destination shall include the wire designation, device or terminal stud number, device location or terminal block name, and destination enclosure. There are two different methods used to document the wire destination. One method is required when referencing the wire destination on a device and the second is used on a terminal block.

4. Wire Destination for Devices

    a. The wire destination from one device to another is arranged in the following order as shown on Figure 13 – SWITCH IN A WIRING DIAGRAM:

        1) Place the wire designation closest to the source device and followed by a dash.
        2) Include the destination device location and stud separated by a comma.
        3) If the wire exits the enclosure or terminates in a different cubicle of the same equipment, the destination enclosure or cubicle designation, as determined by Article 3.2.A. Electrical Equipment List is placed in parentheses. In some cases, a cable or grouping of wires is used instead as defined in Article 8 Cable List and Cable Designation.

3.7 Wire Destination for Terminal Blocks

1. Use the terminal block standard layout to create the wire destination for terminal blocks as shown in Figure 14 – TERMINAL BLOCK STANDARD LAYOUT.

    a. Place the wire designation inside the terminal block rectangle.
    b. The terminal block designation (typically a single letter) is placed over the grouping of terminal blocks.
    c. On the corresponding terminal number, place the wire associated with the wire designation.
    d. For example, in Figure 15, A4 is the fourth terminal and has wire 2UCP landed on it.

2. For cross-referencing to a terminal:

    a. At the end of the wire, place the terminal block designation.
    b. The terminal block stud is next. No comma is used to separate the device location and terminal block stud. The exception to this is when the lack of a comma would place a character next to a character or a number next to a number.
    c. If the wire terminates in a different cubicle of the same equipment, the destination cubicle designation, as determined by Article 3.2.A. Electrical Equipment List is placed in parentheses.

3. If the wire exits the enclosure, it is shown as a cable. Refer to Article 3.6.A.8 Cable List and Cable Designation. In this instance, even a single conductor is considered a cable. The cable is given a cable designation number and listed in Figure 16 – CABLE LIST IN A WIRING DIAGRAM. The cable designation is assigned per Article 3.2.B Cables and Conduit List

a. Some examples are shown:

1) Figure 12 – RELAY IN A WIRING DIAGRAM (callout 3) the wire destination is S2,3-1FCT21. The wire designation is 1FCT21 and terminates at device S2 on stud number 3. Because the device designation and stud number create adjacent numbers, a comma separates two and three.
2) Figure 12– RELAY IN A WIRING DIAGRAM (callout 4) the wire destination is 1FCT2-S1,7. The wire designation is 1FCT2 and terminates at device S1 on stud number 7. Because the device designation and stud number create adjacent numbers, a comma separates two and seven.
3) Figure 12– RELAY IN A WIRING DIAGRAM (callout 5) the wire destination is F11-2FCT2. The wire designation is 2FCT2 and terminates at terminal block F on stud number 11. Because there is no comma between the characters following F, it is determined that the stud number is 11, not 1. (Note: F1,1 would mean the wire terminates at fuse 1 on stud number 1).
4) Figure 12 – RELAY IN A WIRING DIAGRAM (callout 6) the wire destination is (C8) H6-1FCT. The wire designation is 1FCT. It terminates on terminal block H on stud number 6, in panel C8. It terminates in a different enclosure with the equipment name C8, because it is in parenthesis.

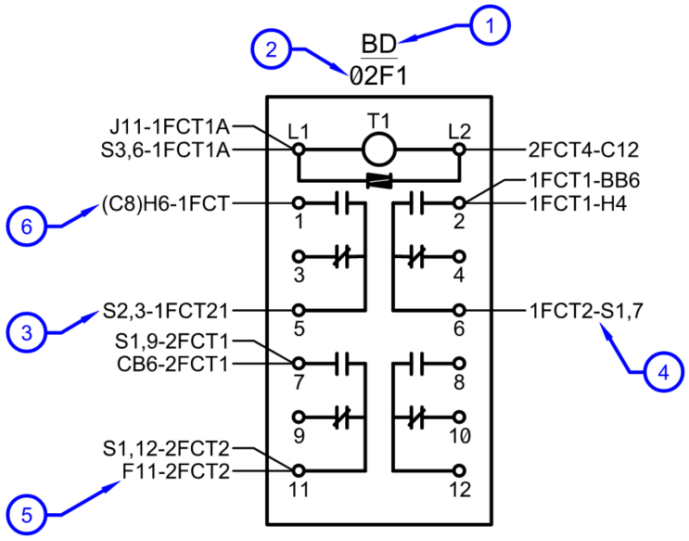
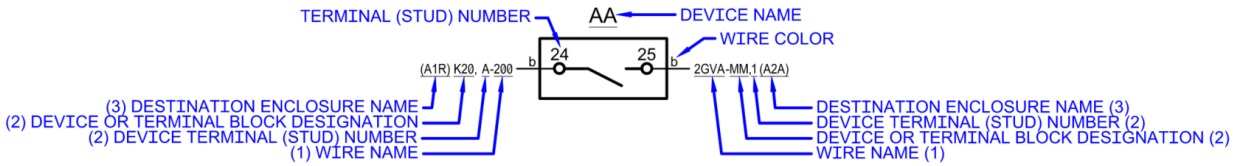


Figure 12 – RELAY IN A WIRING DIAGRAM



1. WIRE NAME DESIGNATION IS CLOSEST TO THE DEVICE FOLLOWED BY A DASH.
2. DESTINATION INCLUDES THE DEVICE OR TERMINAL BLOCK DESIGNATION. THE TERMINAL (STUD) IS SEPARATED FROM THE DEVICE BY A COMMA. NO COMMA IS TYPICALLY USED BETWEEN THE TERMINAL BLOCK DESIGNATION AND STUD.
3. IF THE WIRE DESTINATION LEAVES THE ENCLOSURE, THE DESTINATION ENCLOSURE IS SHOWN IN PARENTHESIS ( ).
4. ONLY THE WIRE NAME SHALL BE ON THE WIRE LABEL. DEVICE NAME, TERMINAL BLOCK NAME OR (STUD) DESIGNATION NUMBER SHALL NOT BE ON THE LABEL.

Figure 13 – SWITCH IN A WIRING DIAGRAM

4. Cable List and Cable Designation

   a. Use a cable list and cable designation number for any wire or wires that exit the enclosure. In wiring diagrams, single conductors that have the same destination enclosure or external device are represented by a cable. The color code designation of each conductor must be included in the wiring diagram shown in Figure 14 – TERMINAL BLOCK STANDARD LAYOUT. For multi-conductor cable, use color code designation per Table 5 – COLOR CODE STANDARD FOR CONTROL CABLES. Assign each cable a unique cable designation as detailed in Article3.2. B Cables and Conduit List.

ICEA Method 1, Table E-2 Colored compound with tracers			
CABLE	NUMBER	BASE	TRACER
2/C	1	Black	-
	2	Red	-
3/C	3	Blue	-
5/C	4	Orange	-
	5	Yellow	-
7/C	6	Brown	-
	7	Red	Black
9/C	8	Blue	Black
	9	Orange	Black
12/C	10	Yellow	Black
	11	Brown	Black
	12	Black	Red
16/C	13	Blue	Red
	14	Orange	Red
	15	Yellow	Red
	16	Brown	Red
36/C	17	Black	Blue
	18	Red	Blue
	19	Orange	Blue
	20	Yellow	Blue
	21	Brown	Blue
	22	Black	Orange
	23	Red	Orange
	24	Blue	Orange
	25	Yellow	Orange
	26	Brown	Orange
	27	Black	Yellow
	28	Red	Yellow
	29	Blue	Yellow
	30	Orange	Yellow
	31	Brown	Yellow
	32	Black	Brown
	33	Red	Brown
	34	Blue	Brown
	35	Orange	Brown
	36	Yellow	Brown

Table 5 – COLOR CODE STANDARD FOR CONTROL CABLES

b. Develop the cable list to include the cable designation number, cable designation, destination drawing number, and size of the single or multiple conductor cable. Refer to Figure 15 – TERMINAL BLOCK IN A WIRING DIAGRAM and Figure 16 – CABLE LIST IN A WIRING DIAGRAM for an example of a cable and cable list in a wiring diagram.

c. Note that the wiring diagram for the destination enclosure must be updated to match with the originating enclosure.

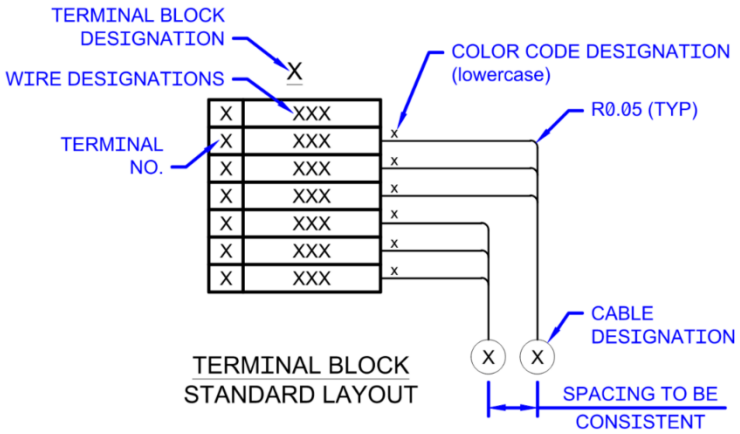


Figure 14 – TERMINAL BLOCK STANDARD LAYOUT

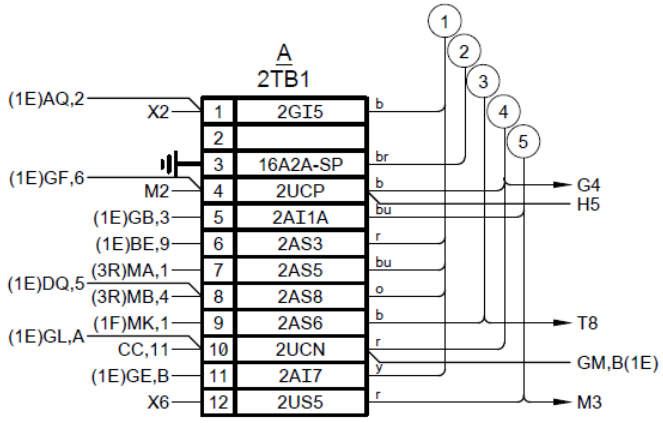


Figure 15 – TERMINAL BLOCK IN A WIRING DIAGRAM

CABLE LIST			
(#)	CABLE	DRAWING NO.	SIZE
1	8M7A-C7A	D03521	1-3/C-10
2	2C7A-CSB4	D03597	1-5/C-10
3	6C7A-CSB4	D03597	1-5/C-16
4	9C7A-CSB4	D03597	1-5/C-10
5	4M7A-C7A	D03521	1-3/C-10

Figure 16 – CABLE LIST IN A WIRING DIAGRAM

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes electrical equipment coordination and installation, firestopping, core drilling, sealant, common electrical installation requirements.

1.3 REFERENCES

A. National Electrical Contractors Association:

1. NECA 1 – Standard Practice for Good Workmanship in Electrical Construction, current edition.

B. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

C. American Society of Testing Materials (ASTM), current edition.

D. American National Standards Institute (ANSI), current edition.

E. National Electrical Manufacturer's Association (NEMA), current edition.

1.4 SYSTEM DESCRIPTION

A. Identify Electrical components as follows:

1. Nameplate for each electrical distribution and control equipment enclosure.
2. Wire marker or label, as required, for each conductor at panelboards, control cabinets, pull boxes, outlet and junction boxes.
3. Identification for electrical systems according to Section 260553.

B. Firestopping: Conform to UL for fire resistance ratings and surface burning characteristics.

C. Firestopping according to Section 078400.

1.5 SUBMITTALS

A. Product Data (PD)

1. Submit manufacturer’s catalog data and material safety data sheets for firestopping products.
2. Submit manufacturer's catalog data and material safety data sheets for sealant products.

B. Shop Drawings (SD)

1. Power and control schematic and wiring diagrams.

    a. Labeling on schematic and wiring diagrams shall include cross reference information (from-point or to-point), in addition to the unique numerical wire label, for each wire.
    b. Wiring diagrams shall be point to point drawings with device designations, circuit numbering, cable designations, wire numbers, and cross-referencing approved by CAWCD.

1.6 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. Allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. Provide for ease of disconnecting the equipment with minimum interference to other installations.
3. Allow right of way for piping and conduit installed at required slope.
4. Connecting raceways, cables, wireways, cable trays, and busways to be clear of obstructions and of the working and access space of other equipment.
5. Verify new cabinet installations meet NEC requirements for spacing and door egress.

B. Coordinate installation of required supporting devices with existing walls and other structural components including all existing mechanical systems.

PART 2 - PRODUCTS

2.1 FIRESTOPPING

A. Firestopping materials and accessories: Comply with requirements of Section 078400.

2.2 CORE DRILLING

A. A CAWCD core drilling permit must be applied for, and approved, prior to any core drilling in accordance with Section 015000. A Coring or Cutting Permit is required when a penetration into a concrete member is extending over 6 inches deep into the member or the penetration depth is greater than one third of the member thickness, whichever is less.

B. Coring/Cutting Permit and Authorization according to CAWCD Engineering Services – Engineering Resources Division.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove electrical equipment that is no longer in use. Ground both ends and label the unused conductors to make them spare and usable in the future.

B. Disconnect and remove all conduit and conductors between equipment that is no longer in use.

C. Conductors which are part of multi-conductor cables that are made spare during construction shall be de-terminated, labeled as spare, landed at a spare terminal block, and grounded.

1. If there are not enough spare terminals to land spare conductors, spares may be grouped together and bonded via a split bolt, and a single connection from the split bolt grounded. Submit an RFI to CAWCD to utilize this method.

D. Provide temporary wiring and connections to maintain existing systems in service during construction.

E. Remove, relocate, and extend existing installations to accommodate new construction.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Loads and circuits added to existing panelboards shall be balanced between phases.

H. Protect existing electrical equipment and installations that are indicated to remain. If damaged or disturbed in the course of the Work, remove damaged parts and install new products of equal standard and functionality.

3.2 INSTALLATION

A. Comply with NECA 1 for installation of all new equipment and modification of existing equipment.

B. Install nameplate parallel to equipment lines. Secure nameplate to equipment front using screws.

C. Firestopping Materials: Comply with requirements of Section 078400.

END OF SECTION 260500

SECTION 260502 – DEMOLITION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. See Section 260500 for Common Work Results for Electrical.

1.2 SCOPE OF WORK

A. Provide all material, equipment and labor required to remove, relocate and/or reconnect all electrical work identified in these specifications and indicated on the project plans.

1.3 SUMMARY

A. This Section includes limited scope, general construction materials and methods for application of selective demolition with electrical installations as follows:

1. Selective demolition including:

    a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
    b. Dismantling electrical materials and equipment made obsolete by these installations.

2. Excavation for underground utilities and services, including underground raceways.
3. Miscellaneous metals for support of electrical materials and equipment.
4. Nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
5. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
6. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.4 PROJECT CONDITIONS

A. Conditions affecting selective demolition:

1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
3. If material is cut or removed that may result in loose conductive materials or sparks being generated, a temporary protective catch/barrier shall be constructed to protect other equipment.

B. Conditions affecting excavations:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. If digging or excavation is required to access equipment, a Blue Stake permit shall be filed through CAWCD as soon as the work is identified (a minimum of 2-weeks notice ahead of time).

    a. Existing utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.

4. Remove existing underground utilities indicated to be removed.

    a. Uncharted or incorrectly charted utilities: Contact utility owner immediately for instructions
    b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to CAWCD prior to utility interruption.

5. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Verify field measurements and circuiting arrangements as shown on plans.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to CAWCD before disturbing existing installation.

D. Beginning of demolition means Contractor accepts existing conditions.

PART 3 - EXECUTION

3.1 PREPARATION

A. Disconnect and remove electrical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate utility service outages with CAWCD a minimum of 72 hours prior to outage.

C. Provide temporary wiring and connections to maintain existing systems in service during construction. As required, provide temporary generator or UPS if power systems are removed or replaced during the construction as specified. When work must be performed on energized equipment, use experienced personnel (as approved by CAWCD) in such operations.

D. Existing electrical services: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from the CAWCD at least 72 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.2 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of this section.

B. Remove, relocate and extend existing installations to accommodate new construction. Re-circuit and reconnect all electrical lighting, outlets, and equipment not scheduled for removal that have become disconnected due to demolition work.

C. Remove abandoned wiring to source of supply. Ground both ends and label the unused conductors to make them spare and usable in the future.

D. Unused electrical equipment must be demolished and removed from site.

1. CAWCD permission must be given to leave any unused equipment abandoned in place.

E. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors and patch surfaces in accordance with Section 078400 Firestopping.

F. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit serving them is removed. Provide blank cover for abandoned outlets which are not removed. Disconnect and remove abandoned panelboards and distribution equipment.

G. Disconnect and remove electrical devices and equipment serving utility equipment that has been removed.

H. Disconnect and remove abandoned luminaries. Remove brackets, hangers and other accessories.

I. Repair adjacent construction and finishes damaged during demolition and extension work. Any damage to building, piping or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to CAWCD.

J. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

K. Removal and replacement of ceiling tile(s) to perform work operations shall be the responsibility of the Contractor. The Contractor shall be responsible for replacement of any ceiling tiles or framework that may become damaged at no cost to CAWCD.

3.3 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Carefully remove equipment or materials which are to be reused.

C. Materials and equipment to be salvaged: Remove, demount, and disconnect existing electrical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.

D. Disposal and cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

3.4 INSTALLATION

A. Install relocated materials and equipment under the provisions of this section.

3.5 ITEMS SALVAGED TO CAWCD

A. All items shall be salvaged to CAWCD, or as specified in the contract. Move and store in dry location as directed. Refuse materials and items not salvaged shall be removed from the site and legally disposed of.

END OF SECTION 260502

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes:

1. Medium voltage cable.
2. Medium voltage cable terminations.
3. Fireproofing tape.
4. Underground cable markers
5. Bedding and cover materials.
6. Testing and other related materials for use in medium voltage systems.

1.3 REFERENCES

A. NFPA 70 – National Electrical Code. Contractor shall confirm the current CAWCD adopted edition.

B. ICEA S-97-682 – Standard for Utility Shielded Power Cables Rated 5 kV Through 46 kV.

C. UL 1072 – Standard for Medium-Voltage Power Cables.

D. NETA ATS – International Electrical Testing Association.

E. IEEE 400-2012 - Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5kV and above.

1.4 QUALITY ASSURANCE

A. Cable shall be tested in accordance with UL Standard 1072, ICEA S-97-682, and NETA Acceptance Testing Specifications.

B. The medium voltage power cable shall have at least 10-year performance record in industrial and utility applications.

1.5 SUBMITTALS

A. Product Data (PD)

1. Cable, terminations, and accessories. Submit in accordance with submittal procedures as described in Section 013300 and as noted on Plans.

B. Quality Control Reports (QCR)

1. Warranty: The manufacturer shall agree to replace any defective section of cable free of charge and extend the same warranty on the replacement cable.
2. Installation instructions and recommendations.
3. Splicing equipment and kits.
4. Termination equipment and kits.
5. Manufacturer's factory test data.
6. Field Test Reports: Indicate results of cable test in tabular form and in plots of current versus voltage for incremental voltage steps, and current versus time at 30 second intervals at maximum voltage.

1.6 CLOSEOUT SUBMITTALS

A. General

1. Project Record Documents: Record actual sizes and locations of cables.
2. Operation and Maintenance Data: Include instructions for testing and cleaning cable and accessories.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect cable from damage during transportation and handling.

B. Protect cable ends from entrance of moisture.

PART 2 - PRODUCTS

2.1 MEDIUM-VOLTAGE CABLE

A. Manufacturers: Manufacturers: Cable shall be manufactured by Okonite; General Cable; Kerite; or as approved by CAWCD.

1. Substitutions: Coordinate approval with CAWCD.

B. Conductor: AWG sized as noted on the Plans. The conductor material shall be annealed copper compact stranded per ASTM B-496.

C. Strand Screen: The conductor shall be covered with extruded semiconducting EPR strand screen. All strand screens shall meet or exceed the electrical and physical requirements of ICEA S-93-639/NEMA WC74, CSA C68.10 and UL 1072.

D. Insulation shall meet or exceed physical and electrical requirements of ANSI/NEMA WC 74/ICEA S-93-639 and ICEA S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

E. Insulation Screen: shall be extruded semiconducting EPR insulation screen applied directly over the insulation. Insulation screens shall meet or exceed electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

F. Insulation thickness shall be 133% (220 mils) and rated 105 degree C for normal operation and 140 degree C for emergency operation.

G. Cable Continuous Operating Temperature Rating: per Plans or Special Provisions.

H. Configuration: per Plans or Special Provisions.

I. Conductor Material: Copper

J. Conductor Construction: per Plans or Special Provisions.

K. Conductor Shield shall be a 5-mil copper tape helically applied with 20% minimum overlap.

L. Non-Armor Jacket: [PVC] [High density, cross-linked, polyethylene (XLPE)] [Thermo-plastic rubber] with red extruded identification stripe.

M. Armor Jacket: per Plans or Special Provisions.

N. Jacket shall meet or exceed electrical and physical requirements of ANSI/NEMA WC 74/ICEA S-93-639 and ICEA S-97-682, CSA C68.3 and UL 1072 for chlorinated polyethylene jackets.

O. The overall jacket shall be free-stripping from the shielding tape.

P. Splices: Splices in duct runs are not allowed.

Q. Grounding conductor shall be grounded and bonded to building only at the final termination at an MV disconnect, breaker, etc. Bonding shall be done with materials that are UL listed for grounding purposes. The power cable shields of all spliced power cables shall also be grounded and bonded to the ground conductor.

R. Testing: Meet or exceeds requirements of NETA ATS and IEEE 400-2012 - Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5kV and above.

2.2 CABLE TERMINATIONS

A. Voltage: per Plans or Special Provisions.

B. Location: per Plans or Special Provisions.

C. Conductor Quantity: per Plans or Special Provisions.

D. Type: per Plans or Special Provisions.

E. Modular Molded Rubber Termination: shall meet or exceed ANSI/IEEE 386. Kit form and Modular Splicing System are suitable for use with specified cables on the Plans.

F. Indoor Cold Shrink Terminations: The termination must be of a pre-stretched cold shrink design, shall be installed without the application heat source. Applications shall meet or exceed IEEE Standard 48 Class 1 for indoor and weather-protected applications. Applications and kits shall be in accordance with the Plans or as approved by CAWCD.

G. Outdoor Weather-Exposed Cold Shrink Terminations: The termination shall be of a pre-stretched cold shrink design, installed without the application heat source. Applications shall meet or exceed IEEE Standard 48 Class 1 for outdoor and weather-protected applications. Applications and Kits shall be in accordance with the Plans or as approved by CAWCD.

H. Motor Terminations: Terminations shall be installed per manufacturer’s instructions or in accordance with the Plans.

I. Loadbreak Elbows: Where required or as specified on Plans, loadbreak elbows shall be molded using high quality EPDM insulation. Loadbreak elbows shall be a fully shielded and insulated plug-in separate connector for connecting 5 kV to 25 kV underground cables to transformers, switchgear and junctions that are equipped with loadbreak bushings.

2.3 FIREPROOFING TAPE

A. Manufacturers:

1. 3M, Plymouth; or as approved by CAWCD . Type per Plans or Special Provisions.
2. Substitutions: Under provisions of Section 00600.3.6.

B. Product Description: Flexible, conformable fabric, coated on one side with flame retardant, flexible polymeric or chlorinated elastomer. Non-corrosive and compatible with cable sheaths jackets. Does not support combustion. The fireproofing tape shall not deteriorate when subjected to water, gases, oil, sewage or fungus.

C. Width: Approximately 3 inches (76 mm).

D. Thickness: Not less than 0.03 inch (0.76 mm).

E. Weight: Not less than 2.5 lb per sq yd (1.4 kg per sq m).

2.4 UNDERGROUND CABLE MARKERS

A. Manufacturers:

1. Almetek Industries, Type E-Z Tag; or equal.
2. Substitutions: Under provisions of Section 00600.3.6.

B. Furnish materials according to standards specified in Plans or Special Provisions.

C. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches (150 mm) wide by 4 mil (0.10 mm) thick, manufactured for direct burial service.

D. Trace Wire: Magnetic detectable conductor, plastic covering, per Plans or Special Provisions, imprinted with **MEDIUM-VOLTAGE CABLE** in large letters.

2.5 BEDDING AND COVER MATERIALS

A. Bedding and Cover Materials are accordance with CAP CS 31-2040 or as specified on Plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

B. Verify the new work is ready to receive cable.

C. Verify routing and termination locations of cable prior to rough-in.

3.2 PREPARATION

A. Use swab to clean conduits and/or ducts before pulling cables.

3.3 EXISTING WORK

A. Remove abandoned medium-voltage cable.

B. Maintain access to existing medium-voltage cable and other installations remaining active and requiring access. Modify installation or provide access panel.

C. Extend existing medium-voltage cable installations using materials and methods compatible with existing electrical installations, or as specified.

D. Existing defective medium-voltage cables shall be replaced.

3.4 INSTALLATION

A. General:

1. Pulling data to be submitted to CAWCD for review prior mobilizing on-site.
2. Avoid abrasion and other damage to cables during installation.
3. Use suitable manufacturer-approved lubricants and pulling equipment.
4. Sustain cable pulling tensions and bending radii below manufacturer's recommended limits.
5. Ground cable shield at each termination and splice.
6. Install cables in manholes along wall providing longest route.
7. Arrange cable in manholes to avoid interference with duct entrances.
8. If a section of cable is damaged during execution of work, the entire section shall be replaced with an entire new cable.
9. Circuits shall have each phase tagged (A, B, and C) at termination points and on either side of each end in a manhole.
10. Cables shall be labeled to identify their destination.
11. The following cable testing shall be performed after the installation:

    a. Insulation resistance testing shall be performed on each conductor.
    b. Shield continuity testing shall be performed on each power cable.
    c. Very Low Frequency (VLF) Tan Delta testing shall be performed per applicable standards or manufacturer's data.

d. Very Low Frequency (VLF) withstand testing shall be performed per applicable standards or manufacturer's data.

3.5 FIREPROOFING

A. Apply fireproofing tape to cables when installed in manholes, cable rooms, pull boxes, or other enclosures.

B. Smooth out irregularities, at splices or other locations, with insulation putty before applying fireproofing tape.

C. Apply fireproofing tape tightly around cables spirally in half-lapped wrapping or in butt jointed wrapping with second wrapping covering joints first.

D. Extend fireproofing 1 inch (25 mm) into conduit or duct.

E. Install tape with coated side toward cable.

F. Install random wrappings of plastic tape around fireproofing tape to prevent unraveling.

G. Install fireproofing to withstand a 200-ampere arc for 30 seconds.

3.6 FIELD QUALITY CONTROL

A. Inspect exposed cable sections for physical damage.

B. Inspect cable for proper connections.

C. Inspect shield grounding, cable supports, and terminations for proper installation.

D. Inspect and test according to NETA ATS, except Section 4.

E. Perform inspections and tests listed in NETA ATS, Section 7.3.

F. Testing specified in Section 3.4 of this specification.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Protect installed cables from entrance of moisture. During installation, cables shall be protected from physical damage and infiltration water.

B. Damaged cables shall be rejected and replaced at the Contractor's expense.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this Section.

1.2 SUMMARY

A. Section includes:

1. Wire and cable rated 600 V and less.
2. Connectors and terminations rated 600 V and less.

B. Section excludes wire and cable used for control signals.

1. Also excluded is control power wiring (e.g. loop power for a transducer). Coordinate with Section 400523 Instrumentation and Control Communication Cabling .

1.3 REFERENCES

A. Underwriters Laboratory:

1. UL 486A-486B – Wire Connectors.

B. International Electrical Testing Association:

1. NETA ATS – Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.

C. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm the current CAWCD adopted edition.

1.4 SUBMITTALS

A. Product Data (PD)

1. Submit manufacturer's catalog information for each type of product.
2. Submit product schedule with indicate type, termination locations, use and location.

3. Submit qualification data for testing agency.

B. Quality Control Reports (QCR)

1. Test Reports: Include results from test procedures outlined in this specification.

1.5 QUALITY ASSURANCE

A. Wires, cables, and electrical components shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to CAWCD and marked for intended use.

PART 2 - PRODUCTS

2.1 WIRE

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Encore Wire.
2. General Cable.
3. Southwire.
4. Substitutions: Under provisions of Section 00600.3.6, and as approved by CAWCD.

B. Description: Single conductor, insulated, stranded wire. Minimum size No. 12 AWG.

C. Conductor Material: Copper.

D. Insulation Voltage Rating: 600 volts.

E. Insulation Material: XHHW-2 unless specified otherwise.

F. Cables shall be labeled to identify their destination. Refer to Section 260553 Identification for Electrical Systems.

G. Flexible cords and cables shall be coordinated with latest NEC requirements.

2.2 MULTI-CONDUCTOR CABLE

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Encore Wire.
2. General Cable.
3. Southwire.
4. Substitutions: Under provisions of Section 00600.3.6, and as approved by CAWCD.

B. Description: Multi-conductor cable with outer jacket and consisting of individually insulated stranded wires with a minimum size of No. 12 AWG.

C. Multi-conductor cable wire colors shall be in accordance with USBR standard as shown in USBR standard drawing 104-D-1033. Coordinate with CAWCD prior to submitting product data.

D. Conductor Material: Copper.

E. Insulation Voltage Rating: 600 volts.

2.3 TERMINATIONS

A. Terminal Lugs: Mechanical type, copper, ring terminal. Coordinate with Section 262726 Wiring Devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Complete raceway installation between conductor and cable termination points according to Section 260533 Raceway and Boxes for Electrical Systems prior to pulling conductors and cables.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means that will not damage cables or raceway.

1. Some specific cable manufacturers have requirements or recommended methods for pulling cables, refer to manufacturer documentation.

D. Support cables according to Section 260529 Hangers and Supports for Electrical Systems.

E. The contractor shall ensure the installation includes drip loops for wet or damp locations if cables are being passed through a gland or into an enclosure.

F. Ground spare conductors according to Section 260526 Grounding and Bonding for Electrical Systems.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Splices are not allowed. If an existing conductor is too short to land, coordinate with CAWCD on next steps.

1. Generally, a terminal block connection shall be used, or a new cable installed in lieu of a splice.

3.3 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 Identification for Electrical Systems.

B. Identify spare conductors as spare at each end with identity number and location of other end of conductor.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage qualified testing agency to perform tests and inspections.

B. Testing Agency Qualifications: Certified by NETA to perform on-site testing.

C. Tests and Inspections: Perform in accordance with NETA ATS Section 7.3.2, "Cables, Low-Voltage, 600-Volt Maximum."

1. Insulation resistance testing (i.e. meggering) for newly installed cables shall be performed at a minimum. Provide CAWCD with a report on insulation resistance values of all new conductors.

D. Test and Inspection Reports: Prepare a written report to record the following.

1. Procedures used
2. Results that comply with requirements.

3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections. Contractor shall remove and replace the malfunctioning cables and retest as specified above.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this Section.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment including rod electrodes, wire, mechanical connectors, and exothermic connections.

1.3 REFERENCES

A. National Fire Protection Association:

1. NFPA 70 - National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

B. Underwriters Laboratory:

1. UL 467 – Grounding and Bonding Equipment.
2. UL 83 – Safety Thermoplastic-Insulated Wires and Cables

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 142 – Recommended Practice for Grounding of Industrial and Commercial Power Systems.

D. National Electrical Testing Association:

1. ANSI/NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

1.4 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 5 ohms maximum.

1.5 SUBMITTALS

A. Product Data (PD)

1. For each type of product indicated.
2. Listed and labeled as defined in NFPA 70.

B. Quality Control Reports (QCR)

1. Qualification Data: For testing agency and testing agency field personnel.
2. Test Reports: Include results from test procedures outlined in this specification.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of a nationally recognized testing laboratory.

1. Testing Agency Field Personnel: Certified by NETA to perform on-site testing.

B. Grounding System Components and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 and IEEE 142 for grounding and bonding materials and equipment.

D. Complete grounding and bonding of building reinforcing steel prior to concrete placement.

PART 2 - PRODUCTS

2.1 ROD ELECTRODES

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Burndy.
2. ERICO.
3. O-Z/Gedney.

B. Description:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Length: 10 feet.

C. Connector: Connector for exothermic welded connection.

2.2 WIRE

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. General Cable.
2. Okonite.
3. Southwire.

B. Material: Stranded copper.

2.3 MECHANICAL CONNECTORS

A. Description: Bolted, bronze connectors, suitable for grounding and bonding applications, in configurations required for installation.

2.4 EXOTHERMIC CONNECTIONS

A. Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ground Rods: Drive rods until tops are 2 inches below final grade.

1. Interconnect ground rods with grounding electrode conductor below grade. Make connections without exposing steel or damaging coating.

B. Conductors: Install solid conductor for #18 AWG and smaller, and stranded conductor for #16 AWG and larger.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Mechanical connectors.
2. Underground Connections: Exothermic.
3. Connections to Structural Steel: Exothermic.
4. Equipment Stands, Cabinets, and Enclosures: Mechanical connectors

D. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NEC article 250; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and equipment branch circuits.
5. Three-phase motor and equipment branch circuits.
6. Circuits in flexible raceways.
7. Circuits in armored and metal-clad cable.

B. Equipment installed within a pumping plant:

1. Equipment grounds shall be bonded to the nearest grounding pad within a pumping plant.
2. Install #4/0 AWG bare copper conductor for bonding to equipment within a pumping plant.
3. Install #4/0 AWG bare tinned copper conductor for bonding to equipment located on the lowest level of the pumping plant.
4. Ground straps shall be installed to secure the grounding conductors. Ground straps shall be installed to secure grounding conductors. Materials and finishes shall be selected to minimize corrosion and prevent galvanic incompatibility with the grounding conductors.

C. Substation Equipment:

1. Install #4/0 AWG bare copper conductor for bonding to equipment in pumping plant substations.
2. Measure ground grid resistance to Earth prior to any outside connection to ground grid area.
3. Measure point to point resistance.
4. Contractor shall analyze the touch and step potentials prior to the grounding design.

    a. If ground grid extension is required, coordinate with CAWCD on requirements. In general, #4/0 AWG bare copper shall be used as

well as ground rods at each corner. Exothermic weld connections shall be used.

5. Contractor shall coordinate with CAWCD for specific ground utility/substation equipment requirements.

D. Exterior Water Line and Conduit Supports: Bond metallic support structures to ground grid using #4/0 AWG bare copper cable.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

F. Butterfly Valves (pumping plants): Contractor shall confirm whether existing lines are already grounded on both ends prior to ground and bond the new grounding jumper between new valve and existing water line. Contractor shall use #6 grounding conductor or above to ground and bond the new valve. Contractor shall coordinate with CAWCD for additional requirements.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system, but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Perform ground resistance testing according to ANSI/NETA ATS.

    a. If applicable, perform fall-of-potential or alternative test according to ANSI/NETA ATS for any new main grounding electrode or system.

4. Perform continuity testing according to ANSI/NETA ATS.

    a. CAWCD requires that point-to-point tests yield 1.0 Ohm or less.
    b. Perform point-to-point testing to verify ground bonding between existing grounding system/network and newly installed electrical equipment. List ground locations utilized as ground references.

5. Provide CAWCD with reports of all testing and inspections.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions, apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.
3. Hangers and supports for electrical equipment and systems.

1.3 REFERENCES

A. American Welding Society:

1. AWS D1.1 – Structural Welding Code – Steel.

B. American National Standards Institute:

1. ANSI/MSS SP-58 – Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation.
2. ANSI/MSS SP-69 – Pipe Hangers and Supports – Selection and Application.

C. ASTM International:

1. ASTM A36 – Standard Specification for Carbon Structural Steel.
2. ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
3. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

D. Metal Framing Manufacturers Association:

1. MFMA-4 – Metal Framing Standards Publication.

E. National Electrical Contractors Association:

1. NECA 1 – Standard Practice for Good Workmanship in Electrical Construction.
2. NECA 101 – Standard for Installing Steel Conduit (Rigid, IMC, EMT).

F. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.
2. NFPA 13 – Standard for the Installation of Sprinkler Systems

1.4 SYSTEM DESCRIPTION

A. Firestopping Materials: Comply with requirements of Section 078400.

B. Firestop interruptions to fire-rated assemblies, materials, and components.

1.5 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.6 SUBMITTALS

A. Product Data (PD)

1. Hangers and Supports: Manufacturers' catalog data including load capacity.

B. Shop Drawings: Show fabrication and installation details and include calculations for the components and equipment supports.

C. Quality Control Reports (QCR)

1. Welding certificates.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code – Steel."

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include but are not limited to the following.

a. Cooper B-Line.
b. ERICO.
c. Thomas & Betts.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Structural Steel for Fabricated Supports and Restraints: ASTM A 36, steel plates, shapes, and bars; galvanized.

D. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following.

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-Line.
2) Empire Tool and Manufacturing.
3) Hilti.
4) ITW Ramset/Red Head.
5) MKT Fastening.

2. Concrete Inserts: Steel slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 PREPARATION

A. Obtain approved core permits from CAWCD before drilling or cutting structural members.

3.2 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for rigid metal conduit as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits, communication systems, and for fastening raceways to trapeze supports.

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements of hangers and supports for electrical equipment and systems.

B. Strength of Support Assemblies: Select sizes of components so strength will be adequate to carry present static load. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.

C. Mounting and Anchorage of Surface Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods:

1. New Concrete: Bolt to concrete inserts.
2. Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
3. Existing Concrete: Expansion anchor fasteners.
4. Steel: Boom clamps complying with MSS SP-69.
5. Light Steel: Sheet metal screws.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.4 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit, and place miscellaneous metal supports in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.5 PAINTING

A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions, apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this Section.

1.2 SUMMARY

A. Section Includes: Conduit and tubing, surface raceways, wireways, outlet boxes, pull and junction boxes, and handholes.

B. Design Requirements shall be verified with CAWCD prior to construction.

1.3 REFERENCES

A. American National Standards Institute:

1. ANSI C80.1 – Rigid Steel Conduit, Zinc Coated.
2. ANSI SCTE 77 – Specification for Underground Enclosure Integrity.
3. ANSI/TIA-569 – Network Closet and General Requirements

B. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA FB 1 – Fitting, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
3. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
4. NEMA TC 3 – PCV Fittings for Use with Rigid PVC Conduit and Tubing.

C. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 DESIGN REQUIREMENTS

A. Minimum Raceway Size: 3/4-inch conduit unless otherwise specified.

B. Material: All conduit shall be galvanized rigid steel UNLESS otherwise specified.

1.5 SUBMITTALS

A. Product Data (PD)

1. For raceways, wireways and fittings, hinged-cover enclosures, and cabinets.

B. Shop Drawings (SD)

1. Include plans, elevations, sections, and details for the following components.
2. Enclosures and cabinets.
3. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.
b. Frame and cover design.
c. Grounding details.
d. Joint details.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to CAWCD.

PART 2 - PRODUCTS

2.1 METAL CONDUIT

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Allied Tube & Conduit.
2. Calconduit.
3. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. Flexible Metal Conduit: Zinc-coated steel.

D. Liquidtight Flexible Metal Conduit: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

E. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Allied Tube & Conduit.
2. Cantex.
3. Carlon.

B. Rigid Non-metallic Conduit: NEMA TC 2, Type EPC-40-PVC, unless otherwise specified.

C. Fittings for Rigid Non-metallic Conduit: NEMA TC 3; match to conduit type and material.

2.3 BOXES AND ENCLOSURES

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Cooper Industries.
2. Hoffman.
3. Thomas & Betts.

B. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

C. Hinged-Cover Enclosures: NEMA 250 type 3R, with continuous-hinge cover with flush latch, unless otherwise specified.

1. Lowest level of a pumping plant: provide NEMA 250 type 4X enclosure, unless otherwise specified.
2. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
3. A factory furnished backplate is required to mount internal components, unless otherwise specified.

D. Cabinets:

1. All enclosures shall be NEMA 250 type 3R, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.

E. Lowest level of a pumping plant: provide NEMA 250 type 4X enclosure, unless otherwise specified.

2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with ANSI SCTE 77.

1. Color of Frame and Cover: Gray.
2. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
6. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

a. Armorcast Products Company.
b. Carson Industries LLC.
c. CDR Systems Corporation.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated.

1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, NEMA 250 type 3R.
6. Application of Handholes and Boxes for Underground Wiring: Polymer concrete.

7. Below Grade Conduit: PVC conduit may be used for exterior underground installations, and installed as follows:

    a. All plastic conduit shall be rigid, Schedule 40, heavy wall PVC.
    b. Install bell ends at all conduit terminations in manholes and pull boxes and under equipment.
    c. All bends over 30 degrees shall be made with wrapped IMC.
    d. Stubups below switchboard/switchgear equipment shall be between 1 and 2 inches above the floor surface with the bell fitting installed
    e. All plastic conduit, except that used for telephone, shall contain a code-sized bond wire.

B. Comply with the following indoor applications, unless otherwise indicated.

1. All indoor applications shall be rigid steel conduit.
2. Boxes and Enclosures: NEMA 250 type 3R.

    a. Lowest level of pumping plant: NEMA 250 type 4X, unless specified otherwise.

C. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated. Threadless couplings and connectors shall not be used on threaded conduit ends.

3.2 INSTALLATION

A. Support raceways as specified in Section 260529.

B. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

C. Install no more than the equivalent of four 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

D. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

E. All cut ends of rigid metal conduit shall be finished to remove rough edges. Contractor shall follow conduit cutting and threading guidelines unless manufacturer’s instructions differ.

F. Boxes shall be placed in a straight section of conduit and not used in lieu of a bend.

G. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

H. Ensure fittings, devices, and fasteners installed on enclosure exteriors are adequately rated to maintain the integrity of the enclosure NEMA rating.

I. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use liquidtight flexible metal conduit inside pumping plants and in damp or wet locations.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as indicated in design documents.
2. Warning Tape: Bury warning tape approximately 12 inches above direct-buried conduits.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to match fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Section 078400.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes:

1. Nameplates.
2. Warning labels and signs.
3. Control cable identification.
4. Power cable identification.
5. Power and control raceway identification.
6. Underground warning tape.
7. Cable ties.
8. Paint for identification.

1.3 REFERENCES

A. American National Standards Institute:

1. ANSI/ASME A13.1-Scheme for the Identification of Piping System
2. ANSI Z535.1 – Safety Colors.
3. ANSI Z535.2 – Environmental and Facility Safety Signs.
4. ANSI Z535.3 – Criteria for Safety Symbols.
5. ANSI Z535.4 – Product Safety Signs and Labels.
6. ANSI Z535.5 – Safety Tags and Barricade Tapes -Temp. Hazards

B. ASTM International:

1. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
2. ASTM D882 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting.

C. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

D. Code of Federal Regulations:

1. 29 CFR 1910.144 - Safety Color Code for Marking Physical Hazards.
2. 29 CFR 1910.145 – Specifications for Accident Prevention Signs and Tags.

E. Underwriters Laboratories Inc.:

1. UL 224 – Extruded Insulation Tubing.

1.4 SUBMITTALS

A. Product Data (PD)

1. Manufacturer's catalog literature for each product is required.
2. Electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.
3. Samples: For each type of sign and label to represent composition, size, colors, lettering style, mounting provisions, and graphic features of identification product.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1.6 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Product Description: Engraved, laminated acrylic or melamine label. Punched or drilled for screw mounting. White letters on a black background. Minimum letter height shall be 3/8 inch.

1. Alternative mounting methods may be approved if screw mounting or punch mounting violates UL certification. Submit to CAWCD for approval prior to installation.

2.2 WARNING LABELS AND SIGNS

A. Comply with NFPA 70, 29 CFR 1910.144 and 29 CFR 1910.145.

B. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with galvanized steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size 10 by 14 inches.

2.3 POWER AND CONTROL RACEWAY IDENTIFICATION

A. Comply with ANSI A13.1 for minimum size of letters for legend.

1. Metal Tags: Brass, 2 by 2 by 0.05 inch, with stamped legend, punched for use with stainless steel self-locking cable tie fastener.

B. Labeling: Conduits shall be labeled as identified in Construction Plans.

C. Naming convention: Coordinate with CAWCD for the current standards.

1. Methodology for labeling conduits is as follows:

a. Conduits are designated in three parts, each separated by a dash.
b. The first part is the size, in inches, of the conduit.
c. The second part consists of the conduit number from the source equipment plus the designation of the source equipment.
d. The third part is the designation for the destination equipment at the other end of the conduit.
e. Where a conduit enters a junction or terminal box and then continues as two or more conduits as a branch, each branch is designated with the designation of the original conduit, plus a sequential suffix starting from lower case a.

2.4 CONTROL CABLE IDENTIFICATION

A. Heat-Shrink Preprinted Wire Labels:

1. Flame-retardant polyolefin tube with machine-printed identification label.
2. Sized to suit diameter of and shrinks to fit firmly around cable it identifies.
3. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.
4. Legend to match cable name(s) presented on construction drawings.

B. Color Coding:

1. Insulation color for control cables shall adhere to CAP standard drawing CTS-E-D01033 (ICEA Method 1, Table E-2) for new installations.
2. Existing installations that do not comply with item 2.4.B.1 shall match existing cable color coding.

C. Naming convention:

2.5 POWER CABLE IDENTIFICATION

A. Color Coding for Phase Identification, 600 V or Less:

1. Color shall be factory applied.
2. Colors for 120/208 V Circuits:

    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.

3. Colors for 277/480V Circuits:

    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.

B. Naming convention:

2.6 UNDERGROUND LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for red-colored tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for orange-colored tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.
4. 3-Inch Tensile according to ASTM D 882: 30 lb-ft and 2500 psi.

2.7 CABLE TIES

A. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install identifying devices after completion of painting.

B. Coordinate identification with Project drawings.

C. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with accessibility and high visibility.

D. Nameplate Installation:

1. Install nameplate parallel to equipment lines.
2. Secure nameplate to equipment front using adhesive. Use materials and methods recommended by manufacturer of identification product. Clean substrates of substances that could impair bond.
3. Screwed and riveted nameplate shall be coordinated with CAWCD and shall be done in a manner consistent with the NEMA/UL standard and same rating of UL listing.

E. Equipment Label Installation:

1. Install label parallel to equipment lines.
2. Secure label to equipment front using adhesive. Use materials and methods recommended by manufacturer of identification product. Clean substrates of substances that could impair bond.

3. Screwed and riveted nameplate shall be coordinated with CAWCD and shall be done in a manner consistent with the NEMA/UL test standard and same rating of UL listing.
4. A sample Equipment Identification Schedule is below.

Equipment ID	Description	Location

F. Wire Label Installation:

1. Install labels at both ends of wire terminations. Wire labels shall be identical at each end.
2. Heat-shrink labels shall be sized to be legible with the naked eye.
3. Spare conductors shall be labeled as SPARE.
4. A sample Cable Identification Schedule is below.

Cable ID	From Panel	To Panel	Type	# of Conductors & Gauge

G. Raceway Tag Installation:

1. Install raceway tag at each end for all raceways longer than 6 feet.

H. Underground Warning Tape Installation:

1. Install underground warning tape along length of each underground conduit, raceway, or cable 6 to 8 inches directly above buried conduit, raceway, or cable.

3.2 EQUIPMENT NAMING CONVENTION

A. Electrical equipment is designated by means of a group of three symbols.

1. The first symbol in an equipment designation is a single capital letter and represents the type of equipment according to Table 1, below.

Table 1 – Key List for Equipment Symbols	
Symbol	**Type of Equipment**
A	Actuator, turbine governor
B	Battery and DC distribution board
C	Control board, high voltage cable
D	Station service switchgear, distribution board (except for lighting and HVAC), unit substation rated less than 600 V
E	Static exciter, junction box, pull box, trench
F	Fuses, fused disconnect switch, fire and carbon dioxide equipment
G	Generator
H	Hydraulic board, turbine or main pump
J	Power circuit breaker (above 600 V)
K	Transformer (except lighting), reactor, regulator, or metering equipment
L	Lighting system equipment
M	Motor, pump, valve board
N	Dampers, HVAC system equipment
U	AC power switchgear above 600 V
W	Bus disconnect switch, phase reversal switch
X	Bypass switch
Y	Line or selector disconnect switch
Z	Grounding switch

2. The second symbol in an equipment designation represents the physical location of the equipment. It is a capital letter (or letters) or a number according to Table 2, below.

Table 2 – Key List for Location Symbols	
Symbol	**Type of Equipment**
C	Control Bay
H	Service building
S	Service bay
W	230 kV Switchyard
X	115 kV Switchyard
Y	69 kV Switchyard
Z	15 kV and below Switchyard
1 through 10	Unit bays inside Pumping Plant

3. The third symbol in an equipment designation is a capital letter, starting from A, used to differentiate between various pieces of equipment of the same type and in the same location.

B. Equipment Identification Schedule: Designer shall create an equipment identification schedule containing all new electrical equipment to be installed and containing the following attributes:

1. Equipment designation
2. Equipment location.
3. Operational voltage and number of phases (single vs. three).
4. Description of equipment functionality.

END OF SECTION 260553

SECTION 260593 - COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00Contract Documents, and Division 01 General Requirements, and Special Provisions apply to this section.

B. Coordinate with other Electrical Standard Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes single- and three-phase motors for application on equipment provided under other sections.

1. This section only applies to motors 50hp or less.

B. Related Sections:

1. Section 260526 - Grounding and Bonding for Electrical Systems.
2. Section 260553 - Identification for Electrical Systems.

1.3 REFERENCES

A. American Bearing Manufacturers Association:

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

C. Institute of Electrical and Electronics Engineers

1. IEEE C50.10 - American National Standard General Requirements for Synchronous Machines

D. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

E. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data (PD)

1. Submit catalog data for each motor furnished loose. Indicate nameplate data, standard compliance, electrical ratings and characteristics, and physical dimensions, weights, mechanical performance data, and support points.

B. Test Reports:

1. Indicate procedures and results for specified factory and field testing and inspection.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.

B. Testing Agency: Company specializing in testing products specified in this section with minimum five years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with Section 016000 - Product Requirements: Product storage and handling requirements.

B. Lift only with lugs provided. Handle carefully to avoid damage to components, enclosure, and finish.

C. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating within enclosure.

D. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR MOTORS FURNISHED WITH EQUIPMENT

A. Motors 3/4 hp and Larger: Three-phase motor specification shall be provided by qualified manufacturer. Manufacturer shall coordinate with CAWCD and Contractor for design criteria and requirements.

B. Motors Smaller Than 3/4 hp: Single-phase motor as specified in section 2.1.D, except motors less than 250 watts or 1/4 hp may be equipment manufacturer's standard.

C. Three-Phase Motors: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds as indicated on project plans.

1. Voltage: As indicated on project plans.

    a. Example: 460V, 230V, 115V

2. Service Factor: As indicated on project plans.

    a. Example: 1.25, 1.15, 1.0

3. Enclosure: Meet conditions of installation unless specific enclosure is indicated on project plans.
4. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
5. Insulation System: NEMA Class F

    a. Coordinate with CAWCD if class insulation other than F is desired.

6. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
7. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
8. Bearings: Grease lubricated anti-friction ball bearings with housing equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
9. Sound Power Levels: Conform to NEMA MG 1.

D. Single Phase Motors:

1. Permanent split-capacitor type where available, otherwise use split-phase start/capacitor run or capacitor start/capacitor run motor.
2. Voltage: As indicated on project plans.

    a. Example: 230V, 115V

E. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

1. Motor terminal leads shall be installed with products similar to 3M™ Motor Lead Pigtail Splice Kits. Submit to CAWCD for approval.

F. Manufacturers:

1. Electric motors shall be manufactured by ABB (Baldor); or as approved by CAWCD.

2.2 THREE-PHASE MOTORS FURNISHED LOOSE

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following

1. General Electric
2. Siemens
3. ABB
4. Mitsubishi Electric
5. Schneider Electric

B. Product Description: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds indicated.

C. Voltage: As indicated on project plans..

1. Example: 460V, 230V, 115V

D. Service Factor: As indicated on project plans.

1. Example: 1.25, 1.15, 1.0

E. Enclosure: Meet conditions of installation unless specific enclosure is specified or indicated.

F. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

G. Insulation System: NEMA Class F

H. Coordinate with CAWCD if class insulation other than F is desired.

I. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

J. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.

K. Bearings: Grease lubricated anti-friction ball bearings with housing equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

L. Sound Power Levels: Conform to NEMA MG 1.

M. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

1. Motor terminal leads shall be installed with products similar to 3M™ Motor Lead Pigtail Splice Kits. Submit to CAWCD for approval.

N. SOURCE QUALITY CONTROL

O. Test motors in accordance with NEMA MG 1, including winding resistance, no-load speed and current, locked rotor current, insulation high-potential test, and mechanical alignment tests.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove abandoned motors.

B. Maintain access to existing motors and other installations remaining active and requiring access. Modify installation or provide access panel.

C. Clean and repair existing motors to remain or to be reinstalled.

3.2 INSTALLATION

A. Install securely on firm foundation. Mount ball bearing motors in accordance with motor manufacturer's requirements.

B. Install engraved plastic nameplates in accordance with Section 260553.

C. Ground and bond motors in accordance with Section 260526.

3.3 FIELD QUALITY CONTROL

A. Section 014400 Quality Requirements and Section 017700 Closeout Procedures

B. Field inspection, testing, adjusting and balancing

1. Inspect and test in accordance with NETA ATS (2025).
2. Perform inspections and tests listed in NETA ATS (2025).

END OF SECTION 260593

SECTION 260800 – COMMISSIONING ELECTRICAL SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the process for documenting and placing into service, newly installed or retrofitted electrical power equipment and systems. The individual electrical components shall be subjected to factory and field tests to validate the individual components and ensure that tested electrical systems are safe, reliable, operational, in conformance with applicable standards and manufacturers' tolerances, and installed in accordance with the Project Specifications and Drawings.

1.2 REFERENCES

A. ANSI/NETA ECS – 2024 (American National Standards Institute / InterNational Electrical Testing Association Electrical Commissioning Specifications.

B. ANSI/NETA ATS –2025(American National Standards Institute/InterNational Electrical Testing Association Acceptance Testing Specifications

C. NFPA 70 (latest edition adopted by CAWCD) – National Electric Code – NEC

D. NFPA 70E (latest edition adopted by CAWCD) – Standards for Electrical Safety in the Workplace

1.3 DEFINITIONS

A. Commissioning Authority (CxA)

1. The Commissioning Authority (CxA) is the designated representative responsible for overseeing and certifying the commissioning activities. The CxA may also be the entity performing the commissioning activities. The CxA could be the prime contractor, design consultant, or an independent third party.

1.4 COMMISSIONING DESCRIPTION

A. The Electrical commissioning process includes the following tasks:

1. If applicable, Preliminary Factory Acceptance Testing and Factory Acceptance Testing (FAT).
2. Testing preparation.
3. Testing and startup of electrical equipment and systems.

4. Equipment and system verification checks.
5. Functional performance testing to verify equipment and system performance.
6. Provide qualified personnel to assist in commissioning tests.
7. Complete and endorse functional performance test checklists provided by the Commissioning Authority to ensure equipment and systems are fully ready to be released for unrestricted operation.
8. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process to fulfill contract and warranty requirements.
9. Provide operation and maintenance information, list of PM tasks, recommended frequency, any instructions or diagrams needed to do the maintenance tasks, and record drawings to Commissioning Authority for review verification and organization, prior to distribution.
10. Provide a detailed list of any spare parts, consumables, or special tools that may be needed for long-term maintenance.
11. Assist the Commissioning Authority to develop, edit, and document system operation descriptions.
12. Provide training for equipment or systems specified in this Section with coordination by the Commissioning Authority.

B. Equipment and Systems to be commissioned:

1. New electrical systems and equipment installed under this Contract.
2. Existing electrical systems and equipment that were modified, adjusted, upgraded, or affected by the work performed under this Contract.

C. The following is a partial list of equipment and systems that may be included in electrical commissioning.

1. Switchgear/Switchboards
2. Transformers
3. Panelboards
4. Motor Controllers
5. Bus Duct and Tap Devices
6. Wire and Cables
7. Generators
8. Generator Controls
9. Transfer Switches
10. Uninterruptible Power Supply (UPS) Systems
11. Lighting Control Systems
12. Power Monitoring
13. Protection Relays
14. Excitation Systems
15. DC Battery Systems
16. Power Circuit Breakers

1.5 SUBMITTALS

A. Contractor shall submit the designated Commissioning Authority (CxA) for CAWCD approval. CAWCD reserves the right to request an independent third party CxA.

B. Draft Forms: Submit draft of system verification forms, functional test checklists, and start up procedures tailored to the specifics of this contract for CAWCD approval.

C. Certificate of Readiness: Signed by the Contractor, certifying that the electrical systems, assemblies, equipment, and associated controls are ready for testing.

D. Commissioning Reports:

1. Test Reports: Indicate data on system verification form for each piece of equipment and system as specified. Form to be approved by CAWCD.
2. Field Reports: Indicate deficiencies preventing completion of equipment or system verification checks to achieve specified performance.

    a. Keep an updated punch-list checklist of deficiencies that need to be corrected by the contractor.

E. Certificate of Completion: Certifying that the installation, prestart checklist, and start up procedures on all equipment in scope have been completed.

F. Project Record Documents: Record revisions to equipment and system documentation necessitated by commissioning. Commissioning Authority to work with contractors on the installation progress and is ultimately responsible for ensuring that the Contractor has accurately updated Record Documents to as-built conditions. Commissioning Authority shall notify CAWCD in the event commissioning necessitates changes in the project record drawings.

G. Operation and Maintenance Data: Commissioning Authority to work with Contractor to provide final Electrical Commissioning package with the final O&M Documents submitted to CAWCD. Provide a list of any ‘as left’ setpoints and other similar metrics if they aren’t already provided elsewhere or in the O&M manuals.

1. Provide ‘as left’ setting configuration files for devices as applicable.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with the following. Forms to be approved by CAWCD.

1. ANSI/NETA ECS – 2024 (American National Standards Institute / InterNational Electrical Testing Association Electrical Commissioning Specifications.
2. ANSI/NETA ATS – 2025 (American National Standards Institute/InterNational Electrical Testing Association Acceptance Testing Specifications

1.7 QUALIFICATIONS

A. Commissioning Authority: A certified commissioning authority (CxA) by the AABC Commissioning Group (ACG) or as approved by CAWCD.

1.8 COMMISSIONING RESPONSIBILITIES

A. General Contractor Commissioning Responsibilities:

1. Provide Commissioning Authority services or retain services for an independent qualified 3rd party Commissioning Authority. CAWCD to provide approval of Commissioning Authority selected prior to Notice to Proceed. CAWCD retains the right to hire the 3rd party Commissioning Authority.
2. Provide CAWCD with a schedule of commissioning activities and meetings including but not limited to the items outlined in Article 1.4. A.
3. Delivery of plans, submittals, system manuals, and any other equipment-related information for the Commissioning Authority to review prior to field commissioning.
4. Any 3rd party Commissioning Authority used shall have prior commissioning experience for Electrical Systems.
5. If applicable, the Commissioning Authority shall coordinate with CAWCD’s design consultant to develop testing plan for existing systems retrofitted with individual components that are not provided with manufacturer’s start-up and testing instructions.

B. Equipment or System Installer Commissioning Responsibilities:

1. Attend commissioning meetings.
2. Ensure electrical installers perform assigned commissioning responsibilities as specified below. Installer shall be identified by the General Contractor as manufacturer, supplier, designer, or contractor/subcontractor at the project kickoff meeting based on project role.
3. Provide instructions and demonstrations for CAWCD's personnel.
4. Ensure subcontractors perform assigned commissioning responsibilities.
5. Ensure participation of equipment manufacturers in appropriate startup, testing, and training activities when required by individual equipment specifications.

6. Develop startup and initial checkout plan using manufacturer's startup procedures and functional performance checklists for equipment and systems to be commissioned.
7. Perform and document completed startup and system operational checkout procedures, providing copy to Commissioning Authority.
8. Provide manufacturer's representatives to execute starting equipment. Ensure representatives are available and present during agreed upon schedules and are in attendance for duration to complete tests, adjustments, problem-solving and training of CAWCD staff.
9. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of warranties.
10. Provide personnel to assist Commissioning Authority during equipment or system verification checks and functional performance tests.
11. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection.
12. Prior to startup inspect, check, and verify correct and complete installation of equipment and system components for verification checks included in commissioning plan. When deficient or incomplete work is discovered, ensure corrective action is taken and re-check until equipment or system is ready for start.
13. Perform verification checks and startup on equipment and systems as specified.
14. Assist Commissioning Authority in performing functional performance tests on equipment and systems as specified.
15. Perform operation and maintenance training sessions scheduled by Commissioning Authority.
16. Conduct electrical system orientation and inspection.

1.9 COMMISSIONING MEETINGS

A. Commissioning Authority shall coordinate all commissioning meetings and progress commissioning meetings with the General Contractor, Electrical Contractor, Commissioning Authority, Designer (if applicable), and CAWCD.

1.10SCHEDULING

A. Commissioning Authority to attend pre-installation meetings prior to any electrical work being performed. Contractor should have Commissioning Authority under contract prior to any electrical installations.

B. Prepare schedule indicating anticipated start dates of all commissioning activities.

1.11COORDINATION

A. Notify CAWCD Project Engineer, Project Manager, Contract Administrator, and Construction Inspector a minimum of two weeks in advance of the following:

1. Commissioning meetings
2. Factory acceptance testing.
3. Equipment and systems testing and startups.
4. Functional performance testing.
5. Training.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Perform commissioning for electrical systems in accordance with:

1. ANSI/NETA ECS – 2024 (American National Standards Institute / InterNational Electrical Testing Association Electrical Commissioning Specifications.
2. ANSI/NETA ATS – 2025 (American National Standards Institute/InterNational Electrical Testing Association Acceptance Testing Specifications.

3.2 FACTORY ACCEPTANCE TESTING

A. General: Before shipment to the CAWCD site, electrical equipment shall be factory-tested and accepted by CAWCD. Not all equipment shall require an FAT (e.g. a panelboard). Typically, custom equipment or large made-to-order equipment (e.g. switchgear) will require an FAT.

1. FAT will be witnessed by CAWCD and/or other representatives of CAWCD. A 20-day notice is required for the confirmation of the FAT date.
2. CAWCD reserves the right to observe all factory test activities including all subsystem preparation, pretests, troubleshooting and retests.
3. CAWCD reserves the right to test any specified function whether explicitly stated in the test submittal.
4. CAWCD reserves the right to determine the level of retesting required for product acceptance.
5. CAWCD reserves the right to specify the amount of time to correct deficiencies and retest. Equipment may be rejected that is not corrected within the allotted time.
6. Preliminary FAT

a. A preliminary factory acceptance test (pre-FAT) shall be conducted utilizing test plans, procedures and forms approved by CAWCD.
b. Submit pre-FAT test results including a letter signed by the Contractor's project manager or company officer certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT.
c. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review 15 days before the start of the FAT.

7. Includes the following:

a. Visual inspections confirming the equipment's appearance and construction.
b. Functional tests verifying that the equipment performs as designed under various operating conditions.
c. Performance tests measuring specific performance parameters, such as voltage, current and power.
d. Insulation tests.
e. Point-to-point wiring checks, verifying wiring diagrams.
f. Safety checks ensuring that the equipment meets safety standards and regulations.

B. Provide a FAT checklist ensuring the equipment functions as intended and meets specifications before delivery. Key components of the FAT checklist shall include:

1. Visual inspection checking for visible damages, correct labeling and adherence to specifications.
2. Functional testing verifying that the equipment operates as intended under normal conditions.
3. Performance testing evaluating the equipment's ability to meet performance requirements.
4. Safety and compliance check ensuring the equipment complies with relevant safety standards and regulations.
5. Documentation review verifying that documentation is complete, accurate and up to date.
6. Compliance verification confirming that the equipment meets all relevant regulatory requirements and industry standards.
7. Documentation of review of supplier documentation, data sheets, drawings, and certifications.

3.3 INSTALLATION

A. Install additional parts or accessories required to meet performance requirements.

B. Place electrical systems and equipment into full operation and continue operation during each working day of commissioning.

3.4 FIELD TESTING PREPARATION

A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.

B. Certify that electrical system instrumentation and control systems have been completed and calibrated, that they are operating in accordance with the Contract Documents and approved submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (for example, normal shutdown, normal auto position, normal manual position, emergency power, and alarm conditions).

3.5 FIELD TESTS AND INSPECTIONS

A. Participate in the initial test of newly installed or retrofitted equipment and systems required to demonstrate performance and compliance with specifications and regulatory and safety requirements.

1. Test individual components to validate their functionality.
2. Verify wiring continuity and control functions to ensure proper wiring and control system functionality.
3. Conduct system functional testing and start up testing to verify that the complete system meets project performance requirements and the basis of design.
4. Pre-energization tests and post-energization tests should be clearly separated in testing documentation. Any pre-energization tests required to be performed prior to energization shall be certified by the Commissioning Authority prior to energizing.

B. Field tests may include but not be limited to:

1. Insulation resistance
2. Continuity tests
3. Point-to-point wiring tests
4. Polarity tests
5. Earth leakage tests
6. Loop impedance tests
7. Voltage and frequency checks
8. Load testing
9. Thermography

10. Protective Relay Testing

3.6 TRAINING

A. Provide training for newly installed or modified electrical systems or equipment to ensure CAWCD staff are trained to properly operate and maintain the electrical systems after project handover. Coordinate with CAWCD for date, time, location and attendees.

1. Train staff to operate the systems optimally.
2. Provide training to help reduce equipment malfunctions.
3. Identify critical aspects of safe work practices and hazard mitigation including lockout/tagout procedures, release of stored energy, and awareness of hazards.
4. Provide guidance on preventative maintenance, troubleshooting and basic repairs.
5. Explain the use of system documentation including technical manuals and schematics.
6. Training sessions to be scheduled and completed before substantial completion.
7. Provide supplemental training after final acceptance if requested by CAWCD.

END OF SECTION 260800

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this section.

B. Coordinate with other Electrical Standard Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes two winding transformers for rated operation under 600 volts with capacities up to 1000kVA.

1.3 REFERENCES

A. National Electrical Manufacturer's Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 volts maximum).

B. International Electrical Testing Association:

1. NETA ATS – Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.

C. National Fire Protection Association

D. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data: Outline and support point dimensions of enclosures, minimum clearances, and accessories, unit weight, voltage, kVA, impedance ratings and characteristics, tap configurations, insulation system type, coil material, and rated temperature rise, and performance of the transformer.

B. Test and Evaluation Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level.

C. Shop Drawings: Detail equipment assemblies, dimensions, required clearances, loads, weights, components and instruction of field installation

1. Schematic and Wiring Diagrams: Power and Control details.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle according to the manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to the transformer's internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.1 TWO-WINDING TRANSFORMERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following.

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

B. Description: Factory-assembled dry type transformers with ratings as indicated on construction plans.

C. Operating Parameters:

1. Insulation system and average winding temperature rise for rated kVA as follows:

    a. 1 to 15 kVA: Class 185 with 115 degrees C rise.
    b. 16 to 500 kVA: Class 220 with 150 degrees C rise.

2. Winding Taps: Two, 2.5 percent below rated voltage unless specified otherwise, full capacity taps on the primary winding. Continuous windings without splices except for taps.
3. Basic Impulse Level: 10 Kv.
4. Mounting: As indicated on construction plans.
5. Enclosure: NEMA 250 Type 3R, ventilated. Furnish lifting eyes or brackets.

    a. NEMA 250 Type 3R enclosure is standard because of fire protection systems installed in pumping plants and/or may be installed in proximity to cooling water piping or other water piping.

6. Nameplate: Include transformer connection data, rated parameters, and percent impedance.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Use flexible conduit, according to Section 260533 Raceway and Boxes for Electrical Systems, for connections to transformer case.

B. Support transformers according to Section 260529 Hangers and Supports for Electrical Systems.

1. In cases where the transformer is to be installed on 1st or 2nd floor of pumping plants, transformer shall be wall mounted off the floor.

a. Use wall mounting brackets and specified anchor mounts certified by transformer manufacturer.
b. Coordinate installation location and clearances with CAWCD.

C. Install grounding and bonding according to Section 260526 Grounding and Bonding for Electrical Systems.

3.2 IDENTIFICATION

A. Identify transformers according to Section 260553 Identification for Electrical Systems.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Perform visual and mechanical inspections and electrical tests listed in NETA ATS, Section 7.2.1. Certify compliance with test parameters.

C. Test and Inspection Reports: Prepare a written report to record the following.

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Labeling: Attach a dated and signed “Satisfactory Test” label to tested components upon completion of satisfactory testing of each transformer.

D. Transformers will be considered defective if they do not pass tests and inspections. Remove and replace transformers that do not pass inspections or tests. Retest units as specified in this section.

3.4 ADJUSTING

A. Measure primary and secondary voltages and make appropriate tap adjustments for the application.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans and Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes switchboards, overcurrent protective devices, transient voltage suppression devices.

1.3 REFERENCES

A. Institute of Electrical and Electronics Engineers:

1. IEEE C62.41 – Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA PB 2 – Deadfront Distribution Switchboards.

3. NEMA PB 2.1 – General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.

C. International Electrical Testing Association:

1. NETA ATS – Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.

D. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

E. Underwriters Laboratories Inc.:

1. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.4 SUBMITTALS

A. Product Data (PD)

1. Electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of equipment and components.

B. Shop Drawings (SD)

1. Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars for each phase, neutral, and ground; and switchboard instrument details.

C. General

1. Operation and Maintenance Data: For switchboards and all accessory components.

a. Routine maintenance requirements.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

D. Quality Control Reports (QCR)

1. Test Reports: Indicate results of field tests and inspections.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept switchboards on site. Inspect for damage.

B. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle according to NEMA PB 2.1. Lift only with lugs provided. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.6 EXTRA MATERIALS

A. Furnish three of each size and type of fuse installed.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

B. Product Description: NEMA PB 2, enclosed switchboard with electrical ratings, configurations, and overcurrent devices as indicated on construction drawings.

C. Service Conditions:

1. Ambient Temperature: Not exceeding 130 degrees F.
2. Altitude: Not exceeding 3000 feet above sea level.

D. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch and Auxiliary Devices: Panel mounted.

E. Bus:

1. Material: Copper, standard size.
2. Connections: Bolted, accessible from front for maintenance.

F. Ground Bus: Copper, extend length of switchboard.

G. Minimum Short Circuit Rating: 35kA as a minimum, or higher as indicated on construction plans.

H. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, insulated and braced for short circuit currents. Furnish continuous current rating.

I. Enclosure:

1. Indoor Installation: NEMA 250 Type 3, at the minimum rating.

2. Outdoor Installation: NEMA 250 Type 3, at the minimum rating.

J. Deadfronts:

1. If an option, switchboards shall be ordered with hinged deadfront access covers for ease of inspection.

2.2 OVERCURRENT PROTECTIVE DEVICES

A. Product Description: UL 489, molded-case circuit breaker, with interrupting capacity to meet available fault currents.

B. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes rated 400 A and below.

C. Ground Fault Protection: ground-fault indicator, relay and trip unit with adjustable pickup and time-delay settings, and push-to-test feature.

D. Additional features and protections shall be reviewed and listed per project requirements.

E. Solid-State Circuit Breaker:

1. Electronic sensing, timing, and tripping circuits for adjustable current settings including long time, short time, and instantaneous.
2. Ground fault trip with integral ground fault sensing.

2.3 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Product Description: Comply with ANSI/IEEE C62.41, factory-mounted transient voltage surge suppressor, selected to meet requirements for medium exposure and to coordinate with system circuit voltage.

B. Surge Protection Device Description: Comply with IEEE C62.41, short-circuit current rating matching or exceeding switchboard short circuit rating. Additional features and protections shall be listed per project requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install according to NEMA PB 2.1.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install engraved plastic nameplates according to Identification for Electrical Systems Specification Section 260553.

D. Install circuit breaker directory.

E. Ground and bond switchboards according to Grounding and Bonding for Electrical Systems Specification Section 260526.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Perform inspections and tests listed in NETA ATS, Section 7.1.

C. Test and Inspection Reports: Prepare a written report to record the following.

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Switchboards will be considered defective if they do not pass tests and inspections.

E. New installation switchboards shall be installed without cosmetic blemishes or damage.

3.3 ADJUSTING

A. Adjust operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections.

C. Adjust circuit breaker trip and time delay settings to values as instructed by CAWCD.

3.4 CLEANING

A. Touch up scratched or marred surfaces to match original finish with factory paint matching touch-up paint.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes distribution panelboards.

1.3 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA PB 1 – Panelboards.
3. NEMA PB 1.1 – General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

B. International Electrical Testing Association:

1. NETA ATS – Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.

C. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

D. Underwriters Laboratories Inc.:

1. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.4 SUBMITTALS

A. Product Data

1. Catalog data showing specified features of standard products.

2. Include manufacturers’ technical data, ratings and electrical characteristics.
3. Include switching and overcurrent protective devices, SPDs and accessories.
4. Include detail enclosure types with dimensions, mounting and anchorage.
5. Include nameplates and additional components as indicated.

B. Shop Drawings

1. Indicate outline and support point dimensions, elevation, sections, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.
2. Include conductor termination sizes.
3. Include bus configuration with voltage and current ratings.
4. Include time-current coordination curves for each type and rating of overcurrent protective device included in the panelboard.
5. Include schematic and wiring diagrams for power and control/signal wirings.
6. Loads shall be balanced across phases.
7. Breakers shall be sized according to NFPA 70.

C. General

1. Operation and Maintenance Data: For panelboards and all accessory components.
2. Routine maintenance requirements
3. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
4. Time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

D. Quality Control Reports (QCR)

1. Test Reports: Indicate results of field tests and inspections.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

B. Description: NEMA PB 1, circuit breaker type panelboard with electrical ratings, configurations, and overcurrent devices as indicated on construction plans.

C. Service Conditions:

1. Ambient Temperature: Not exceeding 130 degrees F.
2. Altitude: Not exceeding 3000 feet above sea level.

D. Panelboard Bus: Copper, current carrying components, ratings as indicated on construction plans. Furnish copper ground bus in each panelboard.

E. Molded Case Circuit Breakers: UL 489, circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Ratings as indicated on construction drawings.

F. Minimum Short Circuit Rating: 35kA as a minimum, or higher as indicated on construction plans.

G. Enclosure:

1. Indoor Installation: NEMA 250 Type 3, at the minimum rating.
2. Outdoor Installation: NEMA 250 Type 3, at the minimum rating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards according to NEMA PB 1.1.

B. Install panelboards plumb and level.

1. If mounted to concrete wall, standoff panelboard with galvanized Unistrut square washers to create space between concrete and back of panelboard.

C. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.

D. Install filler plates for unused spaces in panelboards.

E. Provide typed circuit directory for each branch circuit panelboard. Revise directory to reflect circuiting changes to balance phase loads. Identify each circuit as to its clear, evident and specific purpose of use.

F. Install engraved plastic nameplates in accordance with Section 260553 Identification for Electrical Systems Specification.

G. Ground and bond panelboard enclosure in accordance with NFPA 70 and Section 260526 Grounding and Bonding for Electrical Systems.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Perform circuit breaker inspections and tests listed in NETA ATS, Section 7.6 for the main circuit breaker in each panelboard.

C. Test and Inspection Reports: Prepare a written report to record the following.

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Panelboards will be considered defective if they do not pass tests and inspections.

3.3 ADJUSTING

A. Adjust circuit breaker trip and time delay settings, where applicable, to values as instructed by CAWCD.

3.4 CLEANING

A. Touch up scratched or marred surfaces to match original finish.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions, apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes:

1. Toggle switches.
2. Receptacles.
3. Device plates.
4. Terminal blocks.

1.3 REFERENCES

A. National Electrical Contractors Association:

1. NECA 1 - Standard Practice for Good Workmanship in Electrical Construction.

B. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
2. NEMA WD 1 – General Requirements for Wiring Devices.
3. NEMA WD 6 – Wiring Devices – Dimensional Specifications.
4. UL 498 – Electrical Attachment Plugs and Receptacles.

C. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data (PD)

1. Manufacturer's catalog information showing ratings, dimensions, colors, and configurations.

B. Shop Drawing (SD)

1. List of legends and description of materials and process used for pre-marking wall plates.

PART 2 - PRODUCTS

2.1 TOGGLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Cooper.
2. Hubbell.
3. Leviton.
4. Pass & Seymour.

B. Product Description: Comply with NEMA WD 1, NEMA WD 6, Heavy-duty industrial grade, toggle switch.

C. Body and Handle: Ivory plastic with toggle handle.

D. Ratings: Match branch circuit and load characteristics.

2.2 RECEPTACLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Cooper.
2. Hubbell
3. Leviton.
4. Pass & Seymour.

B. Product Description: Comply with NEMA WD 1, NEMA WD 6, configuration UL 498 and 5-20R, heavy-duty industrial grade duplex receptacle.

C. Device Body: Ivory plastic for convenience receptacles. Orange color receptacle with stainless cover plate is for critical receptacles that are connected to critical system or emergency backup power.

D. Ratings: 125 V, 20 A unless otherwise indicated.

E. GFCI Receptacle:

1. Provide as indicated on construction drawings.
2. All GFCI receptacles shall be provided with a metal, weatherproof in-use cover.

2.3 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035 inch thick, satin-finished, type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp or Wet Locations: Thermoplastic with spring-loaded lift cover, listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R, weather-resistant with lockable cover.

2.4 TERMINAL BLOCKS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Phoenix Contact.
2. Allen-Bradley.
3. General Electric.
4. Marathon.

B. Product Description: Certified and designed to UL listed and/or IEC safety standards. The flammability rating shall meet or exceed UL94V-0. Terminal Blocks are in three main categories:

1. Power Distribution: Standard terminal blocks, securely mounted to housing enclosures, suitable for wire range Copper wires per NEC standard with ring lug terminals. Jumper bar assemblies shall be installed for interconnecting terminal blocks and distributing power as required. Terminal blocks shall be heavy duty, rated for 600 V, and have a minimum of 12 points, unless specified otherwise.
2. NEMA: Standard terminal blocks according to NEMA standards, rated for 600 V, 30 A, securely mounted to housing enclosures, suitable for wire range Copper wires per NEC standard. Jumper bar assemblies shall be installed for interconnecting terminal blocks and distributing power and signal commons as required. Terminal blocks shall be rated for 600V, 30A, and have a minimum of 12 points, unless specified otherwise.

a. Fuse Terminal Blocks: Comply with NEMA standard. Screw connection. Fuse holder shall be draw-out type. Fuse shall comply with Section 262813 – Fuses.

3. IEC: standard terminal blocks, securely mounted to housing enclosures, suitable for wire range Copper wires per NEC standard. Jumper bar assemblies shall be installed for interconnecting terminal blocks and distributing power and signal commons. Terminal blocks shall be rated for 600V, 30A and have a minimum of 12 points, unless specified otherwise.

C. Labeling: Each rung on all terminal blocks shall be numerically labeled. The first rung shall be 1, and the number shall increase sequentially, by one, for each rung on the device.

2.5 WIRE NUTS

A. Wire nuts are not allowed in any new installations on CAWCD property.

1. Any exceptions must be approved by CAWCD.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

1. Exceptions: Match existing heights for nearby similar equipment unless otherwise indicated.

B. Install switches with OFF position down.

C. Install receptacles with grounding pole on bottom.

D. Install wall plates on flush mounted switches, receptacles, and blank outlets.

E. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

F. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

G. End clamps and end sections shall be installed on each terminal block.

3.2 IDENTIFICATION

A. Comply with Section 260553 – Identification for Electrical Systems.

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate.

3.3 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify each receptacle device is energized.

D. Test each receptacle device for proper polarity, ground continuity, and compliance with requirements.

E. Test each GFCI receptacle device for proper operation. Test for GFCI Tripping values shall be specified in UL 1436 and UL 943.

F. Remove malfunctioning devices, replace with new devices and retest as specified above.

3.4 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.5 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Coordinate with Section 406700 – Control Systems – Panels, Enclosures, and Panel Components.

1.2 SUMMARY

A. Section includes cartridge fuses rated 600 V AC and less.

1.3 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA FU 1 – Low Voltage Cartridge Fuses.

B. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data (PD)

1. For each type of product indicated.

a. Electrical characteristics, including time-current curves.
b. Dimensions and manufacturer's technical data on features and performance.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Comply with NEMA FU 1 for cartridge fuses.

E. Comply with UL 248-11 for plug fuses.

PART 2 - PRODUCTS

2.1 FUSES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Eaton - Bussman Series.
2. Eaton – Edison Series.
3. Mersen/Ferraz Shawmut.
4. Littelfuse.

B. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

C. Ratings: Voltage and current ratings as indicated on construction plans.

D. Minimum Short Circuit Rating: As indicated on construction plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affective performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Feeders: Current limiting Class J, time delay.

B. Motor Branch Circuits: Current limiting Class RK1, time delay.

C. Other Branch Circuits: Current limiting Class J, time delay.

D. Control Circuits: Current limiting Class CC, time delay.

3.3 IDENTIFICATION

A. Comply with Section 260553 – Identification for Electrical Systems.

B. Indicating fuse replacement information on the inside door of each fuse switch and adjacent to each fuse block and holder.

3.4 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

END OF SECTION 262813

SECTION 262819 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.

1.3 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA FU 1 – Low Voltage Cartridge Fuses.
3. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data

1. Switch ratings and enclosure dimensions.

B. General

1. Operation and Maintenance Data: For enclosed switches and accessories.

a. Routine maintenance requirements.

b. Manufacturer's written instructions for testing and adjusting enclosed switches.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

B. Description: NEMA KS 1, Type HD, heavy duty, enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Switch Ratings: Horsepower/current rated and suitable for AC voltage as indicated on construction plans.

D. Minimum Short Circuit Rating: As indicated on construction plans.

1. If not indicated on construction plans, submit an RFI to CAWCD.

E. Materials:

1. Fuse Clips: Designed to accommodate NEMA FU 1 with fuses as specified in Section 262813 - Fuses.
2. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

a. Interior Dry Locations: NEMA 250 type 1.

1) If NEMA 250 type 1 is selected for use during a project, submit an RFI to CAWCD for approval.

b. Exterior, Interior Wet or Pumping Plant Locations: NEMA 250 type 3, at the minimum rating.

3. Furnish switches with entirely copper current-carrying parts.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted, insulated, and labeled for copper neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form C) auxiliary contacts arranged to activate before switch blades open.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Eaton.
2. General Electric.
3. Siemens.
4. Square D.

B. Description: NEMA KS 1, Type HD, heavy duty, enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Switch Ratings: Horsepower rated, number of poles, current, and suitable for AC voltage as indicated on construction drawings.

D. Minimum Short Circuit Rating: As indicated on construction drawings.

E. Materials:

1. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

a. Interior Dry Locations: NEMA 250 type 1.

1) If NEMA 250 type 1 is selected for use during a project, submit an RFI to CAWCD for approval. Exterior and Pumping Plant Locations: NEMA 250 type 3 as the minimum rating.

2. Furnish switches with entirely copper current-carrying parts.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.

2. Neutral Kit: Internally mounted, insulated, and labeled for copper neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form C) auxiliary contacts arranged to activate before switch blades open.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install enclosed switches where indicated on project plans.

1. It may be necessary to coordinate with CAWCD on final location.

B. Install enclosed switches plumb. Provide supports according to Section 260529 – Hangers and Supports for Electrical Systems.

C. Height: 5 feet to operating handle. Contractor shall coordinate with CAWCD if this is not feasible.

D. Install fuses for fusible disconnect switches. Conform to Section 262813 - Fuses for product requirements.

E. Install engraved plastic nameplates according to Section 260553 – Identification for Electrical Systems. Engrave nameplates with equipment served and panel and circuit number supplying switch.

F. Apply adhesive tags on inside door of each fused switch indicating NEMA fuse class and size installed.

3.2 FIELD QUALITY CONTROL

A. Inspect each enclosed switch for defects.

B. Verify tightness of accessible bolted connections.

C. Operate each switch with circuit energized and verify proper operation.

END OF SECTION 262819

SECTION 262913 – ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 Specification General Requirements, and Special Provisions , apply to this section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes enclosed full-voltage magnetic controllers rated at 600 V and less.

1. For example: motor starters.

1.3 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA ICS 2 - Controllers, Contactors, and Overload Relays Rated 600V.
3. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

1.4 SUBMITTALS

A. Product Data (PD)

1. For each type of enclosed controller and auxiliary components. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, short circuit current rating of integrated unit, and enclosure types and finishes.

B. Shop Drawings (SD)

1. Include the following for each enclosed controller.

a. Dimensioned plans, elevations, sections, required clearances, and details of the equipment.
b. Wiring diagrams for power, signal, and control wiring.

C. General

1. Operation and Maintenance Data: For enclosed controllers and all auxiliary components.

a. Routine maintenance requirements.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
d. Manufacturer’s written instructions for testing and adjusting trip settings and circuit breakers.

D. Qualification Data (QD): Submit for qualified testing agency.

E. Quality Control Reports (QCR)

1. Test Reports: Indicate results of all field tests and inspections.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space at a uniform temperature. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, corrosive substances, physical damage, and traffic.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, current CAWCD adopted edition.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Preferred:

a. Eaton.
b. Square D.

2. Coordinate with CAWCD for approval for the following:

a. General Electric.
b. Rockwell Automation.
c. Siemens.
d. Hoffman.
e. Rittal.

B. Description: Factory assembled combination of magnetic controller, over-current protective device, and disconnecting means.

1. Configuration: Non-reversing.
2. Contactor Coils: Pressure-encapsulated type.
3. Operating Voltage: As indicated on construction plans.
4. Power Contacts: Totally enclosed, double-break; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120VAC; obtained from integral control power transformer, with primary and secondary fuses, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
6. Bimetallic Overload Relays:
7. Inverse-time-current characteristic.
8. Class 10 tripping characteristic.
9. Automatic resetting.
10. Disconnecting Means: NEMA KS 1, heavy duty, horsepower rated with electrical ratings as indicated on construction plans.
11. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
12. Auxiliary Contacts: Two NO/NC (Form C) auxiliary contacts arranged to activate before disconnect switch blades open.
13. Ground Bus: Furnish copper ground bus in each controller.
14. Push Buttons: Recessed type.
15. Pilot Lights: LED type with push-to-test functionality.
16. Selector Switches: Rotary type.

a. If applicable per contract plans, HAND-OFF-AUTO switch (3-position) shall be used.

1) HAND refers to a manual ON mode.
2) AUTO refers to being controlled by a process or outside device.

a) i.e. a differential pressure switch.

17. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Service Conditions – Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than -22F and not exceeding 130F.
2. Altitude: Not exceeding 3000 feet above sea level.

D. Minimum Short Circuit Rating: As indicated on construction plans.

E. Enclosure: NEMA 250 Type 3.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install controllers in compliance with NECA 1.

B. Install fuses in control circuits if not factory installed. Comply with requirements of Section 262813 - Fuses.

1. Coordinate installation location and clearances with CAWCD.

3.2 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring in compliance with Section 260553 – Identification for Electrical Systems.

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation for defects.
2. Verify proper operation of over-current devices and disconnecting means.
3. Test each motor for proper phase rotation.
4. Test and adjust control functionality and remote monitoring for suitable operation.

C. Controllers will be considered defective if they do not pass tests and inspections.

D. Replace defective equipment.

3.4 ADJUSTING

A. Adjust controls and over-current device settings for suitable operation as instructed by CAWCD and/or project drawings.

3.5 CLEANING

A. Touch up scratched or marred surfaces to match original finish.

END OF SECTION 262913

SECTION 262923 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans Division 00 Contract Documents, Division 01 General Requirements and Special Provisions, apply to this Section.

B. Coordinate with other Electrical Standard Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes: Variable frequency drives (VFD).

1.3 REFERENCES

A. National Fire Protection Association:

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

B. Institute of Electrical and Electronics Engineers

1. IEEE C62.41 – Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

C. National Electrical Manufacturers Association

1. NEMA ICS 7 – Industrial Control Systems: Adjustable Speed Drives

D. National Electrical Testing Association

1. NETA ATS – Acceptance Testing Specifications

1.4 SUBMITTALS

A. Product Data

1. Voltage, controller size, electrical ratings, and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
2. Contractor shall also provide operating characteristics, operating weights, configurations/parameter files and accessories.

B. Shop Drawings

1. Indicate front and side views of enclosures with overall dimensions, mounting arrangements, elevations and sections, and weights shown; conduit entrance locations and requirements; and nameplate legends.
2. Contractor shall include schematic and wiring diagrams for power and control connections.

C. Quality Control Reports (QCR)

1. Product Data: Voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
2. Plans: In accordance with Section 260010 Supplemental Requirements for Electrical (Power and Control Drawing Standard Specifications).
3. Product Certificates from manufacturer.
4. Test Reports: Indicate field test and inspection procedures and test results.
5. Manufacturer's Field Reports: Indicate start-up inspection findings.

D. Operation and Maintenance Data

1. Include procedures for starting and operating controllers and describe operating limits possibly resulting in hazardous or unsafe conditions. Include routine preventative maintenance schedule.

1.5 CLOSEOUT SUBMITTALS

A. General

1. Project Record Documents:
2. Operation and Maintenance Data: For variable-frequency drives and all accessory components. Include instructions complying with NEMA ICS 7.1.
3. Routine maintenance requirements.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Conform to NEMA ICS 7 service conditions during and after installation of variable frequency controllers.

1.7 WARRANTY

A. Furnish five-year manufacturer's warranty for variable frequency controller from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY CONTROLLERS

A. Manufacturers: The variable frequency motor controllers shall be Allen-Bradley or equivalent. Substitutions must be approved by CAWCD.

B. Design Features:

1. 4 to 20 mA input speed reference signal.
2. Electrically isolated auxiliary contacts for ready, running, and trouble status.
3. Terminal blocks for control and signal wires entering and leaving the controller.
4. Programmable automatic restart.
5. 4 to 20 mA output signal proportional to VFD output frequency.
6. Ethernet/IP communication capability.
7. Fused, integral transformer for control power.
8. Device Ratings: as indicated on Construction Plans.
9. Motor overload protection sized to match connected motor per manufacturer recommendations.
10. Allen-Bradley Human Interface Module (HIM) mounted to drive or external face of enclosure.

C. Safeties and Interlocks:

1. Door Interlocks: Mechanical means to prevent opening of equipment with power connected, or to disconnect power when door is opened; include means for defeating interlock by qualified persons.
2. Safety Interlocks: Terminals for remote contact to inhibit starting under both manual and automatic mode.
3. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
4. Manual Bypass: Includes contactor, motor running overload protection, and short circuit protection for full voltage, non-reversing operation of motor. Includes isolation switch to allow maintenance of inverter during bypass operation.

D. Fabrication:

1. Wiring Terminations: Match conductor materials and sizes as indicated on Construction Plans.
2. Wire labels: Wire labels shall be applied according to section 260553 - Identification for Electrical Systems.
3. Enclosure: NEMA 250, Type 3.
4. Finish: Manufacturer's standard enamel.

2.2 LINE REACTORS

A. Provide 3% input and output line reactors for each VFD. Vendor shall be Manufacturer's standard. Install line reactors in the VFD cabinet.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install according to NEMA ICS 7.1.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Install fuses in fusible switches.

D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

E. Install engraved plastic nameplates according to Section 260553 – Identification for Electrical Systems.

F. Neatly type label inside controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place label in clear plastic holder.

G. Ground and bond controller according to Section 260526 – Grounding and Bonding for Electrical Systems.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage qualified testing agency to perform tests and inspections.

B. Perform inspections and tests listed in NETA ATS, Section 7.16 and NEMA ICS 7.1.

C. Variable-frequency motor controllers shall be considered defective if they do not pass tests and inspections.

3.3 DEMONSTRATION AND TRAINING

A. Furnish four hours of instruction each for CAWCD Maintenance operation and maintenance personnel to be conducted at Project Site with manufacturer's representative.

END OF SECTION 262923

SECTION 263213 – ENGINE GENERATORS

PART 1 - -GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Coordinate with Section 263600 – Automatic Transfer Switch and Section 260553 – Identification for Electrical Systems for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes packaged engine-generator sets with optional features as identified within the project plans.

B. The engine generator set, automatic transfer switch and all specified accessories shall be supplied by one manufacturer who shall furnish all wiring diagrams for all equipment which shall constitute the emergency/standby power system.

1.3 REFERENCES

A. National Fire Protection Association (NFPA).

1. NFPA 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
2. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.
3. NFPA 110 - Standard for Emergency and Standby Power Systems.

B. Underwriters Laboratories, Inc. (UL):

1. UL 2200/CSA-Standard for Stationary Engine Generator Assemblies.

C. International Organization for Standardization

1. ISO 3046 - Reciprocating internal combustion engines.
2. ISO 9001 – Quality Management Systems - Requirements

1.4 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. EPS: Emergency power supply.

C. EPSS: Emergency power supply system.

D. Optional Standby Power Supply: NEC702, optional standby.

1.5 SUBMITTALS

A. Product Data - For each type of packaged engine generator indicated:

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective devices.
4. Must show that protective devices are coordinated.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75- and 1.0-times generator capacity.
6. Output circuit breaker.
7. Control panel, alarms, and monitoring system.
8. Fuel tank and subbase tank generator capacities.
9. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor and rated load. Testing shall be performed per ISO3046 standards. Provide plans showing requirements and limitations for location of air intake and exhausts.
10. Include generator characteristics, including, but not limited to kW rating, efficiency, reactance, and short-circuit current capability.
11. Engine performance and specs.
12. Alternator performance and specs.
13. Connecting pipes, muffler, and radiator duct flanges.
14. Enclosure(s)

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified.
2. Include details of equipment assemblies: Indicate dimensions, weights, center of gravity of full assembly, loads, clearance requirements, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.

4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. Design calculations shall be signed by a qualified professional engineer.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights. Vibration Isolation Base Details shall be signed by a qualified professional engineer.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings equipment and functional relationship between all electrical components.
7. Outdoor enclosure color sample, when outdoor enclosure required on project plans.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer and testing agency.

1. Statement of quality from manufacturer detailing acceptance as an ISO9001 manufacturer.

B. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report on factory tests on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report on sound generation.
6. Report on exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty: For special warranty.

E. Blank copy of commissioning & startup reports to be submitted 4 weeks prior to the scheduled commissioning date.

F. Completed and signed copy of the commissioning & startup reports

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation and maintenance manuals.

1. In addition to items specified in "Operation and Maintenance Data," include the following:

    a. List of special tools and recommended maintenance items. Include part and drawing numbers, current unit prices, and source of supply.
    b. Training plan.

1.8 QUALITY ASSURANCE

A. Qualification Data: For Installer, manufacturer and testing agency.

1. Statement of quality from manufacturer detailing acceptance as an ISO9001 manufacturer.

B. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report on factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report on sound generation.
6. Report on exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
8. Field quality-control reports.
9. Warranty: For special warranty.

C. Manufacturer Qualifications: Manufacturer accepted as an ISO9001 manufacturer.

D. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.

E. Testing Agency: Engage a qualified testing agency to inspect and perform tests and prepare test reports.

1. Tests and Inspections: Perform tests recommended and approved by manufacturer. All electrical tests and visual and mechanical inspections shall follow the requirements in NETA Acceptance Testing Specification. Certify compliance with test parameters.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Blue Star or CAWCD-approved equal.

B. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer. Generator set shall be new and of current production from manufacturer. No special ratings will be permitted.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 110 requirements for Level 2 emergency power supply system.

B. UL Compliance: Comply with UL 2200/CSA.

C. Engine Exhaust Emissions: Comply with EPA Tier requirements and applicable state and local government requirements.

D. Vibration Isolation: See Section 2.8B.

E. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40° C for spark-ignited.
2. Relative Humidity: Zero to 95 percent, for outdoor engine-generators.
3. Altitude: Sea level to 4100 feet (1250 m).

2.3 ASSEMBLY DESCRIPTION

A. Generator set, 1-phase, 120/240 and factory-assembled and tested, liquid-cooled engine, with the following accessories:

1. Fuel System:

    a. Single fuel propane vaper

2. Engine:

    a. Engine air cleaner
    b. Shut down – low oil pressure
    c. Extension – oil drain
    d. Alternator:
    e. 120° C (248° F) temperature rise alternator
    f. Permanent magnet generation (PMG) excitation
    g. Programmable Interface Module:
    h. Auxiliary configurable I/O, 2 digital inputs / 6 relay outputs

        1) Configure outputs to:

            a) Relay 1 – Engine Gen Running

            b) Relay 2 – Engine Gen Fault

            c) Relay 3 – Low Battery

            d) Relay 4 – Not in Auto

                (1) Relay 5 - Shutdown

                (2) Relay 6 – Overcrank (Failed to Start)

3. Electrical:

    a. Single circuit breaker, 2-Pole, per project plans

4. Enclosure:

    a. Open set – on skid base

5. Cooling System:

    a. Extension – coolant drain
    b. Cold weather option: <4° C (40° F)
    c. High ambient temperature
    d. Duct adapter – Radiator outlet

6. Exhaust system:

    a. As shown on project plans

7. Generator set application:

    a. Battery rack, larger battery

b. Battery included

8. Battery charger:

a. 15-Ampere, 12Volt

9. Software:

a. Blue Star: Full version, permanent, DSE Software license per generator to be included in delivered generator package.
b. Other: Full, permanent license for maintenance/configuration/troubleshooting software to be included.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. EPSS Class: Engine-generator set shall be classified as a Class 2 in accordance with NFPA 110.

D. Emissions: Comply with EPA Tier and local requirements for standby generation.

E. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

F. Capacities and Characteristics:

1. Output Connections: Single-phase, three wire.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component. Nameplate shall be in accordance with NFPA 70.
3. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 ENGINE

A. Fuel: LP gas

B. Generator set to be liquid-cooled.

1. Cooling System - Liquid: Closed loop, liquid cooled, with radiator factory mounted on engine- generator-set mounting frame and integral engine-driven coolant pump.

    a. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
    b. Cooling System Sizing: Sized to adequately cool the generator set, including aftercooler, without de-rate to an ambient temperature of 104° F (40° C) for gas. Maximum external restriction shall be no greater than 0.5 inch (12.7 mm) of water column.

C. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element.

D. Starting System:

1. Battery: Lead acid, certified to meet NFPA 110, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
2. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
3. Battery Compartment: Factory fabricated metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10° C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
4. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and continuous rating adequate for batteries provided.
5. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236.

    a. Battery chargers mounted within the Automatic Transfer Switch are not acceptable.

2.5 CONTROL AND MONITORING

A. As shown on project plans.

B. Comply with UL 508A.

C. Indicating Devices: As required by NFPA 110 for Level 2 system. All ECM fault codes shall be displayed at the generator set controller in standard language; fault code numbers are not acceptable. Utilizing a digital display, including the following:

1. AC voltage: True single-phase sensing.
2. AC current.
3. Frequency.
4. EPS supplying load indicator.
5. DC voltage (alternator battery charging).
6. Engine-coolant temperature.
7. Engine lubricating-oil pressure.
8. Running-time meter.
9. Current and Potential Transformers: Instrument accuracy class.

D. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 2 system, including the following:

1. Start-stop switch.
2. Over crank shutdown device.
3. Over speed shutdown device.
4. High-temperature shutdown device.
5. Low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Over crank alarm.
8. Over speed alarm.
9. High-temperature alarm.
10. Low-temperature alarm.
11. Low lube oil pressure alarm.
12. Lamp test.
13. Contacts for common alarm.
14. High-temperature pre-alarm/warning.
15. Generator-voltage; digitally adjustable via controller, password protected.
16. Run-Off-Manual selector switch.
17. Control switch not in automatic position alarm.
18. Low cranking voltage alarm.
19. Battery-charger malfunction alarm.
20. Battery low-voltage alarm.
21. Battery high-voltage alarm.
22. Generator overcurrent protective device not closed alarm.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated. Sensors are to be conditioned to a 4 to 20 mA signal level to enhance noise immunity, and all sensor connections shall be sealed to prevent corrosions.

F. System installation to include hardware and labor to connect genset to the CAWCD network for remote monitoring and configuration changes:

1. USB Service Port – Include separate junction box, USB cabling, USB to Ethernet network converter, and ethernet cabling to site router.

G. The control system shall provide pre-wired customer use I/O relay outputs (per user definable functions in this specification).

H. Maintenance:

1. All engine, voltage regulator, control panel, and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set controls:

a. Engine running hours.
b. Service maintenance interval (running hours, calendar days).
c. Engine crank attempt counter.
d. Engine successful starts counter.
e. 20 events are stored in control panel memory.
f. Control software shall time and date stamp all alarms and warnings.

2. Programmable Cycle Timer: To start and run the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

a. Day of the week.
b. Time of the day start.
c. Duration of cycle.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel and each located in a separate box per NEC Article 700 separation of circuits.

B. Generator Circuit Breaker: As shown on the project plans and complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Each circuit breaker installed in separate box in accordance with NEC Article 700 separation of circuits.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and UL2200, sized for 248° F (120° C) temperature rise above ambient at rated load.

B. Electrical Insulation: Class H.

C. Provide 1-phase, 4 lead alternator, 130° C temperature rise at 40° C ambient.

D. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over speed up to 125 percent of rated speed, and heat during operation at 110 percent of rated capacity.

E. Instrument Transformers: Mounted within generator enclosure.

2.8 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized- steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore Scale Durometer Rating: 30
3. Number of Layers: One
4. Minimum Deflection: 1 inch (25 mm)

B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.9 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. See Section 260502 - Electrical Demolition

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Equipment Mounting:

1. Install packaged engine generators on existing steel support structure modified as depicted in the design documents.
2. Coordinate size and location of existing concrete base and steel support structure for packaged engine generator. Cast anchor-bolt inserts into bases, as applicable.

C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Install packaged engine generator with elastomeric isolator pad shaving a minimum deflection of 1 inch (25 mm). Secure enclosure with high grade bolts installed in steel support structure.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Connect new fuel piping to engine with a gate valve and union and flexible connector.

B. Ground equipment according to Section 260526 - Grounding and Bonding for Electrical Systems.

C. Connect wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables. Provide a minimum of one 90-degree bend in flexible conduit routed to the generator set from a stationary element.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection

        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.
        5) Electrical and Mechanical Tests

a) Test protective relay devices per manufacturer recommendations.

b) Verify phase rotation, phasing, and synchronized operation as required by the application.

c) Functionally test engine shutdown for low oil pressure, over temperature, over speed, and other protection features as applicable.

d) Conduct performance test in accordance with NFPA 110.

e) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated auxiliary equipment.

F. Load Test: Perform a 2-hour load test.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 TRAINING

A. The equipment supplier shall provide training for the CAWCD operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration. Training date shall be coordinated with CAWCD.

END OF SECTION 263213

SECTION 263353 – UNINTERRUPTABLE POWER SUPPLY (UPS) and INTEGRATED POWER SUPPLY SYSTEM (IPSS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions, apply to this Section.

B. Coordinate with other Electrical Standard Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Coordinate with Section 263600 – Automatic Transfer Switch and Section 260553 – Identification for Electrical Systems for additional submittals, qualifications, and other Project requirements to Work specified in this section.

D. This specification applies to both AC UPS and AC/DC IPSS systems.

1.2 SUMMARY

A. UPS System:

1. Surge suppression.
2. Rectifier/charger.
3. Inverter.
4. Maintenance transfer switch.
5. Controls and indications.
6. Remote status and alarm panel.
7. Battery monitoring.
8. Battery and battery disconnect device.
9. Remote monitoring provisions.

1.3 DEFINITIONS

A. UPS: Uninterruptible power supply.

B. SPD: Surge protection device.

C. THD: Total harmonic distortion.

D. EMI: Electromagnetic interference

E. LED: Light-emitting diode.

F. IPSS: Integrated Power Supply System

1.4 SUBMITTALS:

A. Submit product information and cutsheets of UPS/IPSS equipment components and devices.

B. The contractor shall provide dimensioned general plan and elevation of equipment.

C. Include as shop drawings:

1. Equipment dimensions
2. Performance curves for range of operation
3. Selection criteria.
4. Installation requirements and layouts.
5. Details of construction.
6. Technical description.
7. Wiring diagrams.
8. Plan clearly indicating field wiring, piping, and the other work to be completed by the Contractor
9. Shop drawings to be included for all accessories, replaceable components and components purchased from third party and becoming part of the installations

D. Complete specifications on overall UPS (or IPSS) systems including sub system specifications from the original manufactures shall be submitted to CAWCD for pre-approval.

E. Review of shop drawings by CAWCD for general conformance only and shall not relieve the Contractor of responsibility for supplying equipment which complies with the specifications and functional requirements and good engineering practice.

F. Supplier qualifications

1. The manufacturers of the UPS (or IPSS) must have a minimum of 5 years of manufacturing experience.
2. UPS (or IPSS) shall be standard products from manufacturers.

1.5 REFERENCES:

A. ANSI C62.41-Recommended practice on surge voltage in low voltage power circuit

B. FCC Rules and Regulation 47, Part 15, subpart J, Class A (Federal communication Commission certified compliance)

C. IEC 60068-1, 2-International Electrotechnical Commission

D. IEC 801-2-Electrostatic discharge

E. NEC-National Electric Code, latest edition

F. NEMA PE-1-UPS system standard

G. UL 1778-Standard for UPS equipment

1.6 WARRANTY:

A. UPS (or IPSS): The warranty of the UPS (or IPSS) shall be no less than 12 months after acceptance and must include all costs including repair, parts, labor, travel and living expenses for the manufacturer's service personnel.

B. Battery: Shall include a minimum 2-year warranty.

C. If required during the warranty period, the UPS (or IPSS) Supplier shall provide all necessary labor, materials, and repair-related expenses.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS:

A. The following system requirements are applicable to all UPS (or IPSS).

1. The UPS (or IPSS) System consists of UPS (or IPSS) Cabinet, and Battery Assembly as specified in the contract documents.
2. All UPS (or IPSS) Equipment to be provided by one manufacturer.
3. Testing of All UPS (or IPSS) Equipment is to be conducted at the site with the UPS systems fully assembled.
4. UPS: The UPS (or IPSS) shall consist of the UPS (or IPSS) Cabinet, isolation transformers, maintenance bypass Cabinet (MBC), static transfer switch and the other features as described in this specification. Overall UPS (or IPSS) system shall have an efficiency of 93%.
5. The following are the typical loads

    a. Control, Communication Systems and Lighting
    b. Emergency lighting inverter for stations
    c. Operation Control Center (OCC)
    d. Computers, servers etc.

2.2 MODES OF OPERATION:

A. UPS (or IPSS): The UPS (or IPSS) shall be an on-line type and make-before-break operation during load transfer.

1. Normal operation: Under normal operation the power will be transferred through the UPS (or IPSS) converter systems. The output ac voltage will be fully regulated and the output will be isolated from the input through an isolation transformer.
2. Loss of normal input power: When the input AC power fails there will be no interruption of power as the UPS (or IPSS) inverter will continue to power the load from stored battery system's dc bus. The battery shall continue to supply power to the inverter at rated full load for the specified time.
3. Return of Normal Power: The UPS (or IPSS) system will automatically return to normal operation as described in (2.2. A.1) with no interruption to essential load. The transfer to normal utility power will be initiated only after ascertaining stable return of input ac voltage after several cycles.
4. UPS (or IPSS) internal fault: When there is failure in the UPS (or IPSS) inverter or the battery system unable to supply power, a control signal will inhibit the inverter operation, and the power will continue to be transferred from input ac to the output through the static bypass switch.
5. UPS replacement/maintenance: In the event the UPS (or IPSS) requires replacement, the input external bypass switch shall be closed and output disconnect switch shall be opened manually, allowing total bypass of the UPS for safe removal.
6. Operation without batteries: If the battery is taken out of service for any reason, the UPS (or IPSS) shall continue to function from the input ac source through static bypass or external mechanical bypass switch.

2.3 POWER RATING:

A. The UPS (or IPSS) shall be sized in accordance with the CAWCD approved power calculations to support the connected load with a minimum of 20% margin of UPS rating. The input line voltage, load voltage and input bypass line voltage shall be as indicated in the Contract plans. Product information for the UPS shall be submitted to CAWCD for approval.

B. The UPS (or IPSS) battery shall have capacity to support the load as calculated above at each location for duration as specified in the project documents for that application.

2.4 ELECTRICAL REQUIREMENTS:

A. Acoustic Noise: Noise generated by the UPS (or IPSS) under any condition of normal operation shall not exceed the allowable sound pressure level of 65 dBA measured 1 meter from the nearest surface of the cabinet.

B. EMI Suppression: The UPS (or IPSS) shall meet FCC rules and regulation 47, part 15, sub part J, for class A devices.

C. Electrostatic Discharge (ESD): UPS shall meet IEC 801-2. The UPS (or IPSS) shall withstand up to 25KV without damage and with no disturbance or adverse effect on the critical load.

D. Efficiency: The UPS (or IPSS) efficiency shall be a minimum 93% at full unity power factor load and nominal input.

E. Input Surge Withstanding Capability: The UPS (or IPSS)/LI shall be in compliance with IEEE 5887/ANSI C62.41, North American and International standards, which include C62.41.

2.5 INPUT RATINGS:

A. Input voltage: As specified in the contract documents.

B. Input Voltage Range: +10%, -20%

C. Input Frequency Range: 53 to 67 Hz

D. Phase Unbalance: The UPS (or IPSS) shall not be impacted by input line phase unbalance up to +10%. The output phase unbalance shall not be contributed by the UPS inverters.

E. Power Factor: 0.8 lagging to 0.8 leading at full load

F. Current Limit: 125% full load maximum

G. Protection: The unit shall be self-protected against unwanted over-voltage including line over-voltage and transients such as switching surge and lightning, over-current including short circuits per NEC requirements.

H. Inrush current: Soft start shall be used to limit no more than 1.5x full load amps.

I. Full load for a duration not exceeding 100 milliseconds.

J. Input Transformer: Δ - Y (Delta – Wye)

K. Isolation: Input shall be isolated from the ac system by an isolation transformer where called for. The isolation voltage of the transformer shall be per applicable standards.

2.6 OUTPUT RATING:

A. Output Voltage Rating: As specified in the contract documents.

B. Output Power Rating: As specified in the contract documents.

C. Output Voltage Regulation: Within + 2 % of output voltage

D. Output Frequency: Nominal 60 Hz, + 0.5 Hz

E. Load Response: 1 millisecond

1. Free running stability: + 0.15% in 24 hr;
2. Stability: + 1% in 6 months

F. Voltage Transients:

1. Voltage transient shall not exceed more than + 5% for any change in load.
2. Return of AC Power: + 2%
3. Manual transfer of load: + 5% to UPS or bypass line
4. Automatic transfer of load must have transient suppression network as well
5. as suppressors.
6. Voltage transient recovery time to within 2 % within 1 millisecond.
7. Load power factor: 0.8 lagging to 0.8 leading
8. Total Harmonic Distortion (THD): <3% RMS maximum; <2% any single harmonic
9. Overloads: 125% for 10 minutes; 115% for 1 hour
10. Static transfer: 1000% full load for 1 switch loading cycle; 200% full load for 5 minutes
11. Hours of operation: 72 Hours at full load for stations, and as specified.
12. Output Transformer: Secondary Y configuration
13. Maximum cabinet size: As specified in the contract documents.
14. Phase unbalance: 100% (i.e. Phase A-15%, phase B-70%, phase C-15%)

2.7 CONTROLS DESIGN AND OPERATING CHARACTERISTICS:

A. Fully automatic operation of each UPS (or IPSS) module shall be provided through the micro controllers.

B. All operating and protection parameters shall be firmware controlled, thus minimizing the need for manual adjustments. All adjustments and calibrations shall be performed once at production and at any time the operational parameter is modified. Printed circuit board replacement shall be possible with minimum calibration requirements.

C. Start up and transfer shall be automatic functions.

D. Multiple micro-controllers shall be used per module, so no single controller in a mission critical application.

E. All configurations, setup and calibration information shall be stored in a non-volatile memory that does not require a control battery for data storage.

F. Emergency transfer to Bypass due to UPS (or IPSS) module failure shall be independent of control logic controlling the rectifier/charger, inverter and monitor panel. Emergency transfer circuitry shall contain all the necessary circuitry to perform an emergency transfer without any other functioning logic.

G. Monitoring and communication logic shall be independent of rectifier/charger and inverter control logic. Circuitry and firmware required for monitoring and communications shall be functionally isolated from those controlling the input, output, and battery power circuits.

H. The UPS (or IPSS) module shall be programmable to optionally provide automatic restart capability following loss of utility and complete battery discharge. When utility power returns, the UPS module shall automatically energize the output terminals and subsequently transfer to Normal mode.

2.8 ENVIRONMENTAL REQUIREMENTS:

A. The UPS (or IPSS) shall withstand any combination of the following external environment conditions without operational degradation.

1. Operating temperature: 32F to 120F (0C to 50C)
2. Relative Humidity: 0% to 95% non-condensing (Operating and storage)

2.9 RELIABILITY AND MAINTAINABILTY:

A. The calculated MTBF for the UPS (or IPSS) shall be no less than 150,000 hours.

B. All power cables to power transformer and chokes shall be secured with permanent cold weld crimps, which required no maintenance or periodic retorquing.

C. Maintainability: Calculate and demonstrate mean-time-to-repair (MTTR) shall not exceed 30 minutes, including the time to diagnose the problem and replace the sub assembly.

2.10MANUALS:

A. Provide copies of maintenance documentation.

B. Manuals to include:

1. Clear and permanent identification on the outside of the binder
2. Detailed index
3. All documentation to be 8½” x 11” format
4. List of supplier and authorized service representatives for the equipment and accessories supplied. Provide names, address and phone numbers

5. Details of warranty
6. List of recommended spare parts
7. Step by step start up and shut down procedures
8. Troubleshooting summary
9. Itemized maintenance schedule and single page summary including recommended daily, weekly, monthly and yearly maintenance.
10. Parts summary including make, model and part number to facilitate ordering of the replacement parts.
11. Dimensioned general arrangement drawings
12. Include parts diagram and assembly drawing to permit tear down maintenance and/or repair.

C. Include similar documentation for all purchased components not manufactured by manufacturer.

D. Manuals for all software shall be provided to the owners as applicable. Include copies of all installation specific or proprietary software necessary to maintain, reload or modify the system. Include latest hard copy and soft copy of software.

2.11EQUIPMENT REQUIREMENTS:

A. General: The UPS shall be designed for the operation in a non-air-conditioned room environment with temperature extremes of 32F and 120F (0C to 50C) and humidity 0% to 95% non-condensing. The UPS (or IPSS) circuit shall be modular for ease of replacement. The system shall have the capability of remote management, monitoring and control.

1. Modules shall be standardized such that Least Replaceable Unit (LRU) modules shall fit in the same slot without any need of modifications.
2. Access for maintenance shall be easy for removal of critical components. All critical components shall be configured for self-diagnoses. System status monitor shall have diagnostics and indicators identifying existing on the printed circuit modules. LED indicators shall light up and alert technician to system fault. Serviceable parts should be designed to physical separation from high voltage areas assuring safety of maintenance personnel.
3. At minimum the UPS (or IPSS) shall include all the sub systems as outlined in this specification. In addition, this will include all the control protection and monitoring circuits as necessary. Additional requirements shall be defined by CAWCD specifications for a particular application. Any deviation from these specifications shall require CAWCD’s written approval.
4. High stress, high voltages electronics switching components shall be plug-and-play for the ease in service and maintenance.

B. RECTIFIER/CHARGER:

1. The rectifier/charger shall convert incoming AC power to regulate the DC output for supplying the inverter and for charging the battery bank. The

rectifier shall be twelve-pulse system design. The charger design shall be constant current type switching converter. The modular design of the UPS module shall permit easy removal of rectifier/charger without removal of any other assembly.

2. The rectifier charger shall automatically boost the charge to the battery after battery is drained. The boost charge shall allow quick recharge and keep batteries in good condition without providing a constant float charge. It shall provide a controlled charging and load exercising of batteries to avoid battery deterioration. Controlled charging of the batteries shall prevent boiling and dehydration of electrolyte. Load exercise of the batteries shall keep batteries continuously cycled, alleviating cell deterioration. To prevent overcharging the boost charge shall stop when ambient temperature could cause damage to the batteries.
3. The charger shall be able to recharge the fully discharged battery capacity in 6 hours.
4. The charger unit shall be programmable and expandable up to as specified in the contract documents for additional battery modules if so desired at a future date.
5. The rectifier/charger shall be furnished with output filtering to limit the ripple currents into the battery.
6. INVERTER: The inverter shall be high frequency switching converter employing devices such as insulated-gate bipolar transistor (IGBT) technology. The inverter shall have the following features:

    a. The inverter shall be capable of providing the specified quality output power while operating from any DC voltage source (Rectifier or Battery) within the specified range.

    b. The modular design of the UPS shall permit easy removal of each phase of the inverter and DC electrolytic capacitors without removal of any other assembly.

7. The inverter shall have all the necessary input/output filtering and circuit necessary for regulation, protection and monitoring.
8. The DC input of the inverter shall have banks of filter capacitors. The loss of one bank shall not disrupt output voltage or a continued full load operation.
9. Protection:

    a. The inverter output shall be protected against over current (OC) and shall have current limiting circuit.
    b. The inverter input shall have surge protection.
    c. The inverter shall have an active soft start circuit to ramp up to output full voltage within 1 second.
    d. The circuitry shall automatically synchronize, and phase-lock the inverter output to the alternate power source as long as the source is within 60 +0.5 Hz. If the alternate source is not within these limits, then the inverter shall lock to an internal oscillator.

e. The inverter shall automatically turn off at the DC voltage low level of 1.75 volts per cell.
f. Test points and LEDs shall be provided to facilitate adjustments, diagnostics and identify circuit integrity.
g. It shall be possible to test logic circuitry without operating the power circuits.

C. BATTERIES:

1. Battery testing: The UPS (or IPSS) shall perform an automatic battery test once a day and allow for user remote and local selected battery tests. The test shall not compromise the output of IPSS system and alert user through local and remote monitoring system of any battery error.
2. Battery Management System: The UPS (or IPSS) shall contain a battery management system which has the following features:

a. The battery management shall provide battery time available, or percent remaining, while operating in Normal mode and battery mode. Battery time available shall be displayed in real time, even under changing load conditions. The battery time available information shall be within + 3%.
b. The battery management system shall automatically analyze the UPS battery during a user defined periodic test. During the test, rectifier/charger shall not de-energize, but shall share load with the battery. For remaining battery time information, the battery shall test under the same load for each user defined periodic test. If the battery is weak or defective, the battery management system shall detect and annunciate the battery failure condition without transferring the critical load to the bypass.
c. The periodic test performed by the battery management system shall not remove more than 10% of the available run time from the battery. The periodic test, if performed monthly, shall not reduce overall battery life.
d. If the utility outage occurs while a test is in progress, the test shall be discontinued and subsequently conducted at the next programmed interval. The occurrence of the test shall be user programmable for day, date and time.
e. The battery management system shall record and display the pass/fail status, battery voltage and indicator value of previous 30 periodic tests.
f. The battery management system shall annunciate a user-programmable “battery time remaining” warning when the UPS (or IPSS) is on battery power.
g. The battery management system shall provide an imminent shut down alarm to signal a low battery condition.
h. The battery management system shall work with either wet cell batteries or valve regulated batteries.

i. The battery management system shall only place a charge on the batteries when the system detects a low battery condition or once a month (programmable). Charge and cycle in conjunction with the rectifier to cycle and preserve the life of the batteries.
j. Charging current and time fully programmable.

D. WIRING TERMINALS:

1. The UPS (or IPSS)/LI shall contain mechanical ratcheting compression terminals (adequately sized to accommodate 75°C wiring) for securing user wiring to the following locations

a. Rectifier/charger connections
b. Bypass connections
c. DC link connections
d. AC output connections
e. Transformer connections

E. CONTROLS: The UPS (or IPSS) system shall be furnished with the following controls on or inside the UPS (or IPSS) module cabinet.

1. Rectifier/Charger

a. Input non-automatic disconnect
b. DC float voltage adjustment
c. DC boost (equalize) voltage adjustment
d. Boost (equalize) voltage timer adjustment
e. Boost (equalize) voltage initiation
f. Boost (equalize) voltage timer reset

2. Inverter

a. Inverter starts
b. Inverter stops
c. DC under-voltage shut off adjustment
d. Output AC voltage adjustment

F. METERING: The following parameters shall be individually metered with a digital read out and with an accuracy of 2% or better

1. DC voltage: Rectifier/charger
2. Direct current: Rectifier/charger
3. AC voltage

a. Input
b. Output

4. Alternating current

a. Inverter
b. Alternate power source
c. Load

5. Frequency

a. Inverter
b. Alternate power source
c. Load

G. INDICATORS:

1. Monitoring components: The following components shall provide monitor and control capability

a. Micro-controller driven circuitry
b. Monitor panel with status indicators
c. Alarm and metering display
d. Various communication ports

2. Monitor Panel Indicator: The UPS (or IPSS) module shall be equipped with a monitor panel providing the following monitor functions and indicators (each alarm and notice conditions shall be accompanied with an audible alarm).

a. NORMAL: This indicator shall be lit when the UPS (or IPSS) module is operating in Normal mode.
b. BATTERY: This indicator shall be lit when the UPS (or IPSS) module is operating in Battery mode. The Normal Indicator remains lit.
c. BYPASS: This indicator shall be lit when the UPS (or IPSS) module is operating in Bypass mode. The critical load is supported by the Bypass source. The Normal indicator shall not be lit when UPS (or IPSS) is in Bypass mode.
d. NOTICE: This indicator shall be lit when the UPS (or IPSS) module needs attention. Some notices may be accompanied by an audible alarm. Notice shall include:

a) Bypass not available

b) Battery under voltage

e. STANDBY: This indicator shall be lit when electricity is present in the rectifier and Inverter. During the startup, this indicator remains lit until the UPS (or IPSS) transfers to Normal mode, at which time the Normal indicator shall be lit. During the shutdown, the standby indictor shall remain lit until all the energy in the UPS module is dissipated and shut down is complete.

f. ALARMS: This indicator shall be lit when the UPS (or IPSS) module needs immediate attention. Alarms in the form of flashing displays shall be provided for the abnormal conditions specified below. Auxiliary contacts shall be provided for each abnormal condition as well as a summary alarm contact for connection to the Supervisory Control and Data Acquisition System. Circuitry shall be provided for one RS-232 (EIA/TIA-232) and one RS-485 communication port. Provide one Ethernet (TCP/IP) I/O Base T, RJ45 connection for remote monitoring. The system shall be IP enabled. Alarm contacts shall latch until reset.

a) Low battery voltage and check battery

b) Over-temperature in the battery enclosure area

c) DC over-voltage

d) DC ground

e) Alternate power source

f) Static transfer switch position (in alternate power source)

g) Fan failure

h) Maintenance transfer switch position-ON

i) Battery carrying the load

g. ALARM SILENCE BUTTON: Display panel shall include alarm reset button. If the alarm reset button is pressed for 1 second, the current audible alarms shall be disabled. If a new alarm occurs, or a cancelled alarm condition disappears and re-appears, then audible alarm is re-enabled.

h. AUTOMATIC MESSAGING SYSTEM: A means shall be provided to generate automatic dial signal for telephone and other messaging in the event of input AC power failure to UPS (or IPSS) and a failure of the UPS (or IPSS) itself.

H. ENCLOSURE:

1. Rectifier / charger, inverter, all filtering, and surge protection shall be installed in NEMA 12 cabinets.
2. The output transformer, output filters and AC signal conditioners shall be installed in separate free-standing NEMA 12 cabinets.

3. The enclosures shall be design for industrial applications in accordance with the environment's requirements. The enclosures shall line up and match up in style and color.
4. Ventilation: The UPS (or IPSS) shall be designed for forced air cooling. Air inlets shall be in the lower front. Air outlet shall be as specified in the contract documents such as rear or the top. Twelve inches of clearance over the UPS air outlets shall be required for proper circulation. Air filters for the UPS (or IPSS) shall be commonly available sizes and shall be easily removable from the base.
5. No back or side clearance shall be required for any enclosure. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.
6. Cooling Fans: The modular design to the UPS (or IPSS) module shall permit removal of each fan without the removal of any other assembly. Fan replacement shall be accomplished by removing no more than one fastener per fan and shall not require the removal of another sub assembly.
7. Cable entry: As specified in the contract documents such as top, bottom or side. A dedicated wire way shall be provided within the UPS for routing user input and output wiring. All wiring compartments to meet NEC size requirements for cable turning radius.
8. Front Access: All serviceable components shall be modular and capable of being replaced from the front of UPS (or IPSS). Removal and replacement of any subassembly shall not require removal of another subassembly. Side or rear access to UPS module shall not be required for UPS (or IPSS) installation, service, repair or maintenance.

2.12 FIELD QUALITY CONTROL AND COMMISSIONING:

A. The following test shall be performed by the Manufacturer representative or qualified installation contractor during the UPS start up:

1. Visual inspection:

    a. Visually inspect all equipment for signs of damage or foreign materials.
    b. Observe the type of ventilation, cleanliness of room, the use of proper signs, and any other safety related factors.

2. Mechanical inspection:

    a. Check all the power connections for tightness.
    b. Check all the control wiring terminations and plugs for tightness or proper seating.

3. Electrical pre check:

    a. Check the DC bus for possible short circuit.

b. Check the input and the Bypass for proper voltage and phase rotation.
c. Check all test functions.

4. Initial Start-up:

a. Verify that all the alarms are in a go condition.
b. Energize the UPS module and verify the proper DC, walkup and AC phase on.
c. Check the DC link voltage, AC output voltages, and output waveform.
d. Check the final DC link voltage and Inverter AC voltage output. Adjust if required.
e. Check for proper synchronization.
f. Check the voltage difference between the inverter output and bypass source.

5. Operational instructions: Before leaving the site, the field service engineer shall familiarize responsible personnel with the operation of the UPS (or IPSS). The UPS (or IPSS) equipment shall be available for demonstration of the modes of operation.

B. The UPS (or IPSS) power equipment manufacturer/supplier representative shall be an integral part of the project commission team. The UPS (or IPSS) power equipment representative will be required to attend the regularly scheduled commissioning meetings to assist in start-up scheduling and resolve system installation conflicts prior to actual start up.

2.13TRAINING:

A. Following commissioning, provide training in maintenance and operation of the equipment to operators. Although the operators may be present during commissioning process, this is not to be considered part of training process.

B. Following commissioning, provide formal classroom and field training to operation staff using the maintenance manual provided.

C. Review contents of manual and discuss regular tear down maintenance and repair. Review maintenance diagnostic procedures and preventive maintenance practices.

D. Allow two separate training sessions, one month apart

1. The first session shall be four hours
2. The second shall consist of a review and questions

2.14SPARE PARTS LIST:

A. UPS (or IPSS) supplier shall provide a recommended spare parts list.

END OF SECTION 263353

SECTION 263600 - AUTOMATIC TRANSFER SWITCH

PART 1 - - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this Section.

B. Coordinate with Section 263213 – Engine Generator for additional submittals, qualifications, and other Project requirements to Work specified in this section. Coordinate with other Division 26 and 40 specification sections for additional submittals, qualifications, and other project requirements to Work specified in this section.

1.2 SUMMARY

A. Furnish and install the low voltage automatic transfer switches having the ratings, features/accessories and enclosures as specified herein and as shown on the Plans.

1.3 REFERENCES

A. The automatic transfer switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of UL and NEMA as follows:

1. Underwriter's Laboratory

a. UL 1008 – Transfer Switches

b. UL 991 - Tests for Safety-Related Controls Employing Solid-State Devices

2. National Fire Protection Association

a. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.
b. NFPA 110 – Emergency and Standby Power Systems

3. National Electrical Manufacturer's Association

a. NEMA ICS 10 – AC Transfer Switch Equipment

4. Institute of Electrical and Electronics Engineers

a. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems

5. International Organization for Standards

a. ISO 9001 – Quality Management Systems – Requirements

6. International Electrotechnical Commission

a. IEC 61000-4-2 - EMC Testing and Measurement Techniques - Electrostatic Discharge Immunity Test
b. IEC 61000-4-3 - EMC Testing and Measurement Techniques - Radiofrequency, Electromagnetic Field Immunity Test
c. IEC 61000-4-4 - EMC Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Test
d. IEC 61000-4-5 - EMC Testing and Measurement Techniques - Surge Immunity Test
e. IEC 61000-4-6 - EMC Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radio-frequency Fields
f. IEC 61000-4-11 - EMC Testing and Measurement Techniques - Voltage Dips, Short Interrupts and Voltage Variations Immunity Tests

1.4 SUBMITTALS

A. Product Data:

1. Makes and models of each transfer switch included in the bid.
2. Front view and plan view of the assembly
3. Electrical diagrams, including separate wiring diagrams and schematic diagrams, and project- specific inter-connection wiring diagrams for equipment to be supplied.
4. Conduit space locations within the assembly.
5. Product data sheets including:

a. Withstand and Closing rating
b. Voltage
c. Continuous current rating
d. Short-Time rating if applicable
e. Short-circuit rating if ordered with integral protection
f. Remote Annunciator and Controller

6. Written warranty document.
7. Operation and Maintenance Manuals.
8. Testing and commissioning documents.

B. Where applicable, the following additional information shall be submitted to CAWCD:

1. Busway connection
2. Connection details between close-coupled assemblies
3. Composite front view and plan view of close-coupled assemblies

1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. Default transfer switch manufacturer selection to be the same manufacturer as the site engine generator unless project requirements or CAWCD personnel necessitate otherwise.

C. For the equipment specified herein, the manufacturer shall be ISO 9001 certified.

D. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the CAWCD, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

E. Provide Seismic tested equipment as follows:

1. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the latest International Building Code (IBC).
2. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

    a. The Contractor shall follow mounting recommendations provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
    b. The equipment manufacturer shall certify that the equipment can withstand a seismic event, including both vertical and lateral required response spectra as specified in above codes, and continue to fully function.
    c. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualifications shall be considered achieved when the capability of the equipment meets or exceeds the specified response spectra.

1.6 REGULATORY REQUIREMENTS

A. Provide a certificate of compliance with UL 1008 for the transfer switches furnished under this section.

1.7 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions.

1. One (1) copy of these instructions shall be included with the equipment at time of shipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide equivalent products as manufactured by:

1. Schneider/Square D
2. Or equivalent approved by CAWCD

B. ATS manufacturer to match installed upstream backup generator (if applicable) unless otherwise approved by CAWCD.

2.2 ASSEMBLY DESCRIPTION

A. Automatic transfer switch, open transition, factory-assembled and tested, and the following accessories:

1. Amperage rating: Determined by project requirements and NEC sizing, 125A minimum.
2. Voltage rating: Determined by project requirements, project plans.
3. Frequency: 60 Hertz
4. Transfer mode:

    a. Open transition/in-phase

    b. Open transition/programmed

5. Application: Utility to generator, source to source.
6. System Option: Determined by project requirements, project plans.
7. Enclosure: NEMA Type 3R unless otherwise specified by CAWCD.
8. Standards: UL 1008/CSA certification.
9. Controls:

a. Display with LED lamps and/or touch screen
b. Pushbutton controls for initiating tests, overriding time delays and setting exercise time.
c. Relay outputs:

a) Normal Switch Position

b) Emergency Switch Position

c) Loss Normal Power

d. Voltage Transducer

a) Factory-install within ATS enclosure.

b) Full site voltage measurement range, connected to all legs of incoming utility power.

c) 4-20mA current output.

d) Phoenix Contact part number 2906239 or CAWCD-approved equivalent.

10. Exercise clock
11. Warranty:

a. 1 year comprehensive

2.3 MICROPROCESSOR LOGIC

A. The transfer switch shall be a microprocessor-type based controller. The controller shall be hardened against potential problems from transients and surges. Operation of the transfer switch and monitoring of both sources shall be managed by the controller.

B. The automatic transfer switch controllers shall meet or exceed the following standards in addition to the basic switch standards:

1. CISPR11, Class B - Industrial, Scientific and Medical Radio-frequency Equipment - Electromagnetic Disturbance Characteristics - Limits and Methods of Measurement
2. FCC Part 15, Subpart B, Class B

2.4 CONTROLLER DISPLAY AND KEYPAD

A. The microprocessor-based controller display shall be UV resistant. The controller shall be capable of displaying transfer switch status, parameters, and

diagnostic data. All set point parameters shall be password protected and programmable using the controller keypad.

B. The microprocessor-based controller shall include a mimic bus display consisting of four (4) individual LED's (3mm) or touchscreen for indicating the following:

1. Availability status of source 1
2. Availability status of source 2
3. Connection status of source 1
4. Connection status of source 2

2.5 VOLTAGE AND FREQUENCY SENSING

A. The controller shall monitor all phases of the Utility and Generator for under-voltage and under-frequency. Both the pickup and dropout set points shall be adjustable through the controller interface.

B. Voltage and frequency dropout and pickup parameters are set as a percentage of the nominal voltage as indicated in the table below.

Set point	Sources	Dropout	Pickup
Under-voltage	Source1 and 2	70 – 90%	90 - 95%
Under-frequency	Source 1 and 2	75%	9%

2.6 TIME DELAYS

A. A time delay shall be provided on transfer to source 2, adjustable from 0 to 300 seconds.

B. A time delay shall be provided to override a momentary power outage or voltage fluctuation, adjustable from 0 to 300 seconds.

C. A time delay shall be provided on retransfer from source 2 to source 1, adjustable from 0 to 30 minutes.

D. A time delay shall be provided after retransfer that allows the generator to run unloaded prior to shutdown, adjustable from 0 to 30 minutes.

E. A pre-transfer time delay output adjustable from 0 to 300 seconds.

F. All delays shall be field adjustable from the microprocessor-based controller without the use of special tools.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to installation, inspect for any physical damage.

B. Verify the field installation matches the final design configuration.

3.2 FACTORY TESTING

A. A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

1. Insulation check to ensure the integrity of insulation and continuity of the entire system.
2. Visual inspection to ensure that the switch matches the specification requirements and to verify that the fit and finish meet quality standards.
3. Mechanical tests to verify that the switch's power sections are free of mechanical hindrances.
4. Electrical tests to verify the complete electrical operation of the switch and to set up time delays and voltage sensing settings of the logic.

B. The manufacturer shall provide a certified copy of factory test reports.

C. Transfer switch shall include a label indicating order number, catalog number and date

3.3 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer’s recommendations. All equipment shall be completely wired according to manufacturer's wiring diagram and project drawings, including power and control wiring.

B. All necessary hardware to secure the assembly in place shall be provided by the contractor

3.4 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. 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. Site Operational Testing: At the completion of the installation of the transfer switches, a test of transfer switch shall be run to confirm functionality of all project related features. During this test, all controls and safety devices shall be tested. All tests and operations must be done to the complete satisfaction of CAWCD. Upon completion of this test provide a test report.

3.5 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 a copy of the manufacturer's representative's certification.

3.6 TRAINING

A. The Contractor shall provide a qualified representative to conduct a training session for 1 normal workday at a jobsite location determined by the CAWCD. The training program shall include instruction on the operation of the transfer switch and the major components within the assembly, including interface and controls.

END OF SECTION 263600

SECTION 264313 - SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes field-mounted Surge Protection Devices (SPD) for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 REFERENCES

A. National Fire Protection Association

1. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

B. American National Standards Institute (ANSI), current edition.

C. National Electrical Contractors Association (NECA)

1. NECA 1: Standard for Good Workmanship in Electrical Construction

D. National Electrical Manufacturer's Association (NEMA), current edition.

1. NEMA LS 1: Low Voltage Surge Protective Devices

E. Underwriters Laboratories (UL)

1. UL 1283: Electromagnetic Interference Filters
2. UL 1449: Surge Protective Devices (SPD)

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, nominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 1449, 3rd Edition, ANS1/IEEE62.45.

C. Maximum Continuous Operating Voltage (MCOV) of the SPD shall be the nominal system voltage.

2.2 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Current Technology, Thomas & Betts Power Solutions.
2. Eaton Corporation.
3. Emerson Electric Co.
4. GE Zenith Controls.
5. Schneider Electric Industries SAS.
6. Siemens Industry, Inc.
7. Or approved equal.

B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

C. SPDs: Comply with UL 1283 (35db up to 100 mHz., minimum noise filtering).

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. NEMA LS1 tested for maximum 8/20 usec.

F. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 600 V.
2. Line to Ground: 600 V.
3. Neutral to Ground: 600 V.
4. Line to Line: 1200 V.

G. Short Circuit Current Rating (SCCR): Equal or exceed 100 kA.

H. Nominal Rating: 10 kA.

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 3R.

B. Outdoor Enclosures: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an Overcurrent Protection Device (OCPD) or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless

specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length.

D. Use crimped connectors or terminal blocks only. Wire nuts or splices are unacceptable.

E. Complete startup checks according to manufacturer's written instructions. Energize SPDs after power system has been energized, stabilized, and tested.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Compare equipment nameplate data for compliance with Plans and Specifications.

2. Inspect anchorage, alignment, grounding, and clearances.

3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train CAWCD maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 400523 – INSTRUMENTATION, CONTROL AND COMMUNICATION CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Refer to Specification Section 406700 Control Systems Panels Enclosures and Components for wiring contained in a control panel.

1.2 SUMMARY

A. Section Includes:

1. Multimode optical-fiber Cable
2. Ethernet Cable (STP/UTP)
3. DeviceNet Cable
4. RS-232/485 Cable
5. Modbus Cable
6. RTU or TCP
7. Instrumentation Cable
8. Low-voltage Control Panel and Switchgear Cable
9. Low-voltage control Cable
10. Low-voltage Control Conductors.
11. Identification products.

1.3 DEFINITIONS

A. The following abbreviations are used throughout this specification.

1. BICSI: Building Industry Consulting Service International
2. EMI: Electromagnetic Interference
3. ICEA: Insulated Cable Engineers Association
4. NETA: InterNational Electrical Testing Agency
5. NRTL: Nationally Recognized Testing Laboratory
6. ODVA: Open DeviceNet Vendors Association
7. OFNR: Optical fiber, nonconductive, riser.
8. TIA: Telecommunications Industry Association

9. RCDD: Registered Communications Distribution Designer.
10. RTD: Resistance Temperature Detector.
11. UTP: Unshielded twisted pair cable typically used for Ethernet wiring.
12. STP: Shielded twisted pair cable typically used for Ethernet wiring in industrial environments where electrical noise can be introduced into cables.
13. Low Voltage Control: Circuits and equipment operating at less than 125VDC/120VAC for remote-control and signaling power-limited circuits.

B. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

C. RS-232: A hardware standard for asynchronous serial communication.

D. RS-485: A standard communication network as defined by TIA-485-A. The standard specifies the physical layer used for multiple automation protocols including Modbus, DH-485, BACNet, and Profibus.

E. Multimode Fiber: a type of optical fiber mostly used for communication over short distances, such as within a building or on a campus. Multi-mode links can be used for data rates up to 100 Gbit/s

1.4 SUBMITTALS

A. Product Data (PD)

1. For each type of product indicated.

B. Quality Control Reports (QCR)

1. Field installation test reports.

a. Follow IEEE 802.3 Standard for Ethernet for copper or fiber.

1) For example: dB return loss drop test on all new installations or modifications.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

B. Flame Travel Distance: 60 inches or less.

C. Peak Optical Smoke Density: 0.5 or less.

D. Average Optical Smoke Density: 0.15 or less.

E. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

F. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

G. Cables installed in tray cables shall have UL 1277 rating.

2.3 OPTICAL-FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following

1. The Light Connection (Part Number M50DX02CGNRA20)
2. Or equivalent, if part number is discontinued.
3. Berk-Tek; a Nexans company
4. CommScope, Inc
5. General Cable Technologies Corporation
6. 3M
7. Corning

B. Description:

1. Multimode cables shall be used for all applications where the overall length of the optical circuit is less than 2 kilometers. Single mode cables shall be used for all applications where the overall length of the optical circuit is greater than 2 kilometers, or when required by a specific application.

    a. Multimode cable shall be 50/125 micrometer (OM4), duplex, loose buffer with a Low-Smoke Zero Halogen (LSZH) rated PVC jacket. Acceptable fiber core counts shall be 12, 24, 36 and 48. Additional cable ratings, such as plenum, riser, or tray shall be provided as required based on application. All fiber optic cables shall be orange jacket unless specifically specified otherwise.
    b. Innerduct shall be used for fiber optic cable installations within plenums, under raised floors, within switchgear cable/wiring channels, tray systems and any other application where cable management and additional protection is warranted. Minimum size shall be 1” diameter.
    c. Single Mode cable shall be application specific. See project drawings for cable and core count requirements.

2. Patch Cable: Multimode, Duplex, 50/125 micrometer, 2 fiber, 2 mm Outer Diameter

    a. Comply with ICEA S-83-596 for mechanical properties.
    b. OFNR / UL1666 Listed
    LC Duplex to LC Duplex End Connections

2.4 OPTICAL-FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Corning Incorporated.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

C. Number of Connectors per Field: One for each fiber core of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

D. Patch Cords: Factory-made dual-fiber cables in standard or custom lengths as required for the application with connectors of the type required for their specific application.

E. Cable Connecting Hardware:

1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA-568-C.3.

2. Quick-connect, simplex and duplex; Most common connector types utilized are ST, SC and LC. Insertion loss of not more than 0.75 dB. The preferred connector type for patch panel application is LC. Generally, the connector type shall be as required by the equipment being connected.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.5 STP/UTP CABLE (Ethernet)

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Belden.
2. KRONE Incorporated.

B. Description:

1. CAT-5e 350MHz network cable.

   a. Comply with ICEA S-90-661 for mechanical properties.
   b. Comply with TIA/EIA-568-B.1 for performance specifications.
   c. Comply with TIA/EIA-568-B.2, Category 5e
   d. Comply with IEEE 802.3 Ethernet Standard for Testing
   e. CAT-5e cable distance shall not exceed 100m.

2. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

   a. Communications, Plenum Rated: Type CMP or Type MPP, complying with NFPA 262.

2.6 STP/UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Belden.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 5e, 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

E. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable indicated, plus spares and blank positions adequate to suit specified expansion criteria.

G. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.

H. Patch Cords: Factory-made, four-pair cables in industry standard lengths, 3ft, 7ft, 10ft, 12ft, 15ft, 20ft, 25ft terminated with eight-pin RJ-45 modular plugs at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

I. Workstation Outlets: Two-port-connector assemblies mounted in single gang faceplate.

J. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.

a. Flush-mounted jacks, positioning the cord at a 45-degree angle.

K. Legend:

1. Factory labeled by silk-screening or engraving.
2. Machine printed, in the field, using adhesive-tape label.
3. Snap-in, clear-label covers and machine-printed paper inserts.

2.7 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMG.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors, Belden 3107A or approved equal.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Follow TIA-485-A

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 24 AWG, stranded (7x30) tinned-copper conductors, Belden 82842 or approved equal.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.
6. Follow TIA-485-A

2.8 RS-232 CABLING

A. Standard Cable: NFPA 70, Type CMG.

1. Paired, two pairs, twisted, No. 24 AWG, stranded (7x32) tinned-copper conductors, Belden 9929 or approved equal.
2. PVC insulation.
3. Shielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Follow TIA-232-C

2.9 MODBUS RTU/TCP CABLE

A. Trunk Cable, Schneider Electric 490NAA27106 or equal.

B. Drop Cable, Schneider Electric 990NAD21130 or equal.

C. Tap, Schneider Electric 990NAD23000 no substitute.

D. Install per the latest version Modicon Modbus Plus Network Planning and Installation Guide (890 USE 100 00).

2.10INSTRUMENTATION CABLE

A. Analog Signal Cable

1. 1 pair, twisted,18AWG, 300V insulation rating, foil shield with drain wire, Belden 8760 or approved equal.
2. Drain wire connected only at one end
3. Positive is red or clear, return is black

B. Analog Signal Cable – Multiple Pair

1. Individual shielded pairs with overall shield, 300V, UL Type CIC, Flame Test FT4

    a. #18 AWG, tinned-copper conductors, 7X26
    b. PVC insulation
    c. Polyester Isolation Tape
    d. PVC Jacket
    e. Each pair individually stamped with pair number at regular intervals
    f. Separate drain wires for each individual pair and overall
    g. 75° C (Wet) temperature rating

2. Drain wires connected only at one end

C. RTD

1. 1 triad, twisted, 18AWG, 300V, foil shield with drain wire, Belden 3089A or approved equal
2. Drain wire connected only at one end

D. Transducer to Transmitter Cabling

1. Provide cable to match specific manufacturer requirements

2.11LOW-VOLTAGE CONTROL PANEL AND SWITCHBOARD CABLE

A. Panel Wiring

1. Refer to Specification 406700 Control Systems Panels Enclosures and Panel Components.
2. Analog and communications wiring within Control Panels shall follow the requirements set forth in their respective sections of this specification.

B. Switchboard Wiring

1. For Switchboard breaker protection and metering circuits, #10 AWG, #12 AWG, or #14 AWG type SIS (grey) wire shall be used (depending on application). Size should match existing or as called out on project plans.
2. CT signals, for example, shall be #10AWG minimum.
3. Analog and communications wiring within Control Panels shall follow the requirements set forth in their respective sections of this specification.
4. Control System I/O wiring within Switchboards shall follow the Panel Wiring requirements (Section A).

2.12RS-232, RS-422 CABLING

A. RS-232 and RS-422 cabling shall follow the requirements of Analog Signal Cables, see respective section of this specification.

2.13LOW-VOLTAGE CONTROL CABLE

A. For discrete I/O applications, run in conduit

1. Unshielded Multi-Conductor Cable, 600V, NEC Type CMG, UL AWM Style

a. #18 AWG stranded tinned-copper conductors, 19X30
b. Acceptable conductor counts are: 5, 9, 12 or 19
c. PVC insulation
d. PVC jacket.
e. 60° C temperature rating

B. Plenum-Rated for underfloor discrete I/O and general control applications

1. NEC Type CMP, 600V, Multi-Conductor with Overall Shield

a. #16 AWG stranded tinned-copper conductors 19X29
b. Acceptable conductor counts are: 5, 9, 12 or 19
c. FEP insulation
d. FEP Jacket
e. 70° C temperature rating

C. For general non-plenum control applications

1. Unshielded Multi-Conductor Cable, 600V Tray Cable, Type TC, NEC Type NPLF

a. #16 AWG stranded copper conductors 7X24
b. Acceptable conductor counts are: 5, 9, 12, 19, 25, or 37
c. PVC/Nylon insulation
d. PVC Jacket
e. 75° C temperature rating

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

1. General Requirements for Cabling:
2. Comply with BICSI ITSIMM, Chapter. 5, "Copper Structured Cabling Systems" and Chapter 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Chapter 5, "Copper Structured Cabling Systems" and Chapter 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Chapter 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed to not damage cables.

B. UTP Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.
3. Raceways: Comply with requirements specified in Section 260533 Raceways and Boxes for Electrical Systems.

C. Optical-Fiber Cable Installation of Control-Circuit Conductors:

1. Comply with TIA-568-C.3.
2. Innerduct shall be used for fiber optic cable installations within plenums, under raised floors, within switchgear cable/wiring channels, tray systems

and any other application where cable management and additional protection is warranted. Minimum size shall be 1” diameter.

3. Terminate cable on connecting hardware that is rack or cabinet mounted.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

E. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 60 inches of cable in a coil not less than 12 inches in diameter.

F. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.2 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.3 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.4 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 Grounding and Bonding for Electrical Systems.

3.5 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.6 TERMINATIONS

A. Instrument and control cable conductors shall be terminated with lugs or ferrules depending on application.

1. Ring lugs shall be used for open screw only terminals.
2. Ferrules shall be used for compression plate terminals and spring clamp style terminals.

a. Ferrules shall only be installed using a calibrated ferrule crimp tool as recommended by the manufacturer.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Testing Agency to perform the following tests and inspections:

1. Visually inspect UTP and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.
4. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. Optical-Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
b. Link End-to-End Attenuation Tests:

1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A.
2) Attenuation test results for links shall be less than 2.0 dB.

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 400523

SECTION 400557 – ELECTRIC VALVE ACTUATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions, apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Section 260020 Supplemental Requirements for Electrical (Power and Controls Drawing Standard Specification).

1.2 SUMMARY

A. Section Includes:

1. Electric Valve Actuators

1.3 REFRENCES

A. The following codes and standards are hereby incorporated into this Section:

1. National Fire Protection Association (NFPA).

a. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

2. American Water Works Association

a. C540-93: AWWA Standard for Power-Actuating Devices for Valves and Sluice Gates.

3. National Electrical Manufacturers Association (NEMA):

a. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

1.4 DEFINITIONS

1. AWWA – American Water Works Association

1.5 SUBMITTALS

A. Product Data (PD)

1. For each type of product indicated.

B. Quality Control Reports (QCR)

1. Factory quality – control reports.
2. Field quality – control reports.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

A. Actuators shall be compatible with associated project valve specifications.

B. All actuators shall be manufactured by AUMA Actuators, Inc. of Pittsburgh, Pennsylvania.

C. All electric valve actuators shall conform to the requirements of AWWA Standard C540-93.

D. The motor shall be specifically designed for actuator service. The motor will be of the induction type with class F insulation and protected by means of thermal switches imbedded in the motor windings. Motor enclosure shall be totally enclosed, nonventilated.

E. Motors shall be capable of operating on 460 volt - 3 phase - 60 hertz power or 240/120 volt - single phase - 60 hertz power.

1. CAWCD “Turn-In” project valve actuators shall use 240/120 volt – single phase – 60 Hz power.

F. Actuator enclosure shall be NEMA 4 (watertight). All external fasteners on the electric actuator shall be stainless steel. Fasteners on limit switch and terminal compartments shall be captured to prevent loss while covers are removed.

G. All gearing shall be grease lubricated and designed to withstand the full stall torque of the motor.

H. Manual over-ride shall be by handwheel. Manual operation will be via power gearing to minimize required rim pull and facilitate easy change-over from motor to manual operation when actuator is under load. Return from manual to electric mode of operation will be automatic upon motor operation. A seized or inoperable motor shall not prevent manual operation.

I. Limit switches shall be furnished at each end of travel. Limit switch adjustment shall not be altered by manual operation. Limit switch drive shall be by counter gear. Limit switches must be capable of quick adjustment requiring no more than five (5) turns of the limit switch adjustment spindle. One set of normally open and one set of normally closed contacts shall be furnished at each end of travel where indicated. Contacts shall be of silver and capable of reliably switching low voltage DC source from the control system furnished by others.

J. Mechanically operated torque switches shall be furnished at each end of travel. Torque switches shall trip when the valve load exceeds the torque switch setting. The torque switch adjustment device must be calibrated directly in engineering units of torque.

K. Quarter turn actuators shall be furnished with mechanical stops that restrict the valve/actuator travel.

L. Actuator must be capable of the following valve closing times/operating speeds: quarter turn valves - 300 second closing time, gate valves and sluice gates - 12 inches per minute operating speed.

M. Actuators shall be capable of operating in an ambient temperature range of -20 to +175 degrees F (without motor controls) and -20 to +160 degrees F (with motor controls). Actuators shall not be installed where they will be subjected to full sunlight exposure.

N. All actuators in open/close service shall be furnished with integral motor controls consisting of reversing starters, control transformer, phase discriminator, monitor relay (to signal fault conditions such as thermal switch trip, torque switch tripped in mid-travel, wrong phase sequence or phase failure), "open-stop-close" pushbuttons, "local-off-remote" selector switch in addition to red and green indicating lights. An interface with the control system must be furnished with optical isolators to separate incoming voltage signals from the internal motor controls.

O. Actuators in modulating service shall be selected such that the required dynamic valve torque is no more than 60% of the electric actuator’s maximum rated breakaway torque. Power gearing in modulating actuators shall have zero backlash between the motor and actuator output.

P. All actuators in modulating service shall be furnished with a feedback potentiometer in addition to the following motor controls: reversing starters, control transformer, phase discriminator, monitor relay, positioner, "open-stop-

close" pushbuttons, "local-off-remote" selector switch in addition to red and green indicating lights. The positioner shall be capable of accepting a 4-20mADC command signal and positioning the valve by comparing the command signal with the present valve position as indicated by the feedback potentiometer mounted inside the actuator. The positioner shall be field adjustable to fail to the "open", "closed" or "last" position on loss of 4-20mADC command signal.

1. CAWCD “Turn-In” project valve actuators are not required to be modulating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer’s instructions.

B. All cables shall be terminated at a plug and socket connector.

C. All wiring shall be terminated with a ring connector for ring terminals and ferrules for clamp\IEC style terminals.

D. Valve actuator shall be grounded per equipment grounding specifications and the NEC.

E. Provide sufficient backup power system or mechanical device to allow valve to be fully closed in the event of a loss of power event.

F. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. AUMA Actuators, Inc. of Pittsburgh, Pennsylvania or as approved by CAWCD.

3.2 QUALITY ASSURANCE

A. Factory testing data.

PART 4 - PRODUCTS

4.1 GROUNDING

A. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

4.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

4.3 TERMINATIONS

A. Instrument and control cable conductors shall be terminated with lugs or ferrules depending on application.

1. Ring lugs shall be used for open screw only terminals.
2. Ferrules shall be used for compression plate terminals and spring clamp style terminals.

    a. Ferrules shall only be installed using a calibrated ferrule crimp tool as recommended by the manufacturer.

4.4 FIELD QUALITY CONTROL

A. Manufacturer’s Representative: Engage with manufacturer qualified representative for commissioning and testing.

B. Prepare test and inspection reports.

END OF SECTION 400557

SECTION 406100 – COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements, and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

C. Section 260010 Supplemental Requirements for Electrical (Power and Controls Drawing Standard Specification).

1.2 SUMMARY

A. General requirements applicable to all Process Control and Instrumentation Work

1. Provide all material and labor needed to install the actual equipment furnished, including any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished.
2. Review the complete set of Plans and Specifications to ensure that all items related to the instrumentation and control systems are completely accounted for. Provide all additional items that are ancillary or appurtenant to the work to provide a complete and functioning installation.

B. Contract Documents

1. General:

a. Project Plans and Technical Specifications are complementary and are to be used together to fully describe the work.

2. Contract Plans:

a. Follow the Plans as closely as possible. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate. If unclear or contradictory in the plans, coordinate with CAWCD for resolution.

b. Installation details:

a) For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the work, and submit to CAWCD for review.

c. Schematic diagrams:

a) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Plans or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

1.3 REFRENCES

A. The following codes and standards are hereby incorporated into this Section:

1. American National Standards Institute (ANSI).
2. International Organization for Standardization (ISO):

a. 9001 – Quality Management Systems – Requirements.

3. International Society of Automation (ISA):

a. 5.1 – Instrumentation Symbols and Identification.
b. 5.4 – Instrument Loop Diagrams.

4. National Electrical Manufacturers Association (NEMA):

a. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

5. National Fire Protection Association (NFPA).

a. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):

a. 508 – Standard of Safety for Industrial Control Equipment.
b. 508A – Standard of Safety for Industrial Control Panels

1.4 DEFINITIONS

A. Specific definitions:

1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or 125 volts direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not part of the power circuit.
2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of electrically powered equipment.
4. Signal circuit: Any circuit operating at less than 50 VAC or 125 VDC, which conveys analog information or digital communications information.
5. Digital bus: A communication network, such as MODBUS, EtherNet/IP, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections.
7. Powered transmitters: A transmitter that requires a separate power source (24VDC, 120 VAC, 240 VAC, etc.) for the transmitter to develop its signal.

B. Acronym definitions:

1. DPDT: Double-pole, double-throw.
2. FAT: Factory acceptance test.
3. HOA: Hand-Off-Auto control function that can be PLC or operator controlled. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction input. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the operator direct input or PLC control.
4. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process and accepts and implements the operator's control instructions. Typically, information is displayed in a graphical format.
5. CS: Control System: A general name for the controller system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, HMIs, and all data management systems accessible to staff.
6. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development,

installation, testing, and commissioning of industrial instrumentation and control systems.

7. I/O: Input/Output.
8. P&ID: Process and instrumentation diagram.
9. PLC: Programmable logic controller.
10. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
11. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment such as pumping units, lift stations, metering stations etc.
12. SPDT: Single-pole, double-throw.
13. SPST: Single-pole, single-throw.
14. UPS: Uninterruptible power supply.

1.5 SUBMITTALS

A. Instrumentation and Control System Contractor (ICSC) Statement of Qualifications: (Note to specifier: For projects that require an external control system contractor)

1. Submit a statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.

B. See individual specification sections for details on specific equipment submittals.

1.6 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for executing and completing the instrumentation and control system work indicated on the Plans and specified in the Specifications and reasonably inferable therefrom including but not limited to:

a. Preparing hardware submittals for field instrumentation.
b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
c. Prepare the system test plan submittals.
d. Fabricate and inspect panels.
e. Verify instrumentation calibration after installation.
f. Oversee and certify the installation of the CS.
g. Oversee, document, and certify loop testing.
h. Prepare operation and maintenance manuals.

i. Integrate the CS with instrumentation and control devices provided under other sections.
j. Provide As-Built Drawings and Loop Drawings associated with Instruments and equipment.
k. Resolve signal, power, or functional incompatibilities between the CS and interfacing devices.
l. Provide all modified or new PLC and HMI screen backups and operating digital files.
m. Provide all new or modified instrumentation configuration files.
n. Provide device or process-specific testing and/or calibration documentation.

2. The entire electrical power, instrumentation, and control system shall be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, and calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether specifically mentioned but which are necessary for successful operation.
3. Furnish detailed, complete, and thorough, as-built wiring drawings, training manuals, and all other documentation required to operate, modify, and maintain all parts of the CS
4. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.

B. According to individual circumstances and in compliance with the Plans, extend or replace conduit and cable connections from existing locations.

1. Where shown or specified, replace existing field instruments with new ones.
2. The Contractor is responsible for verifying the integrity and measurement accuracy of all loops. Any defect found in existing instrumentation, not provided by the Contractor, will be the responsibility of the CAWCD.

C. The standards of instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new instrumentation, apply equally to the existing instrumentation, if they report to a new control system.

1.7 QUALITY ASSURANCE

A. Refer to Specification 408001 -Testing Calibration and Commissioning of Instrumentation and Controls.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, wet/dry location delineation, corrosion, and process and ambient temperatures.

2. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the CAWCD.

B. ICSC qualifications

1. General information on the proposing company:

a. Document that the ICSC has been actively involved in the instrumentation, PLC-based control systems, in business for a minimum of five years, and has adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work as specified.

2. Document that the ICSC has a qualified permanent service facility:

a. Service facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and process start-up of all the instrumentation, control, telemetry, SCADA, and control systems hardware and software furnished under this Contract.
b. Document in-house resources of permanent personnel that will be working on this project that have experience in the design and programming of equipment and systems as specified.

3. The ICSC must have an operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508A requirements.
4. Determination of the proposed ICSC qualifications is at the sole discretion of the CAWCD

C. ICSC Responsibilities

1. The Contractor, using a qualified ICSC, is responsible for the implementation of the CS and the integration of the system with other required instrumentation, and control devices.
2. The ICSC assumes responsibility, through the Contractor, to perform all work to select, furnish, install, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system, for a complete, integrated and functional control system as indicated in the Plans and Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the control system portion of the Project, wherever possible.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.2 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.3 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submitting the shop drawings unless otherwise specified.

1. Update to the latest firmware on all software base components before installation unless otherwise specified.

B. Signal transmission:

1. Analog signals:

a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
b. Furnish electrical analog signals that are 4 to 20 milliamperes 24 VDC, except as indicated.
c. Electrically or optically isolate all analog signals from other signals.
d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
e. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission. Appropriately shield analog signals using foil-shielded control cables (see specification 400523 – Instrumentation Control and Communication Cabling) with the drain wire grounded in the panel or location where the signal is being read.

g. Provide as offered by the manufacturer, input module points that are individually fused with blown fuse indicator lights, mounted external of the module on the output terminal strip.

2. Discrete input Signals:

a. Defined as contact closure or transistor inputs from devices external to the input module.
b. Provide individually isolated inputs that are optically isolated from low energy common mode transients to 1,500 volts peak from users wiring or other I/O modules.

3. Discrete output signals:

a. Dry contact relay (or TRIAC) outputs as needed to coordinate with the field device and as approved by CAWCD.
b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities, when required by the installation.

C. Discrete circuit configuration:

1. Alarm contacts: Fail to the alarm condition.
2. Control contacts fail to the inoperative condition unless otherwise indicated on the Plans.
3. Provide interposing relays as required for the functionality of the control circuit to interface with foreign signals/voltages.

D. Grounding:

1. Provide control panels with a signal ground bus, isolated from the power ground bus.
2. Ground single point ground shields and measurement loops at the source panel terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
3. Ground spare control signal cable conductors to the signal ground bus in the source panel.

2.4 ACCESSORIES

A. Provide signal conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:

1. Provide a nameplate for each controller, instrument transducer, solenoid, or any other control device located either in the field or within panels.
2. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.
3. Use component and instrumentation tag names as depicted in the contract documents schematic diagram or P&ID.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The ICSC is required to visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing site conditions and examine all shop drawings for the various items of equipment to determine exact routing and final terminations for all wiring and cables.

C. Equipment locations indicated on the Plans may change due to variations in equipment size or minor changes made by others during construction:

1. Verify all dimensions as indicated on the Plans.
2. Actual field conditions govern all final installed locations, distances, and levels.

3.2 INSTALLATION

A. Provide a complete instrumentation and control system:

1. Install all required conduits, cables, and interfaces necessary to provide a complete and operating electrical and instrumentation system

B. Review all information indicated on the Plans, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise.

C. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

D. During installation, Contractor shall protect electrical and electronic components from conductive and non-conductive debris with plastic coverings or other approved means. Components found to be covered with or penetrated by metal

shavings or other debris due to Contractor negligence shall be replaced by Contractor as directed by CAWCD.

E. Field instruments installation:

1. Install field instruments as specified by the manufacturer's instructions.
2. Mount field instruments so they can be readily approached, easily read, and serviced, and do not restrict access to mechanical equipment. Mounting of field instruments to be approved by CAWCD.

    a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted or otherwise indicated on the Plans.

3. Make connections from rigid conduit systems to field instruments with PVC coated, liquid tight, flexible metal conduit:

    a. Maximum length of 18 inches.

4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:

    a. Special cable applications shall be in accordance with the NEC.

5. Verify the correctness of each installation:

    a. Polarity of electric power and signal connections.
    b. Ensure all process connections are free of leaks.

F. Process sensing lines and air tubing:

1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Bends:

    a. Use proper tool.
    b. Make bends for parallel lines symmetrical.
    c. Make bends without deforming or thinning the walls of the tubing.
    d. Keep bend radius within manufacturer-specified tolerance.

3. Square-cut with proper tube cutting tool and clean all ends of tubing before being inserted in the fittings.

G. Conduit, cables, and field wiring:

1. Provide terminations and wire identification as specified in the Electrical Specifications.

H. Cable and conductor termination:

1. Terminate all cables and conductors on terminal blocks.
2. Wire nuts or other forms of splicing are not allowed.
3. Cabling bend radius to comply with NEC.
4. Terminal block enclosures:

    a. Enclosure type to be specified according to specification 260533 – Raceways and Boxes for Electrical Systems.
    b. Mount to provide unobstructed access to the terminals, terminal markers, and conductors.
    c. Position terminals so that the internal and field wiring does not cross.
    d. Utilize cord grips, grommets, or other penetrative devices that maintain the enclosure NEMA rating.

I. Surge protection:

1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:

    a. Protect both power source and signal loop.

3.3 FIELD QUALITY CONTROL

A. Inspection:

1. Inspect equipment and materials for physical damage
2. Inspect installation for compliance with Plans and Specifications.
3. Inspect installation for obstructions and adequate clearances around equipment.
4. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
5. Inspect equipment nameplate data to verify compliance with design requirements.
6. Inspect cable terminations.
7. Inspect the installation arrangement, lay lengths, orientation, piping obstructions, etc. that could affect the instrument’s accuracy or repeatability.
8. Inspect/witness instrument calibrations/verifications.

B. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 408001 – Testing Calibration and Commissioning for Instrumentation and Controls.

3.4 CLEANING

A. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

B. Clean all panel surfaces.

C. Seal unused enclosure penetrations using products that maintain enclosure NEMA rating.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Deliver electronic devices containing screens, such as touchscreens or specialized relays, with the factory plastic screen cover intact.

G. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:

H. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the CAWCD.

I. As specified in other sections of the Contract Documents.

END OF SECTION 406100

SECTION 406343 - PROGRAMMABLE LOGIC CONTROLLERS, OPERATOR INTERFACE TERMINALS, AND NETWORK EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents Division 01 General Requirements, and Special Provisions, apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section Includes:

1. Programmable Logic Controllers and accessories.
2. Operator interface terminals
3. Network equipment and accessories

1.3 DEFINITIONS

A. The following abbreviations are used throughout this specification.

1. OIT: Operator Interface Terminal
2. HMI: Human Machine Interface
3. PLC: Programmable Logic Controller
4. UPS: Uninterruptable Power Supply
5. FAT: Factory Acceptance Test
6. SAT: Site Acceptance Test
7. SFP: Small Formfactor Pluggable

1.4 SUBMITTALS

A. Refer to Section 013300 Submittal Procedures for submittal requirements.

B. Product Data (PD):

1. Submit catalog data for each component specified showing electrical characteristics and connection requirements.

C. Project Design Drawings: Schematic and wiring diagrams to be provided per Section 260010 Supplemental Requirements for Electrical (Power and Controls Drawing Standard Specifications).

D. Shop drawings: Not accepted for construction purposes or as project plans. Shop drawings to be submitted in addition to and separately from the project plans.

E. Test and Evaluation Reports:

F. FAT/SAT Procedures: Indicate procedures and results for specified factory and site acceptance testing and inspection per Section 408001 Testing Calibration and Commissioning of Instrumentation and Controls.

1.5 CLOSEOUT SUBMITTALS

A. Refer to Sections 013300 Submittal Procedures and 017700 Closeout Procedures for requirements for closeout submittals.

B. As-Built Drawings: As-Builts shall be completed on site and submitted per Section 017800 Project Record Documents.

C. Submit final pre-FAT, post-FAT, and post-SAT program and configuration files.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Spare PLC and OIT components are not required beyond the specified spare I/O capacity.

1.7 AMBIENT CONDITIONS

A. Conform to specified service conditions during and after installation of programmable controllers.

B. Maintain area free of dirt and dust during and after installation of products. PLCs, OITs, and other electronic components shall be kept free from dirt, dust, metal shavings, and other debris before, during, and after installation. The Contractor shall replace components that are compromised if this requirement is not followed.

C. Components must be rated for the environment they are to be installed in.

1. Precautions shall be taken to ensure that equipment is rated for heat and adverse weather conditions experienced in Central Arizona.

PART 2 - PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. Manufacturer: Allen-Bradley

1. CompactLogix or ControlLogix depending on the number of I/O.
2. Specific part numbers for PLC's are listed in CAWCD Controls Hardware List. This list may be requested by the Designer/Contractor and will be valid for a specified period after which it is subject to change.

B. Service Conditions: Installation of PLCs, OITs, and related components shall comply with manufacturers' ratings for Temperature, Humidity, Altitude and Vibration. If the installation cannot comply with the manufacturer's ratings, then CAWCD must be informed for the purpose of selecting alternate products.

1. Spare Input/Output Capacity: 25 percent.
2. Power Supply Voltage: 24VDC
3. Enclosures: Coordinate with Section 406700 - Panel, Enclosures, and Panel Components for Control Systems.
4. Firmware: Not all firmware versions are compatible or acceptable. Coordinate with CAWCD on firmware version to use.

2.2 OPERATOR INTERFACE TERMINAL (OIT)

A. Specific part numbers for OIT's are listed in CAWCD Controls Hardware List. This list may be requested by the Designer/Contractor and will be valid for a specified period after which it is subject to change.

B. Input Voltage: 24VDC

C. Location: Coordinate location with CAWCD to ensure accessibility for CAWCD personnel.

D. If mounting OIT to a cabinet face or door, ensure mounting hardware and gaskets are applicable to maintain the NEMA rating of the enclosure.

2.3 NETWORK EQUIPMENT

A. Manufacturer: Cisco Industrial Products

1. All managed network switches and routers shall be Cisco Industrial products. All Cisco devices shall be rack-mounted and installed in climate-controlled environments.
2. CAWCD must be consulted about the most up-to-date part numbers to order, prior to ordering.

B. Power Requirements

1. Rack mounted switches and routers shall contain redundant power supplies and be fed from independent UPS sources when possible.
2. The power supplies shall be 24VDC.

C. Wireless Radio for Remote I/O

1. Wireless radios shall NOT be used for I/O applications.

D. SFPs

1. All fiber SFPs shall be Cisco models appropriate to the distance and application.
2. Copper SFPs shall not be used unless no RJ45 ports are available.
3. Contractor to perform terminations and testing. Testing results shall be provided to CAWCD and comply with TIA/ANSI 568.3-D.

2.4 SOURCE QUALITY CONTROL

A. Coordinate with Section 014400 Quality Requirements.

B. Testing: Test Programmable Logic Controller and OIT per Section 408001 Testing, Calibration, and Commissioning of Control Systems.

C. Comply with specification 406100 Common Work Results for Process Control and Instrumentation Systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate with Division 01 General Requirements regarding execution and closeout requirements.

3.2 INSTALLATION

A. Do not install products until major construction is complete and building interior is enclosed and heated/cooled.

B. Install engraved plastic nameplates according to specification 260553 - Identification for Electrical Systems.

C. Ground and bond programmable controllers according to specification 260526 Grounding and Bonding for Electrical Systems.

3.3 FIELD QUALITY CONTROL

A. Coordinate with Section 014400 Quality Requirements regarding QA/QC procedures and requirements for inspecting and testing.

B. Perform operational testing on control systems to verify proper operation and field wiring connections per Section 408001 – Testing Calibration and Commissioning of Instrumentation and Controls.

END SECTION 406343

SECTION 406700 CONTROL SYSTEMS – PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 10 General Requirements and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes:

1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:

a. Custom built instrumentation and control panels, including all enclosures for low voltage power distribution and marshalling panels.
b. Control panels furnished as part of equipment systems specified in other Sections, such as vendor control panels and chemical feed panels.
c. Control components.

1.3 REFERENCES

A. Electrical Standard for Industrial Machinery (NFPA 79):

B. National Electrical Code (NEC) - NFPA 70.

C. UL 508A – Safety Standard for Industrial Control Panels

1.4 DEFINITIONS

A. Specific definitions:

1. The term "panel" in this Section is interchangeable with the term "enclosure."

1.5 SYSTEM DESCRIPTION

A. Enclosure dimensions:

1. Minimum dimensions are scalable from or as indicated on the Plans and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all enclosures:

a. Size panels to provide space for all equipment, wiring, terminations, and other items in the enclosure, including a minimum of 20% spare space for future build out.
b. Panel size and layouts to account for manufacturer’s listed heat clearances for all components.
c. Enclosure sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Plans must be approved by CAWCD.
d. Maximum enclosure depth: 30 inches, unless otherwise indicated.

1.6 SUBMITTALS

A. Provide a control panel hardware submittal for each control panel and enclosure provided on this project, including but not limited to:

1. Product data:

a. Enclosure construction details and NEMA type.
b. Manufacturer's literature and specification data sheets for each component to be installed within or on the enclosure.

2. Design Plans:

a. Scaled, detailed exterior and interior layout showing equipment arrangement and dimensional information:

a) Complete and detailed bill of materials. Include quantity, description, manufacturer, and part number.

b) Complete nameplate engraving schedule.

c) Structural details including anchoring method.

b. Schematic diagram showing all interfaces between any instruments, motor starters, variable speed drives, control valves and other equipment related to the panel.
c. Wiring diagram showing component tag name, wire label, wire color, wire destination, terminal identification as required by

CAWCD standards. Wiring diagram should represent the component layout within the panel.

a) Use component and instrumentation tags as depicted in the contract documents schematic diagram or P&ID.

1.7 QUALITY ASSURANCE

A. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL labeled control panels:

1. Provide all components and equipment with UL 508 listing.
2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling and approved by CAWCD.
3. Provide fuses for all equipment that is not UL listed or recognized (UR).

B. As specified in Section 406100 Common Work Results for Process Control and Instrumentation Systems and Section 014400 Quality Requirements.

1.8 COMMISSIONING

A. As specified in Section 408001 Testing, Calibration, and Commissioning of Instrumentation and Controls.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. As listed below in this Specification.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one manufacturer.

2.2 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments and fitting of

blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.3 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in the installed location, during normal service:

1. Enclosures shall be one of the following types, depending on installation location:

a. NEMA Type 3R: Steel with gasketed door, rain tight.
b. NEMA Type 4: Steel with gasketed door, rain tight.
c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 indicated on the plans). Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
d. NEMA Type 12: Steel with gasketed door, dust tight.

B. Bolting material:

1. Commercial quality, stainless steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
2. Carriage bolts for attaching end plates.
3. All other bolted joints shall have S.A.E. standard lock washers.

C. Finish: Powder-coated, ANSI 61 Gray unless otherwise specified in project plans.

2.4 MANUFACTURED UNITS

A. Panels/enclosures:

1. Manufacturers: One of the following or as approved by CAWCD:

a. Hoffman Engineering.
b. Rittal.
c. Saginaw Control & Engineering.
d. Steeline Enclosures.

2. Panel assembly:

a. General guidelines for panel fabrication include:

1) Continuous welds ground smooth.
2) Exposed surfaces free of burrs and sharp edges.

b. Construct supporting frame structure with angled, channeled, or folded rigid section of metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

c. Door construction:

1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
3) Heavy gauge piano type continuous steel hinges.
4) Gasket installed to seal against roll lip on the enclosure opening.

d. Latches:

1) Provided enclosure with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, forming a compressed seal between door and gasket at the top, side, and bottom.
2) For Type 4 and 4X cabinets or enclosures not available with 3-point latching hardware, provide multiple clips and padlock hasps.
3) Provide quick release latches for all Type 4 and 4X enclosures.
4) Panel cut-outs:

a) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.

b) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.

5) Reinforce around cut-outs with steel angles or flat bars for the following:

a) Large panel cutouts; for example, openings for local operator interfaces.

b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

B. Arrangement of components:

1. Arrange panel internal components for external conduit and piping to enter panel either from above or below.

2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Plans.
3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from CAWCD.
4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:

1. Main overcurrent device:

a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120 VAC circuits:

1) Door-mounted disconnect handles are not acceptable.
2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
3) Provide means to defeat the interlock.
4) Lockable in the off position.

b. Control panels supplied with 120 VAC:

1) Provide an internal breaker with the lineside terminals covered by a barrier.
2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.

2. Selection and ratings of protective devices:

a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
b. Voltage rating: Not less than the voltage of the application.
c. Select current rating and trip characteristics to be suitable for:

1) Maximum normal operating current.
2) Inrush characteristics.
3) Coordination of the protective devices to each other and to the source breaker feeding the panel.

3. Provide a separate protective device for each powered electrical device:

a. An individual circuit breaker for each 120 VAC instrument installed within its respective control panel and clearly identified for function.
b. An individual fuse for each PLC discrete output common. Provide with individual blown fuse indication external of the I/O card. Size external fuse to open before any I/O card mounted fuses.
c. An individual 5-ampere fuse for discrete input common.
d. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
e. Install protective devices on the back mounting panel and identify by a service nameplate as defined in the wiring diagram Control circuit fuses.
f. Provide a durable, readily visible label, clearly indicating the correct type, size, and ratings of replacement for each fuse.
g. Manufacturer: One of the following or as approved by CAWCD:

1) Bussmann.
2) Littelfuse.
3) Ferraz Shawmut.

4. Control circuit fuse holders:

a. Modular type:

1) DIN rail mounting on 35 millimeters rail.
2) Touch safe design: All connection terminals to be protected against accidental touch.
3) Incorporates blown fuse indicator.

b. Manufacturer: One of the following or as approved by CAWCD:

1) Phoenix Contact.
2) Allen-Bradley.
3) Bussmann.

5. Control circuit breakers:

a. DIN rail mounting on 35 millimeters rail.
b. Manual OPEN-CLOSE toggle switch.
c. Rated 250 VAC.
d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
e. Current ratings: As indicated on the Plans or as required for the application.
f. Manufacturer: One of the following or approved as approved by CAWCD:

1) Allen-Bradley

2) Eaton.
3) Square D.

D. Internal panel conductors and cables:

1. Power and control wiring:

a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts type MTW.
c. Minimum sizes:

1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.

d. Color:

1) AC power (line and load): BLACK.
2) AC power (neutral): WHITE.
3) AC control: RED.
4) 24VDC power and control (positive): BLUE.
5) 24VDC power and control (common): WHITE with BLUE stripe.
6) Ground: GREEN.

e. Manufacturer: One of the following or approved as approved by CAWCD:

1) Encore Wire
2) General Cable
3) Southwire
4) Pacer

2. Signal cables:

a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts, flame retardant, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.
d. Shielding:

1) Individual pair/triad

a) Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.

b) Overall braided shield.

(1) Multiple pair or triad shielding:

(2) Group shield: Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.

(3) Completely isolate group shields from each other.

(4) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.

(5) All shielding to be in contact with the drain wire

e. Drain Wire:

1) 18 AWG
2) Stranded, tinned

f. Color:

1) 2 Conductor:

a) Positive (+): BLACK.

b) Negative (-): RED.

2) 3 Conductor:

a) Positive (+): BLACK.

b) Negative (-): RED.

c) Signal: WHITE.

g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.
h. Manufacturer: One of the following or as approved by CAWCD:

1) Belden CDT
2) Encore Wire
3) General Cable

3. Network cables: Refer to specification 400523 Instrumentation Control and Communication Cabling.

E. Conductor identification:

1. Identify each conductor and cable with unique wire numbers as specified in Section 260553 Identification for Electrical Systems.
2. Readily identified without twisting the conductor.

F. General wiring requirements:

1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
4. Provide nonmetallic ducts for routing and organization of conductors and cables. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater
5. Cables within the panel not in nonmetallic ducts shall be fastened with cable mounting clamps or with cable ties in a neat and secure manner.
6. The free ends of cable ties shall be cut flush after final adjustment and fastening.
7. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors
8. Support panel conductors where necessary to keep them in place.
9. Conductors and cables shall be run from terminal to terminal without splice or joints.
10. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to:

    a. Solenoid valves.
    b. Instruments mounted both in the control panel and remotely connected to the control panel.

2.5 COMPONENTS

A. Provide heating, cooling, and dehumidifying to the panel to maintain all instrumentation and control devices within the operating range, as specified by the manufacturer, for the intended installation environment.

B. Pilot devices:

1. General:

    a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    b. Furnish 1 spare normally open contact and normally closed contact with each switch or pushbutton.
    c. Size:

1) 30 millimeters.
2) Heavy duty.
3) Pushbuttons:

a) Contacts rated:

(1) NEMA Type A600.

d. Selector switches:

1) Contacts rated:

a) NEMA Type A600.

b) Standard knob type.

e. Pilot lights:

1) Type: LED for interior installations.
2) Push to test.
3) Lamp color:

a) On/Running/Start/Open: Red.

b) Off/Stop/Closed: Green.

c) Power: White.

d) Status or normal condition: White.

e) Alarm/Failure: Red.

2. Indoor and outdoor areas:

a. NEMA Type 4/13.
b. Manufacturer: One of the following or as approved by CAWCD:

1) Allen-Bradley Type 800T.
2) IDEC TWTD.

3. Corrosive areas:

a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
d. Manufacturer: One of the following or as approved by CAWCD:

1) Allen-Bradley Type 800H.
2) IDEC TWTD.

C. Signal isolators and converters:

1. Furnish signal isolators that provide complete isolation of input, output, and power input.
2. Manufacturer:

    a. Phoenix Contact MCR Series.
    b. Or as approved by CAWCD.

D. Relays:

1. General purpose:

    a. For all types of AC coil relays, provide RC surge protection across the coil of each relay.
    b. For all types of DC coil relays, provide a free-wheeling diode across the coil of each relay.
    c. NEMA Type: As required for the application.
    d. Plug-in type.
    e. LED indication for energization status.
    f. Coil voltages: As required for the application.
    g. Touch safe design: All connection terminals to be protected against accidental touch.
    h. Quantity and type of contact shall be as indicated on the Plans or as needed for system compatibility.
    i. Relays with screw-type socket terminals.
    j. DIN rail mounting on 35 millimeters rail.
    k. Ice cube type relays with retainer clips to secure relay in socket.
    l. Manufacturer: One of the following or as approved by CAWCD:

        1) Potter Brumfield KUEP series relay with Finder SMA series base and Finder

        2) Allen-Bradley Type 700 HK Series.
        3) Square D.

2. Time delay:

    a. Provide time delay relays to control contact transition time.
    b. Contact rating: as required for the application.
    c. Coil voltage: as required for the application.
    d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off delay.
    e. Minimum poles: 2PDT.
    f. Units include adjustable dial with graduated scale covering the time range in each case.
    g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.

h. Manufacturer: One of the following or as approved by CAWCD:

1) IDEC RTE series.
2) Agastat type Series 7000 series (pneumatic).
3) Allen-Bradley type 700HR Series.

E. Terminal blocks:

1. Din rail mounting on 35 mm rail.
2. Suitable for specified AWG wire.
3. Rated for 30 amperes at 600 volts.
4. Single level, screw terminal type.
5. Finger safe protection for all terminals for conductors.
6. Use of factory jumper bars to bridge connections.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 degree Celsius to 105 degrees Celsius.
8. Labels:

a. Plainly identify to correspond with markings on the design plans or numbered sequentially starting at one, if not shown on the design plans.
b. Permanent machine printed terminal identification.

9. Position:

a. So that the internal and external wiring does not cross.
b. To provide unobstructed access to the terminals and their conductors.

10. Provide minimum 25 percent spare terminals.
11. Heavy duty terminal blocks as required by the application are to be securely mounted to housing enclosures, suitable for #10 AWG wire and accept ring lug terminals. Jumper bar assemblies shall be installed for interconnecting terminal blocks and distributing power and signal commons as required. Terminal blocks shall be rated for 600 V, 75 A, and have a minimum of 12 points with a hinge cover.
12. Manufacturer: One of the following:

a. Phoenix Contact.
b. Allen-Bradley.
c. Marathon 1500 Series (Heavy Duty).

F. Wire duct:

1. Flame retardant plastic wiring duct, slotted with dust cover.
2. Type:

a. Wide slot.
b. Narrow slot.

3. Manufacturer: The following or as approved by CAWCD:

    a. Panduit.
    b. IBOCO

G. Power supplies:

1. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
2. Sized to provide 40 percent excess rated capacity.
3. UL 508A listed to allow full rated output without de-rating.
4. Provide fuse or short-circuit protection as required by the manufacturer.
5. Provide individual load protection for power supply output.
6. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
7. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
8. Touch safe design: All connection terminals to be protected against accidental touch.
9. DIN rail mounting on 35 millimeters rail.
10. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
11. Redundant power supply arrangements shall use a dedicated redundancy module.
12. Manufacturer: One of the following or as approved by CAWCD:

    a. Phoenix Contact Quint series.
    b. Allen Bradley 1606-XLE series.

2.6 ACCESSORIES

A. Provide 15-inch floor stands or legs where needed or as indicated on the Plans.

B. Provide nameplate to each panel as indicated on the Plans:

1. Provide an internal nameplate with the following markings that is plainly visible after installation:

    a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Short-circuit current rating of the panel based on one of the following:

        1) Short-circuit current rating of a listed and labeled assembly.
        2) Short-circuit current rating established utilizing an approved method.
        3) Grounding:

2. Provide the following:

    a. Grounding strap between enclosure doors and the enclosure.
    b. Equipment grounding conductor terminals.
    c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
    d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.

3. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND" or the letter "G," or the color green.

4. Signal (24 VDC) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable.
5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.

2.7 SOURCE QUALITY CONTROL

A. As specified in Section 408001 Testing Calibration and Commissioning of Instrumentation and Controls.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

    1. Notify CAWCD promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.2 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high and as indicated on the plans.

D. Provide 3-1/2-inch-high concrete housekeeping pads for free-standing enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:

1. Undercoat floor mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule but shall be shown on the Loop Drawings prepared by the Contractor.

3.3 FIELD QUALITY CONTROL

A. As specified in Section 408001 Testing Calibration and Commissioning of Instrumentation and Controls.

3.4 CLEANING

A. As specified in Section 406100 Common Work Results for Process Control and Instrumentation Systems.

END OF SECTION 406700

SECTION 407113 - FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirement and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes:

1. Full-body magnetic flowmeters for pipes of 24” and less inner diameter.

1.3 DEFINITIONS

A. A Magnetic Flowmeter (aka Magmeter) is a transducer that measures fluid flow by the voltage induced across the liquid by its flow through a magnetic field.

B. Ethernet/IP is an industrial network protocol that adapts Common Industrial Protocol (CIP) to standard Ethernet.

1.4 SUBMITTALS

A. Furnish submittals as specified in Section 0113300.

B. Provide all instruments identified in the Project Plans.

C. Provide shop drawings for all instruments.

1.5 QUALITY ASSURANCE

A. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical conditions:

a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

B. Ensure that all system requirements are met for the flowmeter to measure flow at its highest specified accuracy. This includes, but is not limited to, minimum flow as well as upstream and downstream pipe lengths.

C. Notify CAWCD if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store instruments per manufacturer instructions.

1.7 START-UP AND WARRANTY

A. Setup shall be performed by a factory authorized representative.

B. An additional extended two-year warranty must be purchased in addition to the standard warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following, no equal:

1. Endress+Hauser: Promag W500.

2.2 MANUFACTURED UNITS

A. Magnetic flowmeter:

1. General:

a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
c. Include for each magnetic flow metering system:

1) A metering tube with electrodes (sensor).

2) Signal cable.
3) Remote transmitter unless otherwise specified.
4) Flowmeter grounding rings.

2. Performance requirements:

a. Accuracy:

1) 0.25 percent of flow rate from 10 to 100 percent of full scale for velocities ranging between 1.9 to 10 feet per second.

b. Repeatability:

1) 0.25 percent of rate.

3. Element:

a. Metering tube:

1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
2) Liner material in conformance with:

a) Manufacturer's recommendations for the intended service.

b) NSF certified for all drinking water applications.

3) Electrodes type and material in conformance with:

a) Manufacturer's recommendations for the intended service.

b) Utilize a minimum of 2 self-cleaning electrodes.

c) Meter terminal housing NEMA Type 4X unless specifically noted otherwise in the instrument data sheets.

d) Meter coating consisting of epoxy painted finish.

4) Components:

a) 2 grounding rings:

(1) In conformance with the manufacturer's bore and material recommendation for the meter's intended service.

(2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.

b. Transmitter:

1) Remote unless otherwise specified.
2) Power supply: 24 VDC
3) Outputs:

a) Minimum of one 4-20mA and one discrete output for the purpose of providing courtesy flow and acre-ft signals.

b) 1 pulse = 1 acre-ft

c) Ethernet/IP.

2.3 ACCESSORIES

A. Stainless steel tag label refers to Section 406100 – Common Work Results for Process Control and Instrumentation Systems.

B. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

2.4 SOURCE QUALITY CONTROLS

A. Factory calibrate each flow metering system at a facility that is traceable to the NIST – National Institute of Standards and Technology.

B. A real-time computer-generated printout of the actual calibration date indicating actual velocities and as-read values of the flow tube.

1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
2. Minimum calibration shall be a 3-point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
3. Manufacturer shall archive all calibration reports for future reference.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall comply with all manufacturers' recommendations for the specific application.

B. The installation of the flowmeter shall ensure that the flowmeter is always completely full of water without air. The flowmeter shall be installed at a low point in the piping in a below grade vault.

C. Installed meter location must maintain a certain distance away on both sides from any bends in the pipe as specified in the installation manual.

D. Provide manufacturer's service representative to perform installation inspection and startup/commissioning of the flowmeter.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's service representative to perform quality control.

3.3 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions.

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.4 DELIVERABLES

A. Factory calibration certifications

B. Final setting configuration file

C. Instrument Data Sheets included in this Section

D. Provide all instruments identified in the Contract Documents.

1. Instruments may be indicated on the Plans, in the Specifications, or both.

E. Final commissioning and start up documentation.

END OF SECTION 407113

SECTION 408001 – TESTING, CALIBRATION, AND COMMISSIONING OF INSTRUMENTATION AND CONTROL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Plans, Division 00 Contract Documents, Division 01 General Requirements and Special Provisions apply to this Section.

B. Coordinate with other Standard Electrical Specification Sections for additional submittals, qualifications, and other Project requirements to Work specified in this section.

1.2 SUMMARY

A. Section includes:

1. Testing requirements that apply to all process control and instrumentation systems for the entire Project.

1.3 REFERENCES

A. The following codes and standards are hereby incorporated into this Section:

1. American National Standards Institute (ANSI).
2. International Organization for Standardization (ISO):

a. 9001 - Quality Management Systems - Requirements.

3. International Society of Automation (ISA):

a. 5.1 - Instrumentation Symbols and Identification.
b. 5.4 - Instrument Loop Diagrams.
c. 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

4. National Electrical Manufacturers Association (NEMA):

a. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

5. National Fire Protection Association (NFPA).

a. NFPA 70 – National Electrical Code. Contractor shall confirm with CAWCD for the current adopted edition.

6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):

    a. 508 - Standard of Safety for Industrial Control Equipment.

8. 508A - Standard of Safety for Industrial Control Panels.

1.4 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in accordance with:

1. International Electrotechnical Commission (IEC).
2. Institute of Electrical and Electronics (IEEE).
3. International Society of Automation (ISA).
4. International Organization for Standardization (ISO).
5. National Electrical Code (NEC).
6. National Electrical Manufacturers Association (NEMA).
7. International Electrical Testing Association (NETA).
8. National Fire Protection Association (NFPA).
9. National Institute of Standards and Technology (NIST).
10. Underwriters Laboratories (UL).

B. Specific definitions:

1. Control Strategies: A planned set of attributes, implicit in the design of the control system, which may be detailed in a sequence of operation, piping and instrumentation drawing, control description, process parameters and functional specification that assures the appropriate control responses to system inputs.
2. Instrumentation Summary: A listing of all devices that produce or receive analog control signals. Listing shall include device designation, device description, displayed range, full sensor range, units, manufacturer part numbers, and any applicable notes.
3. Validation: The activity performed to exam and test the system components to produce objective evidence that the product will accomplish its purpose.

C. Acronym definitions:

1. FAT: Factory acceptance test also known as Source Test.
2. HOA: Hand-Off-Auto control function that may be operator or PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode,

the equipment is prohibited from responding from the operator or PLC control.

3. HMI: Human machine interface is hardware and a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
4. ICS: Instrumentation and control system: Includes the entire instrumentation system, the entire control system, and all the Work specified in the Instrumentation and Control Specifications and depicted on the Project Plans. This includes all networking components as well as any servers, workstations, thin clients etc.
5. I/O: Input/Output.
6. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
7. P&ID: Piping and instrumentation diagram.
8. PLC: Programmable logic controller.
9. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
10. SCADA: Supervisory Control and Data Acquisition system: the computerized system that gathers and processes data from controllers located in remote locations and enables remote operator control. The SCADA is located at CAWCD Headquarters.
11. SAT: Site Acceptance Testing associated with Commissioning.

1.5 QUALITY ASSURANCE

A. Test personnel:

1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.
2. Test personnel shall have been actively involved in instrumentation and PLC based control systems for a minimum of five years and have the technical expertise to properly perform the Work as specified.
3. Provide the name and resume of the individual persons who will be responsible for each of the following:

    a. Individual who will be responsible for calibrations, testing, and commissioning.
    b. Individual who will be responsible for operator training.

1.6 SUBMITTALS

A. General:

1. Test Phases:

    a. Factory Acceptance Test (FAT). These tests are typically performed off-site at an OEM site or panel shop.
    b. Pre-commissioning test. This is preliminary testing performed on-site in preparation for actual system Commissioning.
    c. Commissioning/Site Acceptance Testing (SAT). These tests are done on-site and are the final stage in testing the installed system against the control specification and sequences.
    d. Performance test. The Performance Test allows the system to be run and monitored in actual service conditions, for a period, to confirm the system operates as expected with faults.

B. Submit for approval all test plans, procedures, forms, and binders, as described for each test phase as they apply specifically to the Project, before scheduling or performing tests.

1. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
2. Develop and submit detailed test procedures required to show that the ICS hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
3. Test procedures shall describe sequentially the steps to be followed in verifying the correct operation of each control system component, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
4. Each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and place for signature of person witnessing the test, as approved by CAWCD.
5. Fill out headings in advance and all other information known before the test.
6. Describe the expected role of the CAWCD, as well as any requirements for assistance from CAWCD's staff for each test phase.

C. Testing binders:

1. Record test results and verify that all test requirements and conditions have been met.
2. Submit a complete test binder, for each test phase, containing all the completed and verified test plans, procedures, forms, reports and manufacturer’s certificates or checklist.

1.7 FACTORY ACCEPTANCE TEST (FAT)

A. General:

1. Before shipment to the CAWCD site, the complete ICS including all operator stations, servers, network equipment, printers, PLCs, RTUs, and peripherals shall be assembled, connected, and all software loaded for a fully functional FAT of the integrated system.
2. The FAT will be witnessed by CAWCD and/or other representatives of the CAWCD. A 20-day notice is required for the confirmation of FAT date.
3. Right of observation: The CAWCD retains the right to observe all factory test activities including all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
4. The CAWCD reserves the right to test any specified function, whether explicitly stated in the test submittal.

B. Testing simulation:

1. The FAT shall make use of hardware simulators, as required by CAWCD, to validate proper control and system operation.

2. Submit a description of the testing equipment to be used.

    a. Details on the simulator construction, components, and operation.

C. Preliminary FAT:

1. A preliminary factory acceptance test (pre-FAT) shall be conducted utilizing the test plans, procedures and forms approved by the CAWCD.

2. Submit the pre-FAT test results: include a letter, signed by the Contractor's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT.
3. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review 15 days before the start of the FAT.

D. Panel inspections:

1. Provide panel inspection forms as part of the factory acceptance test procedures submittal.

E. I/O test:

1. Test forms to include, but not be limited to:

    a. P&ID sheet number.
    b. PLC and panel number.
    c. Rack/slot/number of I/O point.
    d. Device tag name.
    e. Service description.

f. I/O type.
g. PLC I/O tag name or address.
h. Signal voltage
i. I/O scaling
j. I/O engineering units
k. Alarm set points
l. Alarm priority
m. Panel terminal block numbers.
n. Check-off for correct response for each I/O point.
o. Space for comments.
p. Initials of individual performing test.
q. Date test was performed.
r. Witness' signature lines.

F. System configuration test:

1. The purpose of this test is to verify the setup and configuration of all operator stations, HMIs, servers, development stations, and peripherals.
2. Test forms:

a. Provide a description of the function being tested and steps to be conducted.
b. For each function, list all the different sub-functions or ways the function can be used, and provide a test check-off for each:

1) Include signature and date lines.

G. Control logic test:

1. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels. Use hardware simulators, as required by CAWCD.
2. Test forms:

a. Include the fully revised and approved control schematic and control strategy for the loop being tested.
b. Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:

1) Include signature and date lines.

H. Factory acceptance test procedure additional minimal requirements:

1. Prepare and submit a factory acceptance test procedure which includes:

a. Instrumentation summary.
b. Estimated test duration.

1.8 PRE-COMMISSIONING TEST

A. Calibration:

1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
2. Complete instrument calibration sheets for every field instrument and analyzer.
3. For programmable devices provide a copy of the configuration file of all parameters with final operating values.
4. Calibration tags:

    a. Attach a calibration and testing tag to each instrument, piece of equipment, or system.
    b. Sign the tag when calibration is complete.

B. Loop check and validation:

1. After installation and termination of all field devices perform an independent, individual control loop test.

2. Submit the test results: include a letter, signed by the Contractor's project manager or company officer, certifying that the control loops have been tested successfully, and the ICS is fully ready for a CAWCD witnessed Loop check.
3. Submit all witnessed, completed test forms.
4. Include in the test forms:

    a. Analog input devices:

        1) Calibrated range.
        2) Calibration data: Input, output, and error at each test value.
        3) Analog input associated PLC register address.
        4) Value in PLC register at each test point.
        5) Value displayed at each operator interface station (HMI and SCADA).

    b. Analog output devices:

        1) Calibrated range.
        2) Test value at each test point.
        3) Analog output associated PLC register address.

4) Control variable value at field device at each test point.
5) Physical device response at each test point:

a) Response to be actual valve position, or motor speed, etc.

c. Discrete input devices:

1) Record switch setting, contact action, and dead band when relevant.
2) Valve position switches:

a) Response in the PLC as the valve is stroked from the PLC.

b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.

(1) Operator interface switches (control stations and other pilot devices) and associated response.

(2) Starter and drive auxiliary device contact response.

(3) Response of all other discrete inputs to the PLC.

d. Discrete output devices:

1) Record the response of field device to the discrete output from the PLC.
2) Record the proper operation of Open, Close, Start, Stop, On, Off, etc.

1.9 COMMISSIONING (FUNCTIONAL) TEST

A. General:

1. CAWCD reserves the right to test any specified function, whether explicitly stated in the test submittals.
2. Commence commissioning tests after completion of all pre-commissioning tests are completed.
3. Commissioning shall demonstrate proper operation of all systems with all equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

4. Follow all commissioning requirements and test procedures as required by the equipment manufacture's documentation, in addition to the requirements of this specification.

B. Control logic operational validation:

1. The purpose of control logic validation is to field test the operation of the complete control system, including all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.

C. Loop tuning:

1. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.

D. Failure testing:

1. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:

    a. Equipment failure.
    b. Operator error.
    c. Communications sub-system error.
    d. Power failure.
    e. Process equipment failure.
    f. High system loading conditions.

E. Commissioning validation sheets:

1. Document each commissioning test on an approved test form.

    a. Document that the control functions, as defined in the control strategy, provide the desired control response to each system value or input action.
    b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 set points or process rates approved by the CAWCD. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and CAWCD.
    c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:

        1) Loop number and P&ID number.

2) Control schematic, Control strategy, or reference to specification tested.
3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the commissioning test. Otherwise, create new forms.

d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:

a) Specification page and paragraph of function demonstrated.

b) Description of function and/or text from specification.

c) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the commissioning test.

2. Commissioning certification:

a. Document via a certified report the completion of all commissioning and test activities:

1) Including all test forms with test data entered, submitted to the CAWCD with a clear and unequivocal statement that all commissioning test requirements have been satisfied.

F. If a failure or unexpected operation occurs during commissioning and requires a correction or programming change, all affected and associated systems must be re-tested. Coordinate with CAWCD to determine extent of re-test.

G. Conduct testing Monday through Thursday during normal working hours for no more than 10 hours per day. Testing at other times requires approval of the CAWCD.

1.10PERFORMANCE TEST

A. General:

1. After successful completion of the commissioning test, as accepted by CAWCD, the performance test can proceed.
2. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire Project.

3. The complete ICS must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:

    a. Include time of occurrence and duration of each failure.
    b. If a failure or unexpected operation occurs during the performance test, the performance test duration must be restarted.

        1) Depending on the correction, associated systems may need to be re-tested. Coordinate with CAWCD to determine if re-testing is required.

PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TEST

A. General:

1. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2. The Contractor's test personnel shall be responsible for performing tests and recording results.
3. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
4. Any changes and/or corrections shall be noted on the test forms. CAWCD shall witness the revisions and/or corrections prior to leaving the test site.
5. If the corrections and/or revisions are too extensive to be made while the CAWCD is scheduled to be at the FAT test site, the FAT shall be, at CAWCD's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.

B. Testing simulation:

1. For a simple system, testing shall be performed by sourcing and monitoring signals via signal generators, multimeters, passive elements, and monitoring of PLC logic and associated HMI or SCADA. For complex system with multi-step sequences of operation, a hardware simulator shall be required as determined by CAWCD.

    a. The test simulator may contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which

shall be connected to the I/O points within the ICS. All inputs and outputs shall be simulated, and proper control and system operation shall be validated.

b. The test simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

c. When employing a test simulator, the use of jumper wires and loose meters to act as or supply the functionality of a simulator shall not be allowed.

C. Preliminary FAT:

1. The purpose of the pre-FAT is to provide assurance that the ICS is ready for the full, witnessed FAT, in terms of both stability and functionality. Debugging software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the ICS and fix all deficiencies found before the full FAT.

D. Panel inspections:

1. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, proper ventilation operation, and UL508A compliance.

E. I/O test:

1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the ICS, including all operator interface devices.
2. Test methodology:

a. Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received on all operator interface displays.

b. Discrete outputs: Issue commands from a programming device or operator interface screen, verify output card indicator light and measure response at field wiring terminals.

c. Analog inputs: Apply appropriate analog input signal at panel terminals, and observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.

d. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.

F. System configuration test:

1. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   Verify the proper operation of all peripheral hardware.
2. Demonstrate all general HMI functions.
3. Demonstrate proper operation of log-on and other access security functions.
4. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
5. Test automatic fail over of redundant equipment.
6. Demonstrate the proper operation of the alarm display and acknowledgement functions.

G. Control logic test:

1. Testing requirements are to demonstrate each function required to provide a fully functioning system as specified in the Contract Document. Use hardware simulators if required.

   a. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
   b. Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.
   c. Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.
   d. Failure testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power DC battery power), process equipment failure, and high system loading conditions.

3.2 PRE-COMMISSIONING

A. Calibration:

1. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
2. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
3. Calibration points:

    a. Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to National Institute of Standards and Technology (NIST).

4. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations need adjustment.
5. Calibrate and test instrumentation as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical documents.

B. Loop check/validation:

1. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the ICS.
2. Issue commands from the programming device and local operator interface screen and verify proper responses of field devices. Use actual process inputs wherever available.
3. Provide "end-to-end" tests to SCADA points:

    a. Test SCADA system inputs from field device to SCADA system operator workstations.
    b. Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
    c. Observe and record responses at all intermediate devices.
    d. Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
    e. For each signal, perform separate tests for SCADA computer screens, local operator interface screens, and local control panels.

4. Retest any loop following any necessary corrections.
5. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
6. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).

7. Apply provisional settings on controllers and alarm set points.
8. Record all analog loop test data on test forms.
9. Exercise each field device requiring an analog command signal. Vary during the validation process, the output from the ICS and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
10. Manually set the output at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
11. Exercise each field device providing a discrete input to the system in the field and observe the proper operation shall be observed at the HMI:

    a. Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    b. Exercise starters, relay contacts, switch contacts, and observe proper operation.
    c. Calibrate and test instruments supplying discrete inputs and observe proper operation.

12. Test each device accepting a discrete output signal. Perform the appropriate operator action and confirm the proper operation of the field device:

    a. Stroke valves through outputs from the ICS and confirm proper directional operation. Confirm travel limits and any feedback signals to the ICS.
    b. Exercise motors starters from the ICS and verify proper operation through direct field observation.
    c. Exercise solenoids and other field devices and verify proper operation through direct field and HMI observation.

3.3 COMMISSIONING (SAT) TEST

A. Control logic operational validation:

1. Demonstrate all control functionalities shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
2. Test in detail on a function-by-function and sentence-by-sentence basis.
3. Thoroughly test all hardware and software functions:
4. Including all hardwired and software control circuit interlocks and alarms.
5. Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.

6. Control logic validation tests to include but not limited to a repeat of all control logic tests from the factory acceptance tests, modified and expanded to include all field instruments, control panels, circuits, and equipment.

B. Loop tuning:

1. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
2. If excessive oscillations or system instability occur, as determined by the CAWCD, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.

3.4 PERFORMANCE TEST

A. General:

1. Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the Project Site:

    a. 24 hours or less, for a major failure.

2. The performance test duration:

    a. 14 days.

3. Test and use the entire process control system under standard operating conditions.

B. Failures:

1. Classify failures as either major or minor.

    a. Minor failure:

        1) A small and non-critical component failure or software problem that can be corrected by CAWCD's operators.
        2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.

3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.

b. Major failure:

1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
2) Cause termination of the performance test.
3) Start a new acceptance test when the causes of a major failure have been corrected.
4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

C. Technician report:

1. Each time a technician is required to respond to a system malfunction, he or she must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
2. If a malfunction occurs which clears itself or which the operator on duty can correct, no report is required or logged as specified above.
3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
4. Each report shall be submitted within 24 hours to the CAWCD, or its representative.

3.5 DEMONSTRATION AND TRAINING

A. Complete demonstration and training to CAWCD personnel include all required handouts and hands-on training.

B. Complete training and instruction as specified.

END OF SECTION 408001