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Utilities & Energy Services has been designated as the official steward for the standards, guidelines, procedures, and specifications for design and sustainability on the campus of Texas A&M University. These preferences have evolved from the department's experience in overseeing the construction, operation and maintenance of Texas A&M buildings over many years. It is intended that these standards serve as a uniform reference for consultants providing architectural and engineering design for Texas A&M construction projects.

The value of being able to transmit the large body of specific information and preferences contained in these standards is obvious. It will result in the use of construction systems and materials which have been proven to be cost-efficient and effective. The use of these standards will also improve the efficiency of the design process itself by insuring that relevant information is communicated to project designers in a timely manner.

This information is provided as a technical resource for engineering and architectural professionals for use in design and construction activities on campus. Design professionals assume responsibility for selection, reference, and appropriate application of these resources. It is your responsibility to verify that you have obtained the most current detail sheets. We recommend checking utilities.tamu.edu/design-standards/ for revisions regularly.
Design Standard

15kv Switches – Pad Mounted

Detailed specifications follow.

PART 1 - GENERAL

1.01 SUMMARY
   A. This section specifies the furnishing of dead-front, pad mounted load interrupter switchgear utilizing solid dielectric insulation. SF6 or oil Insulated switches are not acceptable.

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS MUST PROVIDE THE FOLLOWING MINIMUM INFORMATION:
   A. Manufacturer
   B. One line diagram, three-line diagram, control diagrams.
   C. Dimensional drawings, showing:
      1. Outline dimensions.
      2. Top and bottom views showing entry and exit space for conduits.
      3. Front and side elevations showing arrangement of all devices.
   D. Total weight of unit.
   E. Installation procedures.
   F. Operation and maintenance manuals.
   G. Instrument transformer data.
   H. Cut sheets/information on all devices used in switch.

PART 2 - PRODUCTS

2.01 TYPE
   A. Provide solid dielectric vacuum load break switches and vacuum fault interrupters (VFI) 15.5KV, 600 Ampere rated dead-front switchgear assembly with the necessary accessory components, all completely factory-assembled and
operationally checked. Switch ways must be capable of both full fault interruption and fault closing at 20 kA symmetrical.

B. Switch shall have four ways, with all ways rated for 600A. Way shall be defined as a three-phase circuit consisting of three bushings and one vacuum fault interrupter (VFI), connected to a common bus. Switches shall be constructed double sided, 2 way back to back with 2 way.
1. With prior approval switch maybe be 5 way. 5 way switch shall be constructed so all five way are in line with each other and face the same direction.

C. The VFI Trip or VFI Protected Way shall be a solid dielectric insulated, three-phase fault interrupter mechanism with vacuum fault interrupter contacts capable of interrupting both 600 amperes of load current and rated fault current. The VFI-Trip Way shall include the VFI-Trip mechanism, trip circuitry, and current transformers mounted internally in the switch tank on the bushings. The VFI-Trip mechanism shall have three positions, Open, Closed and Tripped.

D. Switch shall have a Visible Open Isolation Point Switch (VOIP) which is a three-phase isolation point switch in series electrically with the vacuum contacts, integral to the VFI-Switch and VFI-Trip mechanism.

2.02 RATINGS

A. Component ratings shall be as follows, and also as shown on the drawings:
2. Maximum Voltage: 15.5 KV.
3. BIL Voltage: 95 KV.
4. Main Bus Continuous Amperes: 600A.
5. Short Circuit Amperes, Symmetrical: 20,000.
7. Fault Closing, Amperes, Symmetrical: 20,000.
9. Peak Current (per IEEE C37.60): 52,000 amps.
10. Frequency: 60 Hertz.
11. Momentary withstand, Amperes, Symmetrical: 20,000.
13. Short-Time withstand, Symmetrical: 20,000.

2.03 BASIC COMPONENTS

A. Solid dielectric insulation.
1. Mechanisms and bus work shall be solidly dielectrically insulated.
2. No liquid insulation allowed.
3. No SF6 gas insulation allowed.
B. Vacuum Fault Interrupters Ways (VFI-Trip).
   1. Each mechanism shall have vacuum fault interrupter contacts rated for both
      load-break and fault interruption.
   2. VFI-Trip Protected Ways shall include internally mounted current
      transformers, trip circuitry, and a connection for an over-current relay.

C. Overcurrent relays shall be Square D P116 and shall be:
   1. Powered by current transformers mounted internally in the switch tank on
      the bushings. Provide twelve, 600: 5CTs, and four CT shorting plugs.
   2. Relay shall be powered and programmed in the field by a USB to mini USB
      connection.
      a. No external power other than a laptop shall be required for
         programming or downloading setting or events. No special
         manufacturer's cable or connections for the relay will be allowed.
      b. Relay shall also have ability to be programmed remotely.
   3. Provide two relays.

D. Switch Tank.
   1. Switch tank shall be constructed of 304 stainless steel.
   2. Switchgear shall be 600 amp rated and shall be maintenance-free, fully-
      sealed, and dead-front design with solid dielectric insulation for the
      mechanisms and bus work.
   3. The switch tank filled with approximately 3 to 5 pounds of dry air pressure
      to maintain the tank structure at sea level.

E. High Voltage Enclosures.
   1. 304 stainless steel construction.
   2. Powder coat finish (Aggie Tan, Sherwin Williams, SW6114 Bagel).
   3. Double-Sided Access Enclosures:
      a. Cable terminations and operating handles are located on both sides.
      b. Phase sequence must follow existing equipment and cable phasing
         ABC-CBA.

F. Electrical Components.
   1. The VFI-Switch device shall be a three-phase, gang-operated mechanism
      having a quick-make, quick-break design operating independently of the
      speed in which the external operating handle is opened or closed. The VFI-
      Switch mechanism shall have a two-position latch for open and closed
      positions. When the operating handle is pulled to the open position the
      vacuum contacts shall de-energize the circuit and the VOIP switch shall
      rotate to isolate the circuit creating a safe to work environment. The VOIP
      contacts shall be visible through the viewing windows on the surface of the
      switch tank.
2. The VFI-Trip device shall be a three-phase, gang-operated mechanism having a quick make, quick break design operating independently of the speed in which the external operating handle is opened or closed. The vacuum fault interrupter mechanism shall have a three position latch for open, closed and tripped positions. When the operating handle is pulled to the open position the vacuum contacts shall de-energize the circuit and the VOIP switch shall rotate to isolate the circuit creating a safe to work environment. The VOIP contacts shall be visibly through the viewing windows on the surface of the switch tank.

3. The internal copper bus shall be silver plated. The bus shall be insulated with solid dielectric material to maintain the BIL rating between phases and to ground.

4. The internal wiring for the current transformers, control trip circuitry, and mechanism status shall be made to connectors located on the switch tank surface. Cabling shall be supplied with appropriate connectors to plug into each connection and to the corresponding connection to the low voltage component or on the low voltage control cabinet. Switch position indication, trip circuit & trip block contacts shall be rated for 24 VDC operation.

G. Connectors.
1. When required, waterproof connectors shall be installed on the switch tank for the following optional features and equipment installed: mechanism status, VFI trip circuitry, internal current transformers, and internal voltage sensors.

H. Current Transformers.
1. Internally mounted 600:5 ratio current transformers shall be installed on all four 600 amp VFI trip bushings.
2. The current transformers will be terminated to a connector on the switch tank.
3. Provide four CT shorting plugs.

I. Ground Bus.
1. Provisions for mounting external ground bus bar or ground rod with short-circuit rating equal to that of the switchgear assembly shall be provided on tank surface.

J. Switch Tank.
1. The high voltage switch tank shall be constructed of type 304 stainless steel.
2. Enclosures and shall be welded using 308 type filler material to maintain the corrosion resistant properties of the stainless steel.
3. Bushing terminations shall be welded in place.
4. Provisions for lifting the switchgear shall be provided.
5. Each switch tank shall have ground nuts welded to the switch tank for customer installation for grounding equipment.

K. Operating Handles and Position Indication.
1. A single external operating handle shall open the vacuum contacts and rotate the visible open isolation point device in one motion.
   a. Designs with two operating handles will not be considered.
2. Each way shall have a vacuum contact position indicator located on the switch handle housing to indicate the Open and Closed positions of the vacuum contacts.
3. **Open position** - a reflective nameplate with silver letters stating “Open” on reflective green background will be seen on the handle housing.
   a. When the operating handle is positioned up and away from the switch tank and the vacuum contact position indicator indicates “Open”, both the vacuum contacts and the visible open isolation point contacts will be in their open positions.
4. **Closed position** - a reflective nameplate with silver letters stating “Closed” on reflective red background will be seen on the handle housing.
   a. When the operating handle is positioned down and flat against the switch tank and the vacuum contact position indicator indicates “Closed”, both the vacuum contacts and the visible open isolation point contacts will also be in their closed positions.
5. **Tripped Position**.
   a. When the overcurrent relay identifies an over load or fault current, a signal from the overcurrent relay will be sent to the VFI-Trip mechanism solenoid to trip open the vacuum contacts.
   b. The vacuum contact position indicator will show “Open”, indicating that the vacuum contacts have been “tripped” open.
   c. The external operating handle will remain in the closed position until the operating handle is pulled to the full open position.
   d. When the external operating handle is pulled to the full open position, the VFI-Trip mechanism will be re-set and the visible open isolation point device will rotate to its open and isolated position.

L. **Bushings**.
1. 600-amp bushings for all ways, rated 20KA.

M. **Nameplates**.
1. Nameplates shall be 304 stainless steel with photo-engraved etched letters, schematics, and numbers.
2. Ratings, schematic diagram, way, termination, and serial number designation nameplates.
   a. The ratings nameplate shall have:
1) Name of manufacturer.
2) Month and year of manufacture.
3) Catalog number.

b. The schematic diagram nameplate shall have:
   1) Diagram of internal bus.
   2) Weight.

c. Each way nameplate shall be numbered and welded to each switch handle housing.

d. The termination nameplates shall include the way and phase designation and will be located on the switch tank near their respective termination.

N. Overcurrent Protection Relays.
   1. Relays shall be CT powered and provide separately or by quantity dictated in part number.
   2. Relays shall be interchangeable between ways.
   3. Overcurrent protection relays shall be microprocessor based, substation quality, programmable overcurrent relays, Schneider P116.
   4. The overcurrent relays shall be installed in a submersible rated enclosure with hinged door and water tight gasket seal. Enclosure shall be designed so that the relay can be drawing out for testing.
   5. The CT connections must short automatically when the relay is drawn-out of its case.

O. Padmount Enclosures.
   1. Enclosure must be constructed from 304 stainless steel and covered with a powder coat finish to protect the enclosure from reclaimed water and fertilizers.
   2. Padmount enclosures shall be delivered with the equipment and shall house the switch tank.

P. Motor operator mounting.
   1. Provisions for mounting a motor operator on each of the switch handle housings shall be provided.

Q. Future Automation.
   1. Each Padmount enclosure must include provisions for installing a future Automation Control cabinet on either side of the Padmount enclosure.
   2. Provisions for mounting and connecting future motor operators shall be through cables with connectors on each end to connect the switch tank to the automation control.
   3. Provisions for mounting two external potential transformers in the Padmount enclosure for future control power must be provided.
2.04 ACCEPTABLE MANUFACTURERS.

A. Innovative switchgear Model. No P40406666-303-Axx or P40406666-303-Axx-P1 (Where AXX indicate number of relays required, A05= 4 relays, A06= 3 relays, A07= 2 relays, A08= 1 relays, A09= 0 relays and P1 indicates Aggie Tan).

1. *With prior approval 5 way PS5050066666-303-AXX or PS5050066666-303-AXX-P1 ( Where AXX indicate number of relays required, A04=5 relays, A05= 4 relays, A06= 3 relays, A07= 2 relays, A08= 1 relays, A09= 0 relays and P1 indicates Aggie Tan).

PART 3 - EXECUTION.

3.01 INSTALLATION.

A. Secure the switch to the concrete pad as recommended by the manufacturer.

3.02 EQUIPMENT ADJUSTMENT.

A. Touch-Up Painting. Restore damaged surfaces to factory finish.

B. Settings. Properly set relay current and time settings. Trip settings shall be set in accordance with the recommendations of the study performed under specification Section 26 05 73, Protective Relay and Device Coordination Study.

C. Inspection. Thoroughly inspect switch for items such as loose connections and presence of foreign material, and remedy prior to energizing.

3.03 Field TESTING.

A. Relays.

1. Test by a relay manufacturer’s certified technician. After installation and before acceptance by the Owner, the Contractor shall provide the services of an independent testing organization to performance test all protective relays. This test shall involve passing a primary current through the current sensor with a suitable, low-voltage test set and timer, which shall allow verification that the protective relays track their published curves and that they actually trip the devices on which they are applied. Refer to Protective Relay and Device Coordination Study, Section 26 05 73. This test shall also include the polarity of the current sensors and give an indication of satisfactory operation.

B. Controls.

1. All control devices and the corresponding operating sequences must be tested to verify operability.
Design Standard

15kv Switches – Underground

Detailed specifications follow.

PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies the furnishing of submersible load interrupter switchgear utilizing solid dielectric insulation. SF6 or oil insulated switches are not acceptable.

1.02 REFERENCE STANDARDS


1.03 SUBMITTALS MUST PROVIDE THE FOLLOWING MINIMUM INFORMATION:

A. Manufacturer

B. One line diagram, three-line diagram, control diagrams.

C. Dimensional drawings, showing:
   1. Outline dimensions.
   2. Top and bottom views showing entry and exit space for conduits.
   3. Front and side elevations showing arrangement of all devices.

D. Total weight of unit.

E. Installation procedures.

F. Operation and maintenance manuals.

G. Instrument transformer data.

H. Cut sheets/information on all devices used in switch.

PART 2 - PRODUCTS

2.01 TYPE

A. Provide solid dielectric vacuum load break switches and vacuum fault interrupters (VFI) 15.5KV, 600 Ampere rated dead-front switchgear assembly with the necessary accessory components, all completely factory-assembled and
operationally checked. Switch ways must be capable of both full fault interruption and fault closing at 20 kA symmetrical.

B. Switch shall have four ways, with all ways rated for 600A. Way shall be defined as a three-phase circuit consisting of three bushings and one vacuum fault interrupter (VFI), connected to a common bus.

C. The VFI Trip or VFI Protected Way shall be a solid dielectric insulated, three-phase fault interrupter mechanism with vacuum fault interrupter contacts capable of interrupting both 600 amperes of load current and rated fault current. The VFI-Trip Way shall include the VFI-Trip mechanism, trip circuitry, and current transformers mounted internally in the switch tank on the bushings. The VFI-Trip mechanism shall have three positions, Open, Closed and Tripped.

D. Switch shall have a Visible Open Isolation Point Switch (VOIP) which is a three-phase isolation point switch in series electrically with the vacuum contacts, integral to the VFI-Switch and VFI-Trip mechanism.

E. Switch shall be design and construction so that it is capable of being lowered through a standard 42-inch manhole opening, without removal of components.

2.02 RATINGS

A. Component ratings shall be as follows, and also as shown on the drawings:
   2. Maximum Voltage: 15.5 KV.
   3. BIL Voltage: 95 KV.
   4. Main Bus Continuous Amperes: 600A.
   5. Short Circuit Amperes, Symmetrical: 20,000.
   7. Fault Closing, Amperes, Symmetrical: 20,000.
   9. Peak Current (per IEEE C37.60): 52,000 amps.
   10. Frequency: 60 Hertz.
   11. Momentary withstand, Amperes, Symmetrical: 20,000.
   13. Short-Time withstand, Symmetrical: 20,000.

2.03 BASIC COMPONENTS

A. Solid dielectric insulation.
   1. Mechanisms and bus work shall be solidly dielectrically insulated.
   2. No liquid insulation allowed.
   3. No SF6 gas insulation allowed.

B. Vacuum Fault Interrupters Ways (VFI-Trip).
1. Each mechanism shall have vacuum fault interrupter contacts rated for both load-break and fault interruption.
2. VFI-Trip Protected Ways shall include internally mounted current transformers, trip cirquitry, and a connection for an over-current relay.

C. Overcurrent relays shall be Square D P116 and shall be:
1. Powered by current transformers mounted internally in the switch tank on the bushings. Provide twelve, 600: 5CTs, and four CT shorting plugs.
2. Relay shall be powered and programmed in the field by a USB to mini USB connection.
   a. No external power other than a laptop shall be required for programming or downloading setting or events. No special manufacturer’s cable or connections for the relay will be allowed.
   b. Relay shall also have ability to be programmed remotely.
3. Provide two relays.

D. Switch Tank.
1. Switch tank shall be constructed of 304 stainless steel.
2. Switchgear shall be 600 amp rated and shall be maintenance-free, fully-sealed, and dead-front design with solid dielectric insulation for the mechanisms and bus work.
3. The switch tank filled with approximately 3 to 5 pounds of dry air pressure to maintain the tank structure at sea level.

E. High Voltage Enclosures.
1. 304 stainless steel construction.
2. Double-Sided Access Enclosures:
   a. Cable terminations and operating handles are located on both sides.
   b. Phase sequence must follow existing equipment and cable phasing ABC-CBA.

F. Electrical Components.
1. The VFI-Switch device shall be a three-phase, gang-operated mechanism having a quick-make, quick-break design operating independently of the speed in which the external operating handle is opened or closed. The VFI-Switch mechanism shall have a two-position latch for open and closed positions. When the operating handle is pulled to the open position the vacuum contacts shall de-energize the circuit and the VOIP switch shall rotate to isolate the circuit creating a safe to work environment. The VOIP contacts shall be visible through the viewing windows on the surface of the switch tank.
2. The VFI-Trip device shall be a three-phase, gang-operated mechanism having a quick make, quick break design operating independently of the
speed in which the external operating handle is opened or closed. The
vacuum fault interrupter mechanism shall have a three-position latch for
open, closed and tripped positions. When the operating handle is pulled to
the open position the vacuum contacts shall de-energize the circuit and the
VOIP switch shall rotate to isolate the circuit creating a safe to work
environment. The VOIP contacts shall be visibly through the viewing
windows on the surface of the switch tank.

3. The internal copper bus shall be silver plated. The bus shall be insulated
with solid dielectric material to maintain the BIL rating between phases and
to ground.

4. The internal wiring for the current transformers, control trip circuitry, and
mechanism status shall be made to connectors located on the switch tank
surface. Cabling shall be supplied with appropriate connectors to plug into
each connection and to the corresponding connection to the low voltage
component or on the low voltage control cabinet.

G. Connectors.
1. Submersible-rated, stainless steel connector(s) shall be installed on the
switch tank for the following optional features and equipment installed:
mechanism status, VFI trip circuitry, internal current transformers, and
internal voltage sensors.

H. Current Transformers.
1. Internally mounted 600:5 ratio current transformers shall be installed on all
four 600 amp VFI trip bushings.
2. The current transformers will be terminated to a connector on the switch
tank.
3. Provide four CT shorting plugs.

I. Ground Bus.
1. Provisions for mounting external ground bus bar or ground rod with short-
circuit rating equal to that of the switchgear assembly shall be provided on
tank surface.

J. Switch Tank.
1. The high voltage switch tank shall be constructed of type 304 stainless
steel.
2. Enclosures and shall be welded using 308 type filler material to maintain
the corrosion resistant properties of the stainless steel.
3. Switch tank is submersible-rated, fully-sealed, and not subject to moisture
intrusion, even when submerged in 10 feet of water.
4. Bushing terminations shall be welded in place.
5. Provisions for lifting the switchgear shall be provided.
6. Each switch tank shall have ground nuts welded to the switch tank for customer installation for grounding equipment.

K. Operating Handles and Position Indication.
   1. A single external operating handle shall open the vacuum contacts and rotate the visible open isolation point device in one motion.
      a. Designs with two operating handles will not be considered.
   2. Each way shall have a vacuum contact position indicator located on the switch handle housing to indicate the Open and Closed positions of the vacuum contacts.
   3. **Open position** - a reflective nameplate with silver letters stating “Open” on reflective green background will be seen on the handle housing.
      a. When the operating handle is positioned up and away from the switch tank and the vacuum contact position indicator indicates “Open”, both the vacuum contacts and the visible open isolation point contacts will be in their open positions.
   4. **Closed position** - a reflective nameplate with silver letters stating “Closed” on reflective red background will be seen on the handle housing.
      a. When the operating handle is positioned down and flat against the switch tank and the vacuum contact position indicator indicates “Closed”, both the vacuum contacts and the visible open isolation point contacts will also be in their closed positions.
   5. **Tripped Position**
      a. When the overcurrent relay identifies an over load or fault current, a signal from the overcurrent relay will be sent to the VFI-Trip mechanism solenoid to trip open the vacuum contacts.
      b. The vacuum contact position indicator will show “Open”, indicating that the vacuum contacts have been “tripped” open.
      c. The external operating handle will remain in the closed position until the operating handle is pulled to the full open position.
      d. When the external operating handle is pulled to the full open position, the VFI-Trip mechanism will be re-set and the visible open isolation point device will rotate to its open and isolated position.

L. Bushings.
   1. 600-amp bushings for all ways, rated 20KA.

M. Nameplates.
   1. Nameplates shall be 304 stainless steel with photo-engraved etched letters, schematics, and numbers.
   2. Ratings, schematic diagram, way, termination, and serial number designation nameplates.
      a. The ratings nameplate shall have:
1) Name of manufacturer.
2) Month and year of manufacture.
3) Catalog number.

b. The schematic diagram nameplate shall have:
   1) Diagram of internal bus.
   2) Weight.

c. Each way nameplate shall be numbered and welded to each switch handle housing.

d. The termination nameplates shall include the way and phase designation and will be located on the switch tank near their respective termination.

N. Overcurrent Protection Relays.
   1. If specified in part number, CT powered relays shall be provided on VFI-Trip ways.
   2. Overcurrent protection relays shall be microprocessor based, substation quality, programmable overcurrent relays, Schneider P116.
   3. The overcurrent relays shall be installed in a submersible rated enclosure with hinged door and water tight gasket seal. Enclosure shall be designed so that the relay can be drawing out for testing.
   4. The CT connections must short automatically when the relay is drawn-out of its case.

O. Motor Operator Mounting.
   1. Provisions for mounting a motor operator on each of the switch handle housings shall be provided.

P. Motor operators (optional).
   1. Motor operators are 24-volt, DC powered, and constructed of 304 stainless steel. Motor operators are sealed and submersible rated. The motor operator bolts directly to the operating handle housing for ease of field installation and future upgradability. Each motor comes with mounting hardware, connector pins and adjustable linkages to connect the motor operator to the operating handle. The quick-disconnect linkage allows for field testing and operation of the motor operator without interrupting service to the customer.
   2. The motor operators must mount directly to the switch tank without requiring a special stand.
   3. The motor operator must open both the vacuum contacts and the visible open isolation point device to de-energize and isolate the circuit in one operation from outside the vault.
   4. 24v DC motor operators must be able to be installed on all ways.
5. When installed on a switch way, the motor operator will open and close both the vacuum contacts and the visible open isolation point contacts.

6. When installed on a VFI protected way, the motor operator will open and close both the vacuum contacts and the visible open isolation point contacts and also re-set the VFI mechanism and open the visible open isolation point after a trip command has been issued by the over-current relay.

Q. Future Automation.
   1. Each enclosure must include provisions for installing a Future Automation Control on enclosure. Controls must be capable on all ways and by any individual configuration of one or more way.
   2. Provisions for mounting and connecting future motor operators shall require the switch tank to be opened.

2.04 ACCEPTABLE MANUFACTURERS.

PART 3 - EXECUTION: BY INSTALLER OF SWITCH.

3.01 INSTALLATION.
   A. Secure the Mounting Stand to the concrete pad as recommended by the manufacturer.
   B. Secure the switch to the Mounting Stand as described by the manufacturer.

3.02 EQUIPMENT ADJUSTMENT.
   A. Settings
      1. Properly set relay current and time settings. Trip settings shall be set in accordance with the recommendations of the study performed under specification Section 26 05 73, Protective Relay and Device Coordination Study.
   B. Inspection.
      1. Thoroughly inspect switch for items such as loose connections and presence of foreign material, and remedy prior to energizing.

3.03 Field TESTING.
   A. Relays.
      1. Test by a relay manufacturer’s certified technician. After installation and before acceptance by the Owner, the Contractor shall provide the services of an independent testing organization to performance test all protective relays. This test shall involve passing a primary current through the current sensor with a suitable, low-voltage test set and timer, which shall allow
verification that the protective relays track their published curves and that they actually trip the devices on which they are applied. Refer to Protective Relay and Device Coordination Study, Section 26 05 73. This test shall also include the polarity of the current sensors and give an indication of satisfactory operation.

B. Controls.
   1. All control devices and the corresponding operating sequences must be tested to verify operability.
Design Standard

Building Automation Systems (BAS)

INSTRUMENTATION AND CONTROL FOR HVAC

This standard was revised on November 7, 2018, and the latest changes are underlined. Please refer to Part 4 of this standard for full revision history.

Detailed specifications follow.

PART 1 - GENERAL

1.01 SUMMARY

A. This section provides information on acceptable Building Automation Systems (BAS) and control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Refer to the Construction Documents for engineers Sequences of Operations for BAS HVAC Controls.

1.02 WORK INCLUDED

A. The BAS Contractor will provide an environmental control/energy management system and control function for the entire HVAC system. The BAS will be a Direct Digital Control (DDC) System manufactured by either:
   1. Johnson Controls
   2. Siemens

B. HVAC Systems or building components to be monitored and/or controlled by the central campus systems include, but are not limited to, the following: temperature control, Air flows, building and room pressurization, indoor & outside building lighting, Fume Hoods and Laboratory Control Systems, and the start and stop of HVAC systems.

C. The BAS Contractor will furnish and install all components but not limited to all temperature, pressure, and flow sensors, transmitters, relays, switches, wire, and all DDC panels as required to meet engineers design and sequence of operations. Also furnish all controls, operators, power supplies, control valves, air and water flow measuring stations, transducers and wiring to connect components. Submit for approval, appropriate product data cut-sheets for all material/components intended for use prior to beginning work. Where BAS is used in specifications and drawings, it is understood to be same as DDC. In
addition, when required, provide a complete installation of the Laboratory Control System (LCS) completely integrated into the appropriate Campus BAS Software.

D. All Controls, damper actuators, Valve actuators, shall be electronically controlled, no pneumatics of any type are allowed.

E. The BAS Contractor shall provide Direct Digital Control (DDC) panels complete with all microprocessors, software, terminal strips, transducers, relays, and regulated power supply with battery backup at the mechanical room field equipment controllers and supervisory engines.

F. The BAS Contractor shall furnish a HVAC Terminal Equipment Controller (TEC), electronic damper actuator(s), and electronic HW valve and actuator for installation on each VAV terminal unit and fan coil unit, as applicable, by the terminal equipment manufacturer. These DDC devices shall be delivered to the manufacturer’s factory in sufficient time for the terminal equipment manufacturer to meet their scheduled delivery obligations.

G. The BAS Contractor shall furnish all DDC LCS components, including TECs, Lab Supply Air Terminal Units with reheat coils (duct mounted), General Exhaust Air Terminals, Fume Hood Exhaust Terminals, and all other associated controls components required to meet the engineers design and sequence of operation. Installation of all air terminals shall be by the mechanical contractor.

H. The BAS Contractor shall provide for each VAV box an inlet flow sensor suitable for interfacing with a pressure transducer, and for VAV boxes and other terminal equipment as the design engineer requires. Also as required, any necessary devices for proper operation to achieve full functionality as required by the engineers design and sequence of operation. The cost of mounting shall be included in the cost of the terminal equipment. All wiring and terminations related to the lab control system components shall be provided by the BAS contractor.

I. The BAS Contractor shall provide for each TEC, a 24 vac, 40 va power source, and mount and connect these devices and the DDC controller as required for proper operation as required under this Section. All other wiring and terminations related to the TEC shall be provided by the BAS contractor.

J. Room temperature, CO₂ sensors and humidity sensors and mounting plates shall be provided and installed by the BAS Contractor.

K. Temperature controls and non-DDC accessories that are standard catalog products as manufactured by Siemens Building Technologies, Inc. or Johnson Controls, Inc., will be acceptable. Industrial instrumentation supplied shall be standard catalog products of Rosemount, Dwyer, Honeywell, Bristol, Foxboro, Leeds and Northrup, Taylor or Brown. All coordination and execution of work
pertaining to the installation, service, and guarantee, under this Section of the specifications, shall be the sole responsibility of the BAS Contractor.

L. All controls to be installed, calibrated and adjusted by trained instrument technicians in the full-time employ of the BAS Subcontractor & low voltage electrical subcontractor. The BAS Contractor will be responsible for all work performed by their subcontractors.

M. Submit engineering/wiring drawings and receive approval prior to beginning work. These drawings shall be submitted in a timely manner to provide sufficient time to review drawings so as not to hold up the project.

N. The DDC field panels will be located in mechanical rooms as shown on the drawings. The BAS cabinets shall be labeled with a permanent labeled indicating its name as shown in the control drawings. All sensor and start/stop wiring will be brought back to the panel responsible for controlling/monitoring the mechanical/electrical equipment for which the sensor, start/stop wiring is directly related. The location of these panels may not be shown on the drawings. The DDC panels in the mechanical room shall be provided with a UPS to allow operation of the panels during switchover to emergency power. The UPS shall provide a minimum of 500 va, be similar to an Invensys Powerware 120, and be installed in a NEMA 1 hinged, lockable cabinet.

O. Power to each BAS panel shall be provided from a breakered, 20 amp dedicated circuit on emergency power having an insulated ground wire from the power panel ground buss wired to the duplex receptacle.

P. The BAS Control System will perform all Sequence of Operations as required by the Design Engineer.

Q. Furnish and install a network communications trunk (N.C.T.) between DDC panels, and a separate LAN communications network between each terminal unit controller (or group of controllers) back to the DDC panel associated with the AHU which serves the terminal units. Trunks shall be connected to the panels with CAT-6 conductors and required components (switches). In addition, the N.C.T. trunk shall be extended from the nearest Panel to an Owner-provided, network drop(s) location.

R. The project shall provide a dedicated Ethernet network connection between the BAS panel and the Campus BAS Software. The BAS Contractor is responsible for coordinating the network drop (s) required for integration to the Campus BAS Software and will not receive final payment for the project until the BAS system is fully integrated and accepted by TAMU Utilities & Energy Services (UES).
S. Provide graphics for all new work, compatible with existing campus front end system. Coordinate and provide BAS graphics that are acceptable to TAMU Utilities & Energy Services (UES). See section 1.10 below for more information.

T. All exposed wiring shall be in conduit (3/4" minimum). Concealed wiring shall be plenum rated. All active Ethernet switches, hubs, and routers required for the communication between BAS panels shall be BAS Contractor-provided and installed. The conduit/wiring system required for the BAS shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted. All conduit shall enter BAS panels and WAGES enclosures from the bottom of the panel or enclosure.

U. A Schneider Electric 9788TAMUWAGESHMI metering panel, of the appropriate capacity, will be provided by the BAS Contractor, complete with all microprocessors, software, programming, point data base, trends, terminal strips, and regulated power supply with battery backup.

V. The WAGES panel will require temperature and flow sensor wiring from the panel to sensors located in the primary supply and return piping on the Chilled Water, Heating Hot Water, and Domestic Hot Water, to be included as part of the BAS Contractor’s responsibilities. The WAGES panel will require flow meter wiring from Domestic Cold Water, Irrigation Water, and Steam. Provide all wiring from the flow tubes and flow transmitters to the WAGES panel. This WAGES panel will require a dedicated 110 volt, 20 amp, single phase standby electric circuit source. This WAGES panel will require a category 6 Ethernet cable. The WAGES system will require start-up & integration to the Campus Metering Software, by the Schneider Electric Square D Vendor. A meeting between the TAMU UES and the BAS contractor will be held as early as possible, prior to purchase of any material, to review the installation and finalize panel and wiring locations. The WAGES panel is used only when campus chilled or heating water is servicing the facility.

W. When only electric and domestic water are being metered, the electric meter that is to be installed must have the option of field installable digital input/output modules that can be added at any time thus allowing monitoring of status points, consumption of water, air, gas, and or steam pulses. Also this unit must be easily integrated in the current TAMU power and energy management system.

X. Integration of the WAGES system to the UES Metering Software shall include loading of the TAMU WAGES program into each WAGES panel, connecting to the UES meter software, as well as five Graphic screens that represent the piping and position of temperature sensors and flow tube for each commodity that is being metered in the WAGES system.

Y. The BAS contractor will be responsible for the connection and integration from the BAS in the building, to the Campus BAS software. The Contractor will be
responsible for programming the DDC panels with operational sequences and set-points as specified.

1.03 RELATED WORK

A. If the project will include Chillers, Boilers, or other DX system the BAS shall have all points mapped through BacNet, Modbus, or other means that will allow for the BAS to see, monitor, trend, alarm, as well as control, at a minimum, the start/stop and set point of each system.

B. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

C. Shop Drawings:
   1. Schematic flow diagrams & graphic display.
   2. Power, signal, and control wiring diagrams.
   3. Details of control panel faces.
   4. Damper schedule.
   5. Valve schedule.
   6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
   7. Control System Software: Schematic diagrams, written descriptions, and points list.
   8. Sequences of operation.
   10. Samples of Graphic Display screen types and associated menus.
   11. Field quality-control test reports.
   12. Operation and maintenance data.

1.04 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:
   1. Three (3) copies of the Operation and Maintenance Manuals, Control Drawings, and written Sequence of Operation, shall be provided to the Utilities & Energy Services upon completion of the project. The entire Operation and Maintenance Manual, Control Drawings, and written Sequence of Operation, shall be furnished on Compact Disc media, and include the following for the BAS provided:
      a. Table of contents.
      b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
      c. Manufacturer’s product data sheets or catalog pages for all products including software.
      d. Archive copy of all site-specific databases and sequences.
e. BAS network diagrams.
f. Interfaces to all third-party products and work by other trades.

2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.05 BAS WIRING

A. All wiring and conduit shall be installed in accordance with related Specification Section Division 26, Electrical.

B. The conduit/wiring system required for the BAS specification Input/Output summary:
   1. Digital Input (D.I.) wiring (Class 2) may be run in a common conduit with Digital Output (D.O.) wiring (Class1) where local codes permit.
   2. Analog Input (A.I.), Analog Output (A.O.), Digital Input (D.I.), and Network Communications Trunk (N.C.T.) wiring may be run in a common conduit.
   3. Digital Output (D.O.) wiring run in a common conduit with Analog Input (A.I.), Analog Output (A.O.), or Network Communications Trunk (N.C.T.) is not permitted under any circumstances.
   4. AC line power to DDC panel shall be #12 THHN.
   5. Digital Output (D.O.) wiring shall be #14 THHN.
   6. Digital Input (D.I.), Analog Input 4-20 mA (A.I.), and Analog Output (A.O.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
   7. Analog Input/Thermistor/or voltage types (A.I.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
   8. Network Communications Trunk (N.C.T.) between DDC panels and TEC’s shall be 2 individual minimum #24 awg TSP (twisted, shielded stranded pair) cables, not to exceed 12.5 pf capacitance per foot, wire-to-wire, and not to exceed 6 twists per foot. TEC controller LAN networks shall be 1 #24 awg TSP of the same type.

C. Wiring between DDC Panels:
   1. Furnish, install and terminate individual CAT-6 cable assemblies to interconnect each BAS panel. Data is passed through an Ethernet switch before continuing to its destination to other main building panels and to the front end. Each cable shall originate and terminate within one designated DDC panel in each mechanical room. Additionally, furnish, install and terminate individual Cat-6 cable assemblies to connect each DDC panel within the mechanical room(s) with others in that same room, as engineered by the BAS Contractor.
   2. All cable runs between mechanical rooms and/or DDC panels shall be no longer than allowed as specified in Division 27. Where runs are required that will be longer than Division 27, furnish and install an additional
enclosure near the midpoint (coordinate location with architect), to be used as a network junction box, complete with 120VAC emergency power source. Terminate and label the cables within this junction box and show the location on the as built control drawings, as directed for each DDC panel.

3. Furnish, install and make connections of all interlock, power for sensors (if required), line and low-voltage wiring external and internal to DDC panels. All wiring shall be clearly and permanently labeled as outlined below.

D. Field devices requiring a 4-20 mA DC input signal shall be non-ground referenced.

E. All wiring in mechanical rooms, electrical rooms, inaccessible areas, or located in areas exposed to occupant view shall be run in conduit (3/4” minimum). Plenum rated wiring shall be acceptable for installation in concealed, accessible locations. Conduit fill limit shall not exceed 40% in any portion of the conduit system.

F. In order to facilitate maintenance, where multiple sensors or devices are connected to a common raceway or conduit, each sensor or device shall be individually connected to a common (non-sensor or device) junction box, which shall then be attached to the common conduit. Under no circumstances shall sensor or device wiring or tubing be routed through any other sensor or device's specific enclosure or junction box.

G. All wiring shall be labeled at both ends and at any spliced joint in between. Wire shall be tagged using a system similar to the Panduit P1 Self Laminating System that utilizes a thermal transfer (or equivalent) printer with a minimum font size of Arial 10. In addition to tagging at field device end and at spliced joints, a tag shall be placed 6 inches after entering each DDC panel. Identification and tag information shall be included in engineering/wiring submittal which must be submitted for Owner approval prior to beginning work. Tag information shall coincide with equipment/point information as written in the specification input/output summary. Each BAS DDC panel shall include a paper wiring document, in a clear sleeve permanently attached to the inside door that shows the name of each point and what terminal they are connected to.

1.06 SYSTEM VERIFICATION--PROCEDURE TO BE FOLLOWED

A. Provide minimum 2 week written notice for all inspections.

B. The system verification also includes the Laboratory Control System.

C. Upon completion of all external sensor mounting, terminations, and wiring into and out of the DDC panels (and WAGES panel), the TAMU Project Inspector & UES representative shall inspect and approve this work. The BAS Contractor shall make his representative(s) available and coordinate with the TAMU Project Inspector & UES representative during this inspection process. At the successful
conclusion of this inspection, the BAS Contractor shall provide a written report stating all work is complete. BAS Contractor, General Contractor and TAMU Project Inspector & UES representative shall sign. This should be filed with Project Commissioning/Startup documents.

D. Upon such approval being achieved, the BAS Contractor shall make terminations within the DDC panels and WAGES panel.

E. Following completion of the work in the DDC panel and WAGES Panel tie-in, a performance test shall be conducted by the BAS Contractor in the presence of the TAMU Project Inspector & UES representative.

F. The BAS Contractor shall conduct testing of proper operation of each and every physical system point to which the Contractor has provided devices, wiring, in order to verify the equipment and installation provided by them (their portion of the work), i.e., when the Owner commands a point, the Contractor verifies in the field that the commanded point operates properly. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete, calibrated and functioning properly per the specified sequences of operation. An electronic and paper copy of which will be provided to UES for signature by the BAS Subcontractor, General Contractor and TAMU Project Inspector & UES representative. This should be filed with Project Commissioning/Startup documents. A representative of the BAS Contractor that can revise control sequences shall be available on site as necessary to make changes during the system verification.

G. TAMU Project Inspector & UES representative shall attend initial inspection and verification of completed punch list for items in paragraphs 1.5C and 1.5F of this Section. Further inspections required due to incomplete/incorrect work shall be at Contractor’s expense.

H. Upon conclusion of final checkout and acceptance, the Contractor’s responsibility reverts to warranty of materials and installation herein specified. System shall be warranted for a period of two (2) years.

I. The Contractor shall coordinate and include the Commissioning Agent as required for the above activities. Commissioning agent will coordinate and witness functional performance test procedures. Refer to 01 91 13 for additional details.

1.07 SYSTEM GRAPHICS

A. Provide a cover page for the project to include graphic links including, but not limited to:
   1. Air Handling Equipment
2. Chilled and Heating Water Pumps (Chilled & Heating Hot Water Flow from WAGES Panel)
3. Domestic Water Pumps.
4. Fans
5. Outside Air Handling Equipment
6. Supply Air Floor Plan
7. Exhaust Air Floor Plan
8. Schedules
9. Other items as indicated on the construction documents

B. Floor plans shall show the following:
1. Show room numbers or list of group of rooms within the colored areas
2. Colored areas indicate different graphic links such as 1st floor North, etc.
3. Links to other floors along with chilled and heating water system links.
4. Links to sequence of operations
5. Links to any operations schedules
6. Links to AHU serving that area

C. Floor Plan of supply shall show the following:
1. Indicate room numbers on plan
2. Indicate different AHU coverage with different colored cloud
3. Indicate VAV box locations along with ductwork
4. Indicate room temperatures for each zone.
5. Separate Graphics will be provided to show each of the following information
   a. Location of 24 volt low voltage xfmrs,
   b. Communications trunk,
   c. Duct pressure sensors with location and value.
   d. Routing of communication lines to each DDC panel and TEC

D. Typical VAV box shall show the following:
1. AHU serving VAV box and the Discharge Air Temperature of its AHU
2. Supply CFM and damper position
3. Reheat valve position
4. Box status, heat or cool
5. Fan proof
6. Room temperature and set point.
7. Occupancy sensor state (if available) with its current value

E. Exhaust fan floor plan layout shall show the following:
1. Indicate room numbers on plan
2. Indicate with different colored bubble or cloud the boundaries of each exhaust fan.
3. Link to each exhaust fan that is shown on that floor
F. Schematic of outside air units shall show the following:
   1. Schematic indicating what other AHU's the outside air handler serves
   2. Indicate flows to each AHU with set points, run status/proof, damper locations (isolation and fire damper.)
   3. Indicate which AHU’s are served.
   4. Show fire alarm status for AHU’s on the AHU graphic

G. Air Handling Units shall show the following:
   1. Provide feedback on devices, but not limited to items such as temperatures, fan speed, static pressure set point and actual, valve position, filter status, airflow measuring station CFM, etc.
   2. Graphics to be a true representation of the actual field equipment.
   3. Chilled and Heating Water systems shall show the following:

H. Pumping Units shall show the following:
   1. Pumps along with their speed and proof of status
   2. Flow meters
   3. Temperature and pressure sensors and their values
   4. Building control valve
   5. Where pumps are lead / lag set up, indicate run time in hours for each pump

I. Other
   1. Refer to construction documents for other systems that require graphics.
   2. Graphics shall include feedback on all devices including set point and actual values.

PART 2 - PRODUCTS

2.01 GENERAL DESCRIPTION

A. The Building Automation System (BAS) shall use an BacNet open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support BacNet open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other Owner provided networks.

B. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices. In existing installation, re-use existing controls equipment System architectural design shall eliminate dependence upon any single device for control execution:
   1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
2. The System shall maintain all settings and overrides through a system reboot.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

2.02 ACCEPTABLE CONTRACTORS:

A. Mechanical contractor shall not serve as BAS contractor. Acceptable BAS contractors, provided they comply with these specifications, are:
1. Siemens Building Technologies, Inc. (branch office)
2. Johnson Controls, Inc. (branch office)
3. No exceptions

B. Integration with Existing Johnson Controls, Siemens or TAC BAS:
1. The BAS Contractor a project shall provide the following:
   a. The BAS contractor shall provide any and all necessary software connectivity licenses within the cost of the bid. Software licenses shall allow specified BAS point information to be broadcast out of the BAS expansion to the existing Johnson Controls or Siemens BAS server software.

2.03 FIELD DEVICES

A. Acceptable Immersion Temperature Sensors and Thermowells

   1) Dwyer Series TTE Explosion Proof RTD Temperature Probe with Dwyer Series W 316 Stainless Steel Thermowells
   2) Rosemount
   3) Honeywell

B. The above Immersion Temperature Sensors shall be equal/better to the specifications below:

   1. Temperature Sensor: RTD using a Pt1000, or Pt 100.
   2. Output Temperature Ranges: User selectable any range between -30 to 250 deg.f. with minimum span of 40 deg.f
   4. Accuracy: Transmitter: +/- 0.1%F.S. Probe: +/- 0.3% F.S.
   5. Thermal Drift Effects: +/-0.02% deg.C max.
   8. Process Connection: ½” male NPT.
   9. Conduit Connection: ½” female NPT.
   10. Probe Length: 2” to 18” depending on model
   11. Pressure Limits: 2000 PSI.
   12. Power Requirements: 10 to 35 VDC.
   13. Output Signal 4-20mA (two wire loop powered).
14. Display: 2 lines X 8 character LCD.
15. Enclosure Rating: NEMA 4X (IP66) and explosion proof for Class I, Groups B, C, D; Class II, Groups E, F, G; Class III.

C. Thermowells shall be equal/better to the specifications below:
   1. Hard Ware: 316SS Sheath
   2. Taper/Bore: Straight/0.260
   3. Inside Threads: ½ NPSF
   4. Process Connections: ½” NPT
   5. Mounting: Threaded
   6. Lag: None
   7. Sheath O.D. Base/Taper: ½” Straight
   8. Length: From 4” to 24” as needed to fit Temperature sensor length required for tip of probe to be in center of piping.

D. HVAC Air Duct Temperature Sensors:
   1. Duct temperature sensors shall be averaging type. Outside air wall mounted sensors shall be provided with a sun shield. Accuracy of transmitter shall be unaffected by wiring distances up to 700 feet. Siemens Building Technologies, Johnson Controls, Rosemount or Dwyer only.

E. Room Thermostats:
   1. Each room thermostat shall come complete with a terminal jack and override switch integral to the sensor assembly. The terminal jack shall be used to connect the portable operator’s terminal to control and monitor all hardware and software point associated with the terminal unit.
   2. Humidity Sensors shall provide a 0 to 100% range corresponding to an isolated 4 to 20 Ma output. Accuracy of ±2% RH, with maximum drift of 1% per year.
   3. An override switch will initiate override of the night setback or unoccupied mode to normal (day) operation when activated by the occupant. The switch function may be locked out, canceled or limited as to time or temperature in software by an authorized operator or a central or remote operator's terminal.
   4. Space thermostats may be Thermistor or 4-20 mA output RTD. The room thermostats shall be firmly attached to the wall using approved construction techniques. Double-sided adhesive tape in lieu of screws is not acceptable.
   5. The room thermostats shall be accurate to within ±.5°F and have a setpoint adjustment range of 45°F to 85°F.
   6. Room carbon dioxide sensors shall provide a range from 0 to 2,000 ppm CO₂, and be accurate to within ±100 ppm. The CO₂ sensor shall experience less than 1% drift per year for the first two years of operation and negligible drift thereafter, no calibration of the CO₂ sensor is necessary.
   7. Room thermostats shall be a full featured unit in all areas.
F. Acceptable Water Flow Meters and Remote Transmitters:

2) Yokogawa AXF Magnetic Flow Meter with AXFA11G Magnetic Remote Converter
3) Siemens Mag 5100 W with MAG 5000/6000 Remote Transmitter

G. The above Water Flow Meters and Remote Transmitters shall be, or equal/better to the specifications below:

a. The Flow Tube and Transmitter shall be calibrated to each other and shall be flow-calibrated and assigned a calibration factor at the factory. The calibration factor is entered into the transmitter, enabling interchangeability of sensors without calculations or a compromise in standard accuracy.

b. Accuracy: Includes the combined effects of linearity, hysteresis, repeatability, and calibration uncertainty. ±0.15% of rate ±1.0 mm/sec from 0.04 to 13 ft/s (0.01 to 4 m/s); above 13 ft/s (4 m/s), the system has an accuracy of ±0.2% of rate.

c. Each Flow Tube shall be sized specifically for the pipe and flow in which it is to be installed and to ensure flow velocity is within 2 to 20 ft./s.

d. A calibration certificate shall be provided from the manufacture.

e. Class 150 carbon steel flanges, Teflon (PTFE) or EDPM lining, and Type 316L stainless steel or Hastelloy C electrodes.

f. Transmitter: 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface.

g. Ambient Temperature Limits: -20 to 140deg.f.

h. Humidity Limits: 0 to 95% RH to 120deg.f.

i. Safety Approvals: FM Class 1 Division 2 for non-flammable; CSA Class 1 Division 2

H. Temperature Transmitters: Temperature transmitters shall be designed for 4-20 mA output for Platinum RTD millivolt input sensor (as specified above). Accuracy shall be the same as specified for the temperature sensors. Stability shall be ±0.2% of calibrated span for 6 months. Transmitter shall be a part of the temperature sensor assembly and shall be in a moisture-proof housing with a moisture-proof seal between the sensor and transmitter. Immersion sensors for piping shall be Dwyer Series TTE explosion-proof RTD temperature transmitter with fully configurable ranges and display options or equal by Rosemount.

I. Humidity Transmitter Space: Sensor shall provide a 0 to 100 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Accuracy of + / - 2
percent RH, with maximum drift of 1 percent per year. Sensor shall be equipped with LCD display.

J. CO₂ Duct-Stat Indoor AQ Sensor: C02 sensor shall be Siemens model number QPA63 or Johnson Controls model number CD-P00-00. The unit shall be self-contained for wall mounting application. The unit shall have a fast response and shall have 0-1 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Visual alarm is not to be provided. The monitor shall utilize the photo acoustic sensor with VOC sampling capability.

K. Electric Room Thermostats: Provide line voltage room thermostats with cover. Set point must be adjustable from approximately 50 to 100 Deg. F. Minimum rating is 6 amps at 120 VAC. Provide removable setting knob. Housings shall not contain thermometers.

L. Duct Relative Humidity Sensor: Duct relative humidity sensors used in the calculation of enthalpy shall be Siemens QFM Series Duct Relative Humidity or similar. The sensor shall have an accuracy of +/- 2% RH. Provide unit with housings suitable for return air plenum installations. Filter material shall be Teflon. The unit shall be operating range of 0 to 100% RH and have a 4 to 20 mA or 0 to 10 Vdc linear output.

M. Pressure Transmitters: Transmitters for water pressure shall provide a 4-20 mA DC signal output directly proportional to pressure. Device shall be constructed with corrosive resistant stainless steel wetted parts and have a die-cast aluminum enclosure specifically designed for NEMA4/IP65 service. Accuracy of ±0.5% of calibrated span. Span not over 200% of sensed pressure. Stability ±0.5% of upper range limit for 6 months. Stainless steel diaphragm, viton 0-rings. Temperature limits: -20°F to 220°F.

N. Fan proof-of-flow switches shall be UL listed adjustable setpoint and differential pressure type. Switches shall be piped to fan inlet and outlet. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inch w.c. All pressure tubing on roof shall be stainless steel.

O. Pump motor proof-of-flow Current Status Switch: Provide a high performance miniature split-core current status switch with adjustable set point (where indicated). The current status switch shall have an operating range of between 1.25 – 50 amps and be able to detect belt loss and mechanical failure.

P. Air flow and static pressure analog sensors shall be ±.5% accuracy, range suitable for the low velocity pressures to be encountered, be selected for approximately 50% over-range, and have an electronic 4 to 20 mA analog output. These differential pressure sensors shall be connected to the air flow measuring
station with valved lines for testing and calibration, and shall have adjustments for zero and span.

Q. Electric Low Limit Duct Thermostat: Snap-acting, two pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 15 feet length of bulb. Provide one thermostat for every 20 sq ft of coil surface.

R. Air Flow Measurement Station (AFMS):
   1. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GT. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.
   2. Each unit shall operate on 24 VAC.
   3. Each sensing point shall independently determine the airflow rate and temperature, and shall equally weight and average by the transmitter prior to output. Pitot tube arrays are not acceptable.
   4. A single manufacturer shall provide probe and transmitter.
   5. The operating range shall be from 0 - 5000 fpm with accuracy of ±2% over the entire operating airflow range and be verified against standards that are traceable to NIST.
   6. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, RS-485 and BACnet.
   7. Sensors shall be UL listed.
   8. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer’s installation requirements.
   9. Any Air Flow Measuring Station of the Thermal Dispersion Type must be protected by a pleated filter in the ductwork upstream of the AFMS.

2.04 CONTROL VALVES

A. Terminal Unit Control Valves:
   1. Characterized Ball, Forged brass body, Stainless Steel trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
   2. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
   3. Sizing: 5-psig maximum pressure drop at design flow rate, to close against pump shutoff head. Select control valves for a minimum Cv of 1.0 to reduce the risk of system dirt accumulating in very small orifices in characterizing-discs.
   4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
B. Butterfly Valves:
   1. 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
   3. Disc Type: Elastomer-coated ductile iron.
   4. Sizing: 1-psig maximum pressure drop at design flow rate.

PART 3 - EXECUTION

3.01 GENERAL

A. All DDC and LCS panels shall be connected to emergency power system.

3.02 INPUT/OUTPUT SUMMARY

A. The I/O Summary on the drawings is provided as a list of the minimum points required by this contract for connection to the Energy Automation system. Furnish all devices, wiring, tubing, etc., necessary to serve and transmit to the DDC panels. Any points not shown on the I/O Summary yet required to accomplish the sequence of operation shall be provided under this contract at no additional cost to the Owner.

3.03 EQUIPMENT, AIR HANDLING UNIT AND FAN START-UP AFTER POWER FAILURE

A. In case of power failure, all AHUs and fans with 7-1/2 HP and larger motors shall be started sequentially at 15 second intervals (adjustable) through the DDC system.

B. DDC to send alarm if any equipment does not start within 15 minutes and omit that item from remaining starting sequence.

PART 4 - REVISIONS TO DESIGN STANDARD

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
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<tbody>
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<td>1</td>
<td>10/8/2018</td>
<td>2.03R</td>
<td>Changes made to Air Flow Measurement Station</td>
</tr>
</tbody>
</table>
Design Standard

Building Energy Efficiency Analysis

PART 1 GENERAL

1.1 The objective is to ensure the efficient use of energy at the planning and design phase of a new or renovated building project, rather than attempt to manage and pay for an inefficient design over the life of the building. Implementing this strategy can be a positive game changer when it comes to the future of energy consumption on campus as well as ensuring that Texas A&M will not be taking on undue financial exposure as a result of inefficient building design. It is much more cost effective to ensure that efficiency is designed into a building when built or renovated so the university can benefit from an ongoing annuity of reduced operating cost over the life of the building. The work required to implement this strategy will be called Energy Efficiency Analysis (EEA). The EEA will start with an initial requirement for all project managers for new or renovated buildings to perform a design review to ensure university standards will be met for design and ensure overall building operating efficiency will meet or exceed the campus standard. The university building energy design standard is a requirement that new buildings will exceed the ASHRAE 90.1-2013 efficiency standard by 6% and meet ASHRAE 90.1-2013 for existing building renovations. Achieving this target will require that cost-effective energy conservation measures be used which do not compromise building performance or occupant comfort.

1.2 Utilities & Energy Services (UES) will work directly with the FP&C or SSC project manager and through the CBE sub-council review process to ensure that the required steps have been completed for all new construction. For new construction, each project manager shall complete the EEA and obtain written verification from UES Technical Services. An overview of the Energy Efficiency Analysis (EEA) is provided below.

PART 2 ENERGY EFFICIENCY ANALYSIS (EEA) FOR NEW CONSTRUCTION

2.1 New buildings shall be designed to exceed the requirements of the ASHRAE 90.1-2013 energy standard by 6% and incorporate cost effective energy conservation measures that do not compromise building performance or occupant comfort. Energy modeling by the project team will be required to verify energy performance of buildings. Energy modeling shall be conducted with the latest version of Trane Trace 700, Carrier HAP, or IESVE for Engineers. The use of other energy modeling software shall only be permitted with the prior approval of the Utilities and Energy Services Department’s Manager for Technical Services. ASHRAE 90.1-2013 Appendix G shall be used for establishing the baseline building. Modeling to demonstrate EEA compliance shall be completed during the Design Development (DD) phase of a project. The project manager shall submit information on the modeling including the software used, model inputs and outputs, as well as a brief
project description including the design features that result in the additional 6% savings to the UES Manager for Technical Services.

2.2 Residential projects, as defined by the State Energy Conservation Office (SECO), shall be designed to comply with International Code Council’s International Energy Conservation Code, IECC 2015.
Design Standard

Cable Splicing & Termination Qualifications

The majority of premature cable accessory failures in the electrical industry are due to poor workmanship. To ensure that TAMU has safe and reliable power to the campus, the following guidelines have been implemented to ensure only authorized personnel perform terminations on the TAMU Campus.

This standard provides for maintaining a list of personnel approved to perform cable terminations and splices on University medium voltage systems. This standard applies to all personnel who install terminations, splices, and insulated separable connectors on medium voltage shielded, solid dielectric insulated conductors. At TAMU, most of the terminations consist 200A load break elbows, 600A dead break (T-Bodies), stress cones. Most splices are in line, cold shrink splices.

Detailed specifications follow.

PART 1 SPlicing / TerminationS REQUIREMENTS AT TAMU

1.1 Minimum of 3 years’ experience in 5 kV to 15 kV systems.

1.2 Must have performed at least 25 terminations over the last 2 years.

1.3 Must have completed and documented formal training (splicing school or manufacturer training).

1.4 Must complete T-body termination demonstration for TAMU Utilities Distribution Department.
   A. Must supply own T-Body Kit to complete termination
   B. Must supply own 500 MCM demonstration cable

PART 2 STANDARD PROCEDURES

2.1 Prior to cable termination or splicing, contractor shall submit in writing to the Supervisor of Electrical Distribution the qualifications of personnel directly responsible for completing the work required. The following information should be provided for approval:

   A. Training certificate and/or professional license.
   B. Years of experience in cable termination and/or splicing.
   C. Number of cable terminations and/or splices performed.
   D. Manufacturer certifications if applicable.
E. Must be able to successfully perform a termination and/or splice under the supervision of the Supervisor for Electrical Distribution.

2.2 After successfully meeting the above requirements and receiving approval of the Supervisor for Electrical Distribution:

A. The personnel that have been approved will be added to the university’s list of approved installers for the TAMU campus.

B. The contractor may proceed on the requested work once approval is received from the Supervisor of Electrical Distribution.

C. All cable terminations and/or splicing must be tagged with the installer’s TAMU identification number and the date of the work performed.

D. The tag must be made of brass or 304 stainless steel, approximately 1-1/4” diameter and with numbers a minimum 1/4-inch high.

E. The contractor shall submit a list of all terminations completed for the project; the list shall have manhole number, type of termination, date and the installer’s name.

F. Qualifications shall be updated every three years to remain on the authorized personnel list.

PART 3 DISTRIBUTION

3.1 TAMU UES shall maintain current list of approved splicers.
Design Standard

Capacitor Bank

Detailed specifications follow.

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Assemblies of outdoor metal-enclosed capacitor bank including:
   1. Foundations.
   2. Receiving, unloading, and storage.
   3. Final placement.
   4. Exterior cable connections.

1.02 INFORMATIONAL SUBMITTALS.

A. Quality assurance data:
   1. Ratings of switching device calculations showing need for reactors and size.
   2. Certified test reports of ground switch.
   3. Capacitor unit tank rupture curve.
   4. Capacitor unit watt losses performance data.
   5. Certified copies of test data and reports.
   6. Calculations for neutral voltage shift from ground or current flow for unbalance protection relay coordination.
   7. Calculations of peak in-rush, RMS inrush current and inrush frequency and duration.
   8. Calculations verifying need for inrush current limiting reactors, and that rating selected is sufficient to protect capacitor unit fuses and switching devices.
   9. Time-current fuse curves for fuses provided, including manufacturer and model numbers.

1.03 ACTION SUBMITTALS.

A. Product Data: Component material lists.

B. Shop Drawings:
   1. Certified complete and accurate Data Sheets.
   2. Certified outline and general arrangement drawing including dimensions, weight, and shipping sections.
   3. Floor plan drawing showing locations for anchor bolts and leveling channels.
4. Elementary diagrams including 3-line diagrams of potential and current secondary circuits showing device terminal numbers and internal diagrams.
5. Schematic control diagrams.
6. Complete wiring diagrams showing connections of component devices and equipment.
7. Interconnection diagrams shall include control cable numbers.
8. Maximum load ampacity requirements for external 120 volt ac control power source.
9. Clear indication of logic state (de-energized vs. energized state with description of each) for all contact signals sent to external controller.
10. Manufacturer recommendations for protection and control of capacitor banks, including (but not limited to):
   a. Recommended alarm or trip setpoints and time delays (i.e. power factor, harmonics, overvoltage, temperature, etc.) for safe operation of overall capacitor bank and individual capacitor stages.
   b. Recommended logic and/or permissives for safe operation of overall capacitor bank and individual capacitor stages.
   c. Recommended logic and/or permissives to avoid conflicting operation or “hunting” where multiple capacitor banks are supplying reactive power in parallel.

1.04 CLOSEOUT SUBMITTALS:
A. Operation, maintenance and instruction manuals containing at a minimum:
1. Instructions for receiving, inspection, storage, and handling.
2. Assembly drawings.
3. Complete installation and maintenance instructions for equipment components.
4. Parts identification for replaceable parts and assemblies.
5. Statement of equipment warranty.

1.05 MAINTENANCE MATERIALS.
A. Provide 3 spare current-limiting fuses for each size required.

1.06 QUALITY ASSURANCE.
A. Design, manufacture, and test in accordance with applicable requirements of:
2. NEMA CP 1 – Shunt Capacitors.
4. OSHA – Occupational Safety and Health Administration.
5. Applicable standards for auxiliary equipment.
6. Standards of foreign organizations shall not be used without written approval from Engineer.

B. Perform design and routine tests in accordance with NEMA CP1. Test results shall indicate that equipment meets standards prior to shipment.

1.07 DELIVERY, STORAGE, AND HANDLING.

A. Provide suitable crating, blocking, and supports so equipment withstands normal domestic shipping and handling shocks and vibration.

B. Weatherproof equipment as required for shipment. Cover openings to prevent entrance of foreign material during shipment and storage.

C. Ship equipment in one complete unit without further assembly required at destination.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION.

A. Type: Outdoor, 3-phase, single line up in NEMA 3R enclosure.

B. Construction: Metal-enclosed complete with equipment, relays, instruments, wiring and all accessories as specified.

C. Service conditions: See Appendix A Data Sheets. Equipment will be located outdoors inside fenced substation yard.

D. Ratings: See Appendix A Data Sheets.

2.02 DESIGN REQUIREMENTS.

A. Single assembly shall be comprised of following section types:
   1. Incoming disconnect.
   2. Capacitor.
   3. Control.

B. Assembly shall contain switching and fuse protection functionality necessary for full operation of capacitor bank.

C. Overall outside dimensions of length and width, as well as power cable entry location, shall be in accordance with dimensions given on Detail “A”. Provisions for bottom-fed conduit into control box shall accommodate two 2-inch conduits as indicated on Drawings.

D. Environmental requirements:
   1. Ambient conditions: See Appendix A Data Sheets.
2. Design equipment in accordance with relevant sections of most recent local building code.

2.03 INCOMING DISCONNECT SECTION EQUIPMENT.

A. Terminal lugs:
1. Copper, 2-hole NEMA spacing.
2. Provide for termination of power cables from below.
3. Provide 36” (900 mm) minimum space from bottom of compartment to terminal lugs for spreading cables and installation of stress cones.

B. Disconnect switch:
1. 3-pole, gang-operated, nonload break.
2. External operating handle with padlock and key interlock provisions.
3. Viewing window for visual indication of blade position.

C. Grounding switch:
1. 3-phase, gang-operated.
2. Manually-operated with fully insulated handle to ensure stored energy has been discharged from capacitors while providing safety and visual ground indication.
3. Provide key interlocked with isolating disconnect switch and compartment access doors to obtain proper operating sequence and operator safety.
4. Grounding switches that require use of control power to ensure grounding of capacitors not acceptable.
5. Use of multi-position switch for Disconnect Switch and Grounding Switch is acceptable.

D. Main in-line fuses:
1. 3 fuses for short-circuit protection of bank.
2. Type: Nonexpulsion, clip-style.
3. Size and rating: As determined by manufacturer.
4. Locate behind hinged access door with screen protector. Fuse may serve as means of isolating bank.
5. Blown fuse indication (by way of dry contact or other means) shall be provided on main fuses to alert maintenance personnel of a blown fuse condition.


F. Main bus: Electrical grade copper, full round edge, 3-phase.

G. Provide interlock mechanism to prevent opening capacitor housing before source power is disconnected.
2.04  CAPACITOR SECTION EQUIPMENT.

A. Reactors:
   1. Inrush current-limiting reactors, single-phase, air core.
   2. Provide single-phase, varnish-encapsulated reactor on each phase to limit high-frequency inrush current to values below $I^2T$ rating of fuses as well as below kA x kH.
   3. Size: As determined by manufacturer.

B. Vacuum switches:
   1. The capacitor bank stages shall be controlled by single phase motor/solenoid operated vacuum switches that have been tested for capacitor switching.
   2. If single-phase switches are used, switches must be operated by a single contact, to ensure simultaneous command delivery to all three phases. Separate contacts from one relay not acceptable.
   3. While in remote, the capacitor bank stages shall be controlled by magnetically-held switches, such that one signal provides both “on” and “off” command. Thus, capacitor stage shall be “on” when incoming run signal is logical “0”, and “off” when incoming run signal is logical “1”.
   4. Capacitor switches shall be tested in accordance with ANSI Standard C37.66.
   5. The vacuum switches/contactors shall be controlled by a local/remote switch. In the remote position, the switches shall accept control from an external power factor controller (SEL-351-7). In the local position, the vacuum switches will be forced on or off, regardless of the external controller output signal.
   6. The vacuum switches shall be interlocked with the bank’s air-disconnect switch and ground switch.

C. Power capacitor units:
   1. All-film type and stamped with BIL rating consistent with voltage class of tank.
   2. Externally fused. Individually fuse each capacitor to protect against case rupture with current limiting fuse.
   3. Low loss design with losses of each capacitor unit shall not exceed 0.07 watt/kilovar, measured at 1.1 times rated voltage and 46ºC ambient temperature.
   4. Design mounting frame and connecting bus work to permit replacement of one unit without disturbing adjacent units.
5. **Tank:** Stainless steel, light gray finish for resistance to severely corrosive environments.

D. **Individual capacitor fuses:**
   1. Each individual capacitor shall be protected by single, dedicated current limiting fuse.
   2. **Type:** Nonexpulsion, capacitor-rated, current limiting, with blown fuse indication.
   3. Provide viewing window for visual indication of fuse status.
   4. Mount fuses in manner that will permit replacement of individual fuse without disturbing adjacent units.
   5. **Size and rating:** As determined by manufacturer to ensure protection against case rupture.

E. **Interlocks:** As required to prevent entry into bank while energized.

F. **Auxiliary contacts:** (2 NO and 2 NC) for each switch and alarm. Wire from relays and indicators to terminal blocks for remote status and control.

G. **Blown fuse detection shall be provided at every stage using fuse sensing.**

H. **Tank:** Stainless steel or aluminum, with light gray finish for resistance to severely corrosive environments.

I. **Bushings:**
   1. Light gray, wet-process porcelain material, glazed for high-strength and durability.
   2. Hermetically sealed to capacitor tank.

J. **Mounting brackets:**
   1. Stainless steel, with industry standard mounting centers for unit interchangeability.
   2. Underside of each bracket shall be unpainted for allowing positive grounding to mounting surface.

K. **Bushing terminals:**
   1. Provide complete with parallel-groove, stud-type terminal on each bushing.
   2. Parallel groove terminals shall accommodate No. 8 solid to No. 1 stranded aluminum or copper conductors.

L. Provide with internal discharge resistor to reduce terminal voltage to less than 50 volts or less, within 5 minutes after capacitor has been disconnected from source of supply.

M. **Nameplates:** Stainless steel, listing required NEMA and ANSI/IEEE data.
N. Each capacitor shall contain no PCB contaminates and be labeled with blue "non-PCB" decal.

2.05 CONTROL COMPARTMENT EQUIPMENT.

A. Protection: Provide sensing and stage isolation for neutral unbalance and blown fuse detection. Capacitor bank shall continue to operate upon isolation and loss of a single stage to match reactive power requirements of system as closely as possible.

B. Selector switches.
   1. One “Local/Remote” 2-position.
   2. One “On/Off” 2-position per stage.

C. Indicating lights (LED).
   1. One green (open) and one red (closed) for the status indication of the following:
      a. Each individual stage vacuum switch.
      b. Main disconnect switch.
      c. Grounding disconnect switch.
   2. One red per fuse (main and individual stage) for blown status indication.
   3. One green (healthy) and one red (alarm) for health status of capacitor bank (provided by external controller).

D. Segregation: Controls shall be completely isolated from medium-voltage compartment allowing access while capacitor bank is energized.

E. Provide 120V GFI convenience outlet.

2.06 ENCLOSURE.

A. Construction: Totally enclosed, NEMA 3R, 11-gage steel assembly with 4” (100 mm) (minimum) welded structural steel channel base. Hinged doors shall be provided for all maintenance requiring internal access.

B. Lifting lugs:
   1. Reinforce base at each corner with 1/4” (6 mm) steel plate welded to web of channel. Provide with bolted, removable steel lifting lugs in reinforced portion.
   2. If enclosure exceeds 9’ (2.7 m) in length, provide additional reinforcement and lifting lugs at centerline on each side.
   3. Enclosure shall be capable of being lifted, skidded or sledded into position on concrete pad without damage to any portion of enclosure or contents.

C. Anchor bolt holes: 3/4” (19 mm) diameter at each corner of enclosure.
D. Conduit access: Provide opening in floor of enclosure with removable cover plate drilled to accommodate 6” (150 mm) conduit with bushing.

E. Doors:
   1. Flush design. Extended door sills which can trap water or debris not acceptable.
   2. Provide padlockable, 3-point latching (top, bottom, and center).
   3. Hinges: Welded to door and to enclosure in configuration to allow removal of doors in open position only.
   4. Provide automatic sliding stainless steel door stays so doors hold open in approximately 140° position.

F. Main bus: Copper, ASTM hard drawn, electrical grade; silver-plated joints, uninsulated.

G. Ground pads:
   1. Two 1/4” (6 mm) steel pads, diagonally located at opposite ends of capacitor bank enclosure. Weld to base channel or sheet steel.
   2. Provide with 2, horizontally oriented, 9/16” (14 mm) holes at 1-3/4” (44 mm) NEMA spacing. Ground pads shall be free of paint.

H. Ground bus: 1/4” x 2” (6 mm x 50 mm) continuous copper ground bus for entire length of enclosure. Bus shall be silver-plated at each joint position.

I. Control power: Provided by external 120 volt ac source. Control power shall provide all wetting voltage for incoming/outgoing signals between capacitor bank and external power factor controller, as well as power for space heaters, convenience receptacle, local LED lights, etc.

J. Ventilation:
   1. Provide adequate ventilation including permanently embossed louvers with baffling screens welded to enclosure interior to prevent insects, protrusions, or entry of No. 14 wire into enclosure while increasing airflow.
   2. Heat-rise:
      a. Determine additional ventilation requiring forced air (fans) for increased air circulation based on heat-rise calculations by manufacturer.
      b. Calculations shall be based on mVAR rating.
   3. Fans shall be rated to operate on ac volts.
   4. Unit filters shall be replaceable without de-energizing equipment.

K. Heaters and thermostats:
   1. Include proper number of heaters and thermostats to reduce effect of condensation within bank.
   2. Heater shall be rated to operate on ac volts.
L. Paint:
   1. The enclosure shall be prepared and painted with a high-solid epoxy coating as specified below. The paint shall be ANSI gray 61 – Munsell No. 8.3G 6.10/0.54.
   2. **Surface Preparation:** All steel surfaces shall be prepared per SSPC-SP2, 3, 6, 7, 10, 11 or the paint manufacturer’s recommendations. Exceptions to the manufacturer’s requirements shall be approved by the paint manufacturer and provided with the submittal documents.
   3. **Inaccessible Surfaces:** Prepare and coat steel surfaces inaccessible to preparation and coating after fabrication with all coats before fabrication. Inaccessible surfaces shall be considered Zone 2A per SSPC specifications.
   4. **Paint Specification:** All surfaces, inside and out, shall be coated with a High-Solid Epoxy Siloxane Marine paint with a dry film thickness of 2 to 3 mils.
   5. The paint utilized shall have the following properties:
      - Salt Spray (ASTM B117) 5500 Hours with no face blistering.
      - Humidity (ASTM D2247) 5500 Hours with no face corrosion or blistering.
      - Gloss retention (ASTM G53) QUV-B bulb: Greater than 50% gloss retention at 26 weeks.
      - Elongation (ASTM D5222) 14%.
      - Abrasion resistance (ASTM D4060) 1kg load/1000 cycles, CS-17 wheel: 53 mg weight loss.
      - Impact resistance (ASTM D2794): Direct 24 in.lb and Reverse 6 in.lb.
      - Adhesion, elcometer (ASTM D4541): 2700 PSI.
      - NFPA Class A Qualification.

   Paint shall also provide excellent chemical resistance to splash, spillage, fumes and weather for acidic, alkaline, salt solutions (acidic, neutral, and alkaline salt solutions), fresh water, solvents and petroleum product environments.

   6. Upon request, the manufacturer shall provide supporting documents (surface preparation procedures as well as paint manufacturer’s paint specifications) showing the above requirements are met. Failure to comply with this request will be cause for cancellation of order.

M. **External welds except roof welds** shall be ground and sanded; internal welds shall be wire-brushed.

N. **Labeling and markings:**
   1. Mark and label enclosure in accordance with IEEE/NEMA standards.
2. Affix labels identifying component compartments to exterior of enclosure. Labels shall be clearly visible with doors in open or closed position.
3. Labels shall meet ANSI/IEEE guidelines for extended exposure to elements.
   a. "Danger High Voltage" sign shall be attached on each door of capacitor bank enclosure.
   b. "Caution - Before Compartment Entry, Allow At Least (factory recommended time with minimum safety factor of 2) Minutes After De-energization for Capacitors to Discharge."
   c. "Ground Switch - Allow (factory recommended time with minimum safety factor of 2) Minutes For Capacitors To Discharge Before Operating"
   d. "Warning – Line-Side Energized When Switch Open" sign shall be attached on door of incoming disconnect section.
   e. “Danger - Equipment Supplied by Two (2) External Sources”.
   f. “Danger - Equipment Switching Controlled by External Source”.

O. Nameplate: Affix permanently stamped, noncorrosive nameplate to enclosure indicating:
   1. Nominal system voltage.
   2. Maximum design voltage.
   3. Basic insulation level.
   4. Continuous current rating.
   5. Fuse type.
   6. Fuse rating maximum.
   7. Fuse symmetrical ampere interrupting rating.
   8. Interrupting rating for each switch type.
  10. Customer code number.
  11. Date of manufacture.

2.07 CONTROL AND SECONDARY WIRING.

A. Wire: Stranded, tinned copper. Flame-resisting switchboard type, SIS No. 12 AWG minimum.

B. Accessories: Terminals, auxiliary devices, wiring troughs, and miscellaneous materials as required. Use ring-tongue or locking fork terminals.

C. Wiring termination shall facilitate connection of control, potential, and power supplies to high-side circuit breaker, transformer, and protective relaying.

D. Terminal blocks:
   1. Washer-head connecting screw type; General Electric EB-5, Westinghouse KCE, Cutler-Hammer 10987, or equal.
2. Mount terminal blocks on vertical surfaces; provide legible, permanent marking on terminals; plug-in or stab-type terminal blocks not acceptable.
3. Terminate current transformer secondary leads on short-circuiting type terminal blocks.

2.08 MIMIC BUS.
A. Provide on front of segregated control compartment section.
B. Type: 3/8" (10 mm) wide, phenolic, fastened with screws.
C. Color: Red.
D. Show disconnect switch, vacuum switch, reactors, capacitors, ground switch, and fuses.

2.09 SUPERVISORY CONTROL EQUIPMENT.
A. Power factor controller shall be SEL-351-7, externally located in 12.47kV switchgear cubicle supplying capacitor bank (controller supplied by switchgear manufacturer).
B. Provide switching controls on capacitor bank enclosure to allow capacitor bank to be locally or remotely controlled. In “Remote” operation, control will be by external controller. In “Local” operation, control will be by switching controls on capacitor bank enclosure.
C. Provide switching controls on capacitor bank enclosure to allow capacitor bank to be automatically or manually controlled, via Local/Remote switch. In “Remote” operation, control will be by external controller. In “Local” operation, control will be by selection of “On” or “Off” control. Local On/Off control shall be prohibited while in “Remote” operation and Remote control shall be prohibited while in “Local” operation.
D. Blown fuse detection of an individual stage shall immediately open and block closing of Vacuum Switches for that stage, regardless of “Remote/Local” control status. This shall be done by means of interlocking connections.
E. Provide terminal blocks to accommodate all incoming conductors between external controller (SEL-351-7 relay) and capacitor bank, in accordance with cable schedule. External wiring connections shall include:
   1. Outgoing signals to external SEL-351-7 power factor controller:
      a. 89G ground switch “a” status.
      b. 89D main disconnect “a” status.
      c. Stage 1 blown fuse indication.
      d. Stage 2 blown fuse indication.
      e. Stage 3 blown fuse indication.
f. Main blown fuse indication.
g. Key interlock status.
h. Stage 1 “on” indication.
i. Stage 2 “on” indication.
j. Stage 3 “on” indication.
k. Over temperature indication.
l. Local/remote status.
m. Note: Items a-l above shall all share a single “common” conductor routed to external controller.

2. Incoming signals from external SEL-351-7 power factor controller:
   a. Stage 1 open/close.
   b. Stage 2 open/close.
   c. Stage 3 open/close.
   d. Common alarm (to local red LED).
   e. Healthy indication (to local green LED).

F. Locate terminal blocks in auxiliary compartment.

G. Provide 24 spare terminals for future supervisory functions.

2.10 NAMEPLATES.
   A. Material: White plastic engraving stock, 1/16” (2 mm) thick with black core.
   B. Lettering: Engraved approximately 3/16” (5 mm) high.
   C. Wording: Prepared by manufacturer, subject to review by Engineer.
   D. Locations:
      1. Front of each unit.
      2. Each control switch.
      3. Each relay.
      4. Each set of low voltage fuses.
      5. Each ac circuit protective device.

PART 3 - EXECUTION

3.01 EXAMINATION.
   A. Verify site conditions.

3.02 PREPARATION.
   A. Clean interior and exterior of equipment prior to placing into service.
   B. Debris shall be removed an appropriately discarded.
3.03 INSTALLATION.
   A. Install in accordance with manufacturer’s recommendations.

3.04 FIELD QUALITY CONTROL.
   A. Perform filed tests required by manufacturer.
   B. Perform installation tests as required by relevant industry standards.
   C. Provide necessary testing facilities.

3.05 MANUFACTURER’S FIELD SERVICES.
   A. Provide manufacturer’s service representative(s) to supervise and/or check installation.
APPENDIX A
DATA SHEETS: METAL ENCLOSED CAPACITOR BANK
# DATA SHEETS
## METAL ENCLOSED CAPACITOR BANK

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
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<tr>
<td>Manufacturer</td>
<td>N/a</td>
<td>GE or equal (must be approved by)</td>
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<tr>
<td>Catalog/Serial No.</td>
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<tr>
<td>Ratings:</td>
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<tr>
<td>Nominal Line-to-Line Operating Voltage</td>
<td>kV</td>
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<tr>
<td>Maximum Line-to-Line Continuous Voltage</td>
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<td>System Grounding</td>
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<td>Capacitor Bank Grounding Configuration</td>
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<tr>
<td>Number of Stages</td>
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<td>Altitude Above Sea Level</td>
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<tr>
<td>Specific local Building Code and specific relevant sections used in equipment design.</td>
<td>...</td>
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Appendix A - Metal Enclosed Capacitor Bank Data Sheets

Page 53
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<thead>
<tr>
<th>DESCRIPTION</th>
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<th>SPEC DATA</th>
<th>VENDOR DATA</th>
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**Grounding Switch Rating:**

| Voltage | kV | 15          |
| Current | A  | By Manufacturer |

**Reactor Rating**

| Voltage | kV | By Manufacturer |
| Current | A  | By Manufacturer |
| Inductance | H | By Manufacturer |

**Surge Arrester Rating:**

| Class (Intermediate or Station) | - | Intermediate |
| Type                            | - | Metal-Oxide Varistor |
| MCOV Rating                     | kV | 15.3        |
| Duty Cycle                      | kV | 18          |

**Control Compartment Rating:**

| Control Voltage (ac or dc)     | - | 120Vac      |

**Unit Dimensions:**

| Height | ft. | By Manufacturer |
| Width  | ft. | 6               |
| Length | ft. | 12.75           |
Design Standard

Electric Motors

Detailed specifications follow.

PART 1 - GENERAL

1.01 SCOPE

A. This design guidelines contained herein include the requirements of electric motors utilized for electric motor driven systems at Texas A&M University. It is the intention of this document to provide a standard for electric motors at Texas A&M and to provide the highest level of quality and standardization possible; it is not intended to be a guide specification.

1.02 STANDARDS

A. Motors shall be designed, built, and tested in accordance with the latest revision of the following standard documents.

1. NEMA MG 1 - Motors and Generators
2. ANSI/IEEE 112 - Test Procedures for Motors / Generators
3. UL 1004 – Motors, Electric.
4. UL 674 – Motors, Generators, Electric, for Use in Hazardous Locations: Class I, Groups C and D; Class II, Groups E, F, and G.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Toshiba
B. Teco - Westinghouse
C. General Electric
D. Marathon

2.02 MOTORS LESS THAN ½ Hp:

A. Unless otherwise specified, motors less than 1/2 Hp shall be squirrel-cage, induction type, capacitor start with copper stator windings as the Standard low-horsepower motor.
B. Motors shall be continuously rated with 1.15-service factor for operation at 115 volts, single-phase, 60 Hz.

C. The driven load for constant speed applications shall not exceed the motor's continuous nameplate rating, exclusive of any service factor, under any normal operating condition.

2.03 MOTORS LARGER THAN ½ Hp THROUGH 250 Hp

A. Motors shall be 3-phase, continuously rated, squirrel-cage, random-wound copper, induction motors designed for 460 volt, 60 Hz operation. Provide motors rated for continuous operation with 1.15-service factor only.

B. Provide motors with Class F insulation and a Class B temperature rise based on 40°C ambient. When ambient temperatures exceed 40°C, temperature rise shall be adjusted according to MG 1-12. Locked Rotor Current: Provide motors with locked rotor starting currents not exceeding Code L under 3 hp, Code K for 3 and 5 hp, Code H for 7-1/2 and 10 hp, and Code G for 15 hp and above.

C. Provide motors meeting the energy efficiency and power factor requirements in section 3.01 of this document, when tested in accordance with NEMA MG 1-12.53a and IEEE Standard 112, Test Method B.

D. Provide motors rated for continuous operation with 1.15-service factor. For constant speed motors, the driven load shall not exceed the motor's brake horsepower nameplate rating, exclusive of any service factor, under any normal operating condition.

E. Provide all TEFC motors with anti-friction grease lubricated ball bearings, with a bearing AFBMA B-10 life of 100,000 hours, and sealed from the environment. Provide factory lubrication of all motors prior to shipment. Provide all motors with grease-lubricated bearings with relief fittings.

F. Provide all ODP motors with anti-friction grease lubricated ball bearings, with a bearing AFBMA B-10 life of 100,000 hours. Provide factory lubrication of all motors prior to shipment. Provide all motors with grease-lubricated bearings with all grease and relief fittings.

G. Provide motors with conduit boxes that are fully rotatable, diagonally split, including gasket between cover and box, and box and frame, with threaded hubs and a grounding lug located within the box for ground conductor connection. The conduit box shall be of a size to permit connections without undue crowding. All 3 phase motors with a specific voltage shall have 3 leads only.

H. Provide nameplates of stainless steel or other approved corrosion resistant material to provide a permanent legible marking, containing NEMA data plus
guaranteed minimum efficiency. Attach nameplates and connection plates to the motor frame by rivets or screws.

I. Variable torque, inverter duty rated motors shall be provided for variable speed applications.

J. All hermetic sealed motors shall be of the type recommended by the chiller Mfg.

2.04 MOTOR TYPES

A. The following Standard motor types shall conform to the following requirements:

1. **Horizontal Drip Proof**: Provide horizontal motors with an enclosure that meets NEMA Standard MG 1 for open, drip proof construction. Provide screen over all air openings.

2. **Horizontal Totally Enclosed Fan-Cooled**: Provide totally enclosed fan-cooled (TEFC) motors with frame sizes 182 and larger with cast iron frames and end shields. Smaller frame sizes may be constructed of rolled steel with cast metal end shields. Provide motors with condensate drain holes. For frame size 286 and larger, provide automatic breather/drain device in drain hole.

3. **Vertical Weather Protected Type I**: Provide vertical motors with an enclosure that meets NEMA Standard MG 1 for weather protected Type I (WP-I) enclosure. Provide screens over all air openings.

4. **Vertical Totally Enclosed Fan-Cooled**: Provide vertical motor with an enclosure identical to the requirements for the horizontal TEFC motors.

5. **Submersible**: Submersible motors UL listed for explosion proof atmospheres in accordance with subsequent sections of this specification. In addition, provide submersible motors with two mechanical seals; the lower one outside the motor and protecting the upper one, which is in an oil filled chamber. Provide moisture detector probes in the oil filled seal chamber to indicate the presence of moisture in the seal chamber. Provide a temperature detector and switch rated 3 amperes, 120 volts minimum, set to operate when the internal motor temperature exceeds a preset limit. Provide any relays or solid-state controls for separate mounting.

6. **Horizontal, Totally Enclosed, Fan-Cooled, Severe Duty**: Provide horizontal (TEFC), severe duty motors suitable for contaminated environments, including gasketed conduit box, stainless steel drains, and corrosion resistant paint.

7. **Vertical, Totally Enclosed, Fan-Cooled, Severe Duty**: Provide vertical (TEFC), severe duty motors with the requirements identical to horizontal (TEFC), severe duty motors, above.
2.05 MOTORS FOR USE WITH VARIABLE FREQUENCY DRIVES

A. Motor Application Considerations:

1. NEMA Standard MG1 definite purpose inverter duty rated motors shall be used for all IGBT Pulse Width Modulated drive installations. Inverter duty motors shall be designed and manufactured to meet NEMA Standard MG1 for definite purpose inverter duty motors. The inverter duty motors shall be able to withstand voltages greater than 1600 volts peak and rise times of 0.1 microseconds.

2. Applications where the motor specification does not meet NEMA MG1 Part 31 (1600V peak and 0.1 microsecond rise time), and the cable length between the inverter and motor exceeds the drive manufacturer recommended maximum cable length; load sideline reactors shall be used. The load sideline reactor shall be designed and constructed to operate with pulse width modulated IGBT inverter drives with switching frequencies up to 20 Khz. Line reactor insulation dielectric strength shall be greater than or equal to 4000 volts and shall carry a UL506 & UL508 approval.

3. Mfg. Standard grease shall be used for the inverter duty rated motors.

4. The inverter duty motor shall be constructed with triple film wire, increased winding slot insulation, increased insulation between phases, and increased first turn insulation. The inverter duty motor shall use slot fillers as required to avoid loose windings.

5. The inverter duty motor insulation class shall be class F insulation and a class B temperature rise based on 40°C.

6. The inverter duty motor nameplate shall indicate that the motor is an inverter duty motor.
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<th>Nominal Speed (rpm)</th>
<th>Percent Guaranteed Minimum Rated Load Efficiency</th>
<th>Percent Guaranteed Minimum Rated Load Power Factor</th>
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PART 4 - INSTALLATION

4.01 Coordinate with electrical designs.

4.02 Motors and associated devices shall be installed as per NEC requirements.
Design Standard

Electrical Manholes

Detailed specifications follow.

PART 1 - GENERAL INSTALLATION PROCEDURES

1.01 Manholes shall have a minimum of a 42" hole opening.
1.02 Ladder ups will be mounted in the center of every ladder.
1.03 All 600 amp T-bodies and 200 amp elbows will have test points.
1.04 All manholes will be clean at the completion of the project.
1.05 Stabilizing sand shall be used for installation of all manholes.
1.06 A minimum of 10 feet of rigid conduit with galvanized bell ends shall be required on each duct bank coming in and going out of the manhole.
1.07 All conduits shall be cut off flush with the wall in the manholes.
1.08 All electrical manhole covers shall be labeled with ‘ELECTRIC’ on the top of them.
1.09 All cables shall be labeled with feeder number and bldg. numbers, cables should be marked with red and blue marking tape to identify the phases.
1.10 All switches shall be anchor down and set so that it can be operated from manhole lid opening.
1.11 Any position on the switch that is not used shall have a bushing well insert on the switch and a dust cover on the bushing and shall be grounded.
1.12 Any terminations in the manhole shall be supported between the rack in the manhole and as close the wall as possible.
1.13 All empty ducts coming into manholes shall be sealed off.
1.14 All fire taping shall be wrapped with cloth taping (3M 77cloth tape).
1.15 All ducts shall be swapped before sealing or pulling cable and shall have a pull string in each conduit.
1.16 All racks shall be as high as possible in manhole.
1.17 All racks and rack arms shall be fiber glass.
1.18 Tie wraps shall be 3' in length and ½" in width.
1.19 Manhole lids shall be 4" above final grade.
1.20 Iron castings for manhole rings and covers shall conform to ASTM A48, Class 30, and be traffic rated.

PART 2 - MANHOLE DIAGRAMS

2.01 Precast concrete TAMU electrical manholes 8’ x 10’ x 8’ including thin-wall knockout, pull irons, sump box with grate, ground rod sleeve, “Safrail” fiberglass ladder, “Bilco” ladder up. 1 neck extension and a McKinley #SS381 ring and a ductile iron cover marked “ELECTRIC” cast bin to a 42” diameter precast concrete neck extension X21” high.
Provide ladder safety post and attach to ladder per manufacturer's instructions. Post shall be a Bilco hot dip galvanized steel model LU-2.

First ladder rung to be within 12" of top of neck ladder rail to extend 6' above first rung. Provide flat steps for ladder.

18" neck section minimum or as required to meet slope requirements in specification and grading shown on civil plans.

Finished grade to be sloped gently away from manhole opening to prevent runoff from entering manhole.

Heavy duty non-metallic vertical cable rack anchored to wall with stainless steel expansion bolts, typical.

Conduit entry as required typical.

Pulling eye typical.

Corrosion resistant ground bus cup.

Seal after ground rod is installed.

3/4" x 10'-0" ground rod.

Sump pit locate near ladder.

#2/O ground ring around inside of manhole 6".
PART 3 - MANHOLE CABELING

3.01 All cables are to be wrapped one time around manhole.

3.02 Every wall shall have two support racks mounted in order to support cable.

3.03 Zip tied down.

3.04 Fire taping shall be used from duct to the termination.

PART 4 - GROUNDING

4.01 All manholes shall have a minimum of two 5/8" by 10' grounding rods.

4.02 All switches and electrical equipment mounted in manholes shall be grounded.

4.03 The ladder shall be grounded.

PART 5 - SUMP PUMP

5.01 All manholes will have sump pumps installed in them.

5.02 Three 2" PVC pipe shall be used for sump pump circuit.

5.03 All manholes shall have a sump pit that is a minimum of 1 foot deep, and 18" x 18" in width and length with grate.

5.04 2" sump pump drainage PVC will be run to manhole lid with one way check valve with quick disconnect.
Design Standard

Electrical Safety

This document defines the UES electrical safety design standards in order to provide the safest, most efficient and reliable electrical equipment installations to Texas A&M University.

This document covers employee safety-related design concepts for electrical equipment and installations in workplaces related to or derived from NFPA 70E -2018. This document specifies design considerations that have impact on the application of the safety-related work practices only.

PART 1 - GENERAL

1.01 General Contractors, subcontractors or other contracted parties working for or on Texas A&M projects who have responsibility for facilities and installations having electrical energy as a potential hazard to employees and other personnel shall ensure that electrical hazard risk assessments are performed during the installations. The design A/E for all new building projects and renovation projects that involve electrical upgrades shall do breaker coordination to ensure that a fault within the building doesn’t trip gear upstream. The design engineer shall also complete an arc flash study and provide appropriate arc flash labels for building electrical equipment. TAMU Utilities and Energy Services will provide the design engineer with max and min fault current values to use in the calculations. ETAP is the TAMU standard and shall be used for all calculations. Equipment shall be labelled with this information as specified by NFPA 70E before being accepted by Texas A&M University. Labels shall be applied adjacent to the on/off switches or disconnects for devices or at the point of maintenance access. See label template on next page as an example. Any deviations from this basic format must be approved by TAMU UES.
1.02 Design option decisions shall facilitate the ability to eliminate hazards or reduce risk by doing the following:

A. Reducing the likelihood of exposure.

B. Reducing the magnitude or severity of exposure.

C. Enabling achievement of an electrically safe work condition.

1.03 INCIDENT ENERGY REDUCTION METHODS

A. The following methods have proved to be effective in reducing incident energy and shall be included as appropriate in final equipment and installation design:

1. Zone-selective interlocking. This is a method that allows two or more circuit breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault with no intentional delay. Clearing the fault in the shortest time aids in reducing the incident energy.
2. Differential relaying. The concept of this protection method is that current flowing into protected equipment must equal the current out of the equipment. If these two currents are not equal, a fault must exist within the equipment, and the relaying can be set to operate for a fast interruption. Differential relaying uses current transformers located on the line and load sides of the protected equipment and a fast acting relay.

3. Energy-reducing maintenance switching with a local status indicator. An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to operate faster while the worker is working within an arc flash boundary, as defined in NFPA-70E, and then to set the circuit breaker back to a normal setting after the work is complete.

4. Energy-reducing active arc flash mitigation system. This system can reduce the arcing duration by creating a low impedance current path, located within a controlled compartment, to cause the arcing fault to transfer to the new current path, while the upstream breaker clears the circuit. The system works without compromising existing selective coordination in the electrical distribution system.

5. Arc flash relay. An arc flash relay typically uses light sensors to detect the light produced by an arc flash event. Once a certain level of light is detected, the relay will issue a trip signal to an upstream overcurrent device.

6. High-resistance grounding. A great majority of electrical faults are of the phase-to-ground type. High-resistance grounding will insert an impedance in the ground return path and will typically limit the fault current to 10 amperes and below (at 5 kV nominal or below), leaving insufficient fault energy and thereby helping reduce the arc flash hazard level. High-resistance grounding will not affect arc flash energy for line-to-line or line-to-line-to-line arcs.

7. Current-limiting devices. Current-limiting protective devices reduce incident energy by clearing the fault faster and by reducing the current seen at the arc source. The energy reduction becomes effective for current above the current-limiting threshold of the current-limiting fuse or current limiting circuit breaker.

8. Shunt-trip. Adding a shunt-trip that is signaled to open from an open-fuse relay to switches 800 amperes and greater reduces incident energy by opening the switch immediately when the first fuse opens. The reduced clearing time reduces incident energy. This is especially helpful for arcing currents that are not within the current-limiting threshold of the three current-limiting fuses.

1.04 ADDITIONAL SAFETY-BY-DESIGN METHODS

A. The following methods have proven to be effective in reducing risk associated with an arc flash or shock hazard and shall be included as appropriate in final equipment and installation design:
1. Installing finger-safe components, covers, and insulating barriers reduces exposure to energized parts.

2. Installing disconnects within sight of each motor or driven machine increases the likelihood that the equipment will be put into an electrically safe work condition before work has begun.

3. Installing current limiting cable limiters can help reduce incident energy. Additionally, cable limiters can be used to provide short-circuit protection (and therefore incident energy reduction) for feeder tap conductors that are protected at up to 10 times their ampacity, a situation where the tap conductor can easily vaporize.

4. Installing inspection windows for noncontact inspection reduces the need to open doors or remove covers.

5. Installing a single service fused disconnect switch or circuit breaker provides protection for buses that would be unprotected if six disconnect switches are used.

6. Installing metering to provide remote monitoring of voltage and current levels reduces exposure to electrical hazards by placing the worker farther away from the hazard.

7. Installing Type 2 “no damage” current limiting protection to motor controllers reduces incident energy whenever the arcing current is within the current limiting threshold of the current-limiting fuse or current-limiting circuit breaker.

8. Installing adjustable instantaneous trip protective devices and lowering the trip settings can reduce the incident energy.

9. Installing arc-resistant equipment, designed to divert hot gases, plasma, and other products of an arc-flash out of the enclosure so that a worker is not exposed when standing in front of the equipment with all doors and covers closed and latched, reduces the risk of arc flash exposure.

10. Installing provisions that provide remote racking of equipment, such as remote-controlled motorized remote racking of a circuit breaker or an MCC bucket, allows the worker to be located outside the arc-flash boundary. An extended length hand-operated racking tool also adds distance between the worker and the equipment, reducing the workers exposure.

11. Installing provisions that provide remote opening and closing of circuit breakers and switches could permit workers to operate the equipment from a safe distance, outside the arc flash boundary.

12. Class C, D, and E special purpose ground fault circuit interrupters exist for circuits operating at voltages outside the range for Class A GFCI protection. See UL 943C for additional information.
Design Standard

Emergency Generator Systems

This standard was revised on December 20, 2017, and the latest changes are underlined. Please refer to Part 6 of this standard for full revision history.

Detailed specifications follow.

PART 1 - GENERAL

1.01 This specification covers requirements for a complete and operable Emergency/Standby electric Generating system, including all devices and equipment specified herein, shown on the drawings, and/or required for the service. Materials and equipment shall be new, and delivered to the job site completely wired, tested and ready for installation. The system shall include the following:

A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator. Outdoor generator shall be housed in a weatherproof enclosure.

B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.

C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

D. Drawings and General provisions of Contract, including General and Supplementary Conditions, and Division 1 specification sections, apply to this and the other sections of Division 16. - Code for Safety to Life from fire in Buildings and Structures.

E. Mounted and loose accessories, including skid mounted 24 hour (minimum) fuel tank at full load, batteries and battery charger, remote annunciators, exhaust mufflers, control devices, and other equipment as specified herein.

F. Other components, accessories, parts, tests, documents, and services as needed to meet the performance requirements of this specification.

G. The manufacturer shall insure that the Owner will be able to obtain any required Air Quality Management District, AQMD permits for the emergency standby system.
H. The generator system and the enclosure shall be selected and the installation made in a manner to minimize operating noise levels as much as possible and remain under the maximum dB levels as dictated by the local authority having jurisdiction. Consult with specifying engineer if special acoustic housing is required.

I. The alternate power source can supply emergency loads as well as other loads. However, the emergency system transfer switch is limited to supplying emergency loads. Legally required standby loads or optional standby loads require separate transfer switches.

1.02 CODES AND STANDARDS

A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards:

2. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
3. NFPA37 – Installation and use of stationary combustion engines and gas turbines
4. ANSI/NEMA MG1 Motors and Generators and MG2 Safety and Use of Electric Motors and Generators
5. NFPA70 – National Electrical Code: Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702
8. NFPA 110 - System Performance for Level One installation
9. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

B. The generator set and supplied accessories shall meet the requirements of the following standards:

1. NEMA MG1. Alternator shall comply with the requirements of the current version this standard as they apply to AC alternators.
2. UL142 – Sub-base Tanks
3. UL1236 – Battery Chargers
4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.

5. NEMA Standard Publication 250 – Enclosures for Electrical Equipment

C. The control system for the generator set shall comply with the following requirements.

1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.


3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.

4. FCC Part 15, Subpart B.

5. IEC8528 part 4. Control Systems for Generator Sets

6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.

7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.

D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

E. Local Code Compliance – Comply with all applicable local code requirements of the authority having jurisdiction.

1.03 SUBMITTALS

The following information shall be submitted for this project:

A. A complete review of this specification, noting for each paragraph whether or not the proposed equipment complies with the project specifications, or deviates in some fashion. For each deviation, a justification for that deviation must be given.

B. Outline drawings of the equipment showing overall dimensions, power and control wiring entrance locations, breaker sizes and locations, lug sizes, and front panel drawings showing all devices to be provided. Each device shall be referenced to a material list with a complete description for the device. Complete details of the proposed enclosure shall be included.

C. Estimated fuel consumption at rated load.

D. Interconnection detail drawing showing all related field control and power connections in the entire emergency / standby system. Differentiate between portions of wiring that are manufacturer installed and portions that are field installed.
E. Literature, describing in detail, the equipment proposed, and all possible operating modes.

F. Complete test specification detailing the testing procedure to be used to verify the performance of the equipment provided.

G. The manufacturer shall provide at least two complete set of operation manuals for the proposed equipment, at the time of the submittal for the engineer's review and approval.

H. Provide a list and separate price for the maintenance tools and spare parts required to maintain the generating set.

I. Schedule indicating the system delivery date, submission date for the shop drawings, installation drawings, Factory and Site Acceptance Test Procedures, and O&M manuals.

J. Upon completion of the onsite testing, a complete set of "as built" drawings shall be furnished for the emergency system, consisting of the following.

1. Equipment outline, showing front and side plan views, electrical power one line diagram, conduit entrances, and equipment ratings.

2. Schematic & Wiring drawings.

3. Interconnection wiring diagram, showing all field interconnections between generator set, panelboards, and other remote devices (such as transfer switches if applicable, annunciators, and day tanks).

4. Material list cross-referenced to schematics for component identification.

5. Narrative sequence of operation description, detailing all possible operating modes.

   a. All equipment drawings shall specifically show the interface between the automatic transfer switches, generator set, and remote devices. Standard or typical drawings are not acceptable.

   b. Operator's manuals shall be provided for the emergency power system which include all the information noted above, plus troubleshooting guidelines, spare parts data, final test certificates and maintenance instructions.

   c. Operator's manuals shall be specific to the project. Standard or typical, pre-printed manuals will not be acceptable.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The emergency standby electrical generating system equipment shall be the standard of a single manufacturer. It shall be factory-built, tested and shipped by this single manufacturer. Subject to compliance with requirements, provide products by the following:
1. Caterpillar
2. Stewart & Stephenson
3. Kohler

B. The manufacturer shall have a minimum ten years of successful operating experience with the rating of the equipment being proposed.

C. Technical Support: The manufacturer shall provide factory-trained service and parts support through a factory authorized distributor or dealer that is regularly doing business in the area of the installation.

D. Single Supplier: The supplier shall be the system manufacturer’s authorized local representative, who shall provide initial start-up services and be responsible for conducting field acceptance testing. The supplier shall have 24-hour service availability. The supplier shall have factory-trained service technicians who are qualified to isolate and correct any typical malfunction of the engine, generator, voltage regulator system control, fuel day tank system, and implement repair.

2.02 PRODUCT SPECIFICATION

A. Diesel Engine-Generator Set

The outdoor type AC engine-generator set shall be rated by the manufacturer for continuous standby operation as specified by the following rating:

1. Ratings:
   The generator set shall operate at 1800 rpm and at a voltage of:
   ___________ Volts AC, Three phase, __________-wire, __________ hertz.
   The generator set shall be rated at ___________ kW, ___________ kVA at 0.8 PF, __________ rating, based on site conditions of: Altitude 400ft., ambient temperatures up to 120 degrees F

2. Performance:
   a. The generator set manufacturer shall verify the diesel engine is capable of driving the generator with all accessories in place and operating, at the generator set kW rating.
   b. The generator set manufacturer shall verify the diesel engine is capable of driving the generator with all accessories in place and operating, at the generator set kW rating.
   c. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random Voltage Variation: the cyclic variations in RMS voltage shall not exceed 0.5% of rated voltage for constant loads from
no load to rated load, with constant ambient and operating temperature.

d. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random Frequency Variation: speed variations for constant loads from no load to rated load shall not exceed 0.25% of rated speed, with constant ambient and operating temperature.

e. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Balanced Telephone Interference Factor (TIF) shall not exceed 50 per NEMA MG1-22.43.

f. The diesel engine-generator set shall be capable of picking up 100% of nameplate kW and pf in one step with the engine-generator set at the specified operating temperature, in accordance with NFPA Standard 100, Paragraph 5-13.2.6.

g. For parallel generators: The generator set shall share real and reactive load proportionally within plus or minus 3% with all other generator sets in the system.

h. For parallel generators: The time required to automatically start, accelerate to rated speed and voltage, synchronize and parallel all generator sets to the system bus on a normal power failure shall not exceed 15 seconds.

i. Motor starting capability shall be a minimum of 50% of rated kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.

j. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.

k. The generator shall be capable of start-up and accepting rated load within 10 seconds.

3. Construction

a. The engine-generator set shall be mounted on a heavy duty steel base to maintain proper alignment between components, and each set shall incorporate vibration isolators of the type and quantity as specified by the set manufacturer, whether mounted internally or externally.
b. All switches, lamps, and meters in the control system shall be oil tight and dust tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

4. Connections

a. The generator set load connections shall be composed of tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings.

b. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.

c. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

B. AC GENERATOR, REGULATOR AND EXCITER

The AC generator, exciter and voltage regulator shall be designed and manufactured by the engine-generator set manufacturer as a complete generator system.

1. The AC generator shall be synchronous, four pole, revolving field, drip proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc(s).

a. The armature shall have skewed laminations of insulated electrical grade steel, two-thirds pitch windings.

b. The rotor shall have amortissuer (damper) windings; layer wound mechanically wedged winding construction. The rotor shall be dynamically balanced.

c. The exciter shall be brushless, three phase, with full wave silicon diodes mounted on the rotating shaft and a surge suppressor connected in parallel with the field winding. Field discharge resistors shall not be acceptable. Systems using three-wire solid-state devices (such as SCRs or transistors) mounted on the rotor shaft shall not be acceptable.

2. AC output leads shall be brought out to field connection bus bars accessible through removable plates on either side of a sheet metal output box.

3. All insulation system components shall meet NEMA MG1 standard temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees
Centigrade to provide additional allowance for internal hot spots and superior generator performance. The main generator and exciter insulation systems must be suitably impregnated for operation in severe environments for resistance to sand, salt and sea spray.

4. A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator for immunity from voltage distortion caused by nonlinear SCR controlled loads on the generator. The PMG shall sustain main field excitation power for optimum motor starting and to sustain short circuit current for selective operation and coordination of system overcurrent devices. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

5. The automatic voltage regulator shall be temperature compensated, solid-state design and include overvoltage and over excitation protection functions. The voltage regulator shall be equipped with three phase RMS sensing.

6. The regulator shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. Overvoltage protection shall sense the AC generator output voltage and in the event of regulator failure or loss of reference, shut down regulator output on a sustained overvoltage of one (1) second duration. Both overvoltage and over excitation protection shutdowns shall be latched, requiring the AC generator to be stopped for reset.

7. The generator shall be capable of operating with a load exceeding 35% total current harmonic distortion. The manufacturer shall provide certification of generator harmonics tolerance. The most significant harmonics are the fifth, seventh, eleventh and thirteenth.

8. The subtransient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.

9. The alternator shall be capable of operation with at least 0.15 per unit reverse kVAR.

10. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

C. ENGINE GENERATOR SET CONTROL

The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local and remote monitoring and control of the generator set.
The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The generator set mounted control shall include the following features and functions:

1. Control Switches
   a. Mode Select Switch: The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
   b. EMERGENCY STOP switch: Switch shall be Red "mushroom head" push button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
   c. RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
   d. PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

2. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
   a. Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0 90% of generator set standby rating: green; readings from 90 100% of standby rating: amber; readings in excess of 100%: red.
   b. Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW hours, and power factor. Generator output voltage shall be available in line to line and line to neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.
   c. Both analog and digital metering are required. The analog and digital metering equipment shall be driven by a single microprocessor, to provide consistent readings and performance.
3. Generator Set Alarm and Status Display
   a. The generator set shall be provided with alarm and status indicating lamps to indicate non automatic generator status, and existing warning and shutdown conditions. The lamps shall be high intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:

   - low oil pressure (alarm)
   - low oil pressure (shutdown)
   - oil pressure sender failure (alarm)
   - low coolant temperature (alarm)
   - high coolant temperature (alarm)
   - high coolant temperature (shutdown)
   - engine temperature sender failure (alarm)
   - low coolant level (alarm or shutdown--selectable)
   - fail to crank (shutdown)
   - fail to start/overcrank (shutdown)
   - overspeed (shutdown)
   - low DC voltage (alarm)
   - high DC voltage (alarm)
   - weak battery (alarm)
   - low fuel-daytank (alarm)
   - high AC voltage (shutdown)
   - low AC voltage (shutdown)
   - under frequency (shutdown)
   - over current (warning)
   - over current (shutdown)
   - short circuit (shutdown)
   - ground fault (alarm)
over load (alarm)
emergency stop (shutdown)

In addition, the control shall display all warning and shutdown message produced by the electronic engine control module.

b. Provisions shall be made for indication of four customer specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

4. Engine Status Monitoring.
   a. The following information shall be available from a digital status panel on the generator set control:
      - engine oil pressure (psi or kPA)
      - engine coolant temperature (degrees F or C)
      - engine speed (rpm)
      - number of hours of operation (hours)
      - number of start attempts
      - battery voltage (DC volts)

   b. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

5. Engine Control Functions.
   a. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods. Two means of cranking termination shall be provided, one as a backup to the other. Failure to start after three cranking cycles (75 seconds) shall shut down and lockout the engine and visually indicate an overcrank shutdown on the panel.

   b. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

   c. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted
elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

d. The control system shall include time delay start (adjustable 0 300 seconds) and time delay stop (adjustable 0 600 seconds) functions.

e. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

f. For paralleled generators: The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this contract. The generator set supplier shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.

6. Alternator Control Functions:

a. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from mis-operation due to load induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulator shall be full wave rectified design. The voltage regulation system shall be equipped with three phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58 59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers or for system adjustments are not acceptable.

b. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. Performance of this function shall be 3rd party certified.
c. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. Performance of this function shall be 3rd party certified.

d. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

e. A line to neutral AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

f. The control System shall include a ground fault monitoring relay. The relay shall be adjustable from 3.8 1200 amps, and include adjustable time delay of 0 10.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay that will function correctly in system as installed.

g. For paralleling applications: The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

7. The generator set shall be provided with a network communication module to allow MODBUS over Ethernet and RS485/232 communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.

a. Control Interfaces for Remote Monitoring:

1) All control and interconnection points from the generator set to remote components shall be brought to a separate connection
box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

2) Form "C" dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.

3) One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

4) A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

5) A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

D. ENGINE

The diesel engine shall be designed specifically for generator set duty. The engine shall be four cycle, fan cooled, #2 diesel fueled, direct injection, with forged steel crankshaft and connecting rods. The cylinder block shall be cast iron with replaceable wet liners, and have four valves per cylinder. Design shall be turbocharged and after-cooled where required by the generator set manufacturer. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories.

1. An electronic governor; consisting of a magnetic pickup speed sensor, adjustable electronic control, and an electric actuator mounted integrally with the fuel pump, shall provide automatic engine-generator set frequency regulation adjustable from isochronous to 5% droop. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.

2. The engine shall be cooled by a skid-mounted closed loop radiator system including belt-driven pusher fan, coolant pump and thermostat temperature control. The cooling system shall be rated for full rated load operation in ambient conditions as specified in the attached Data Sheet. The cooling capability of the generator set shall be demonstrated by prototype tests on a representative generator set model. The generator set manufacturer will
conduct these tests; calculated data from the radiator manufacturer only is not sufficient.

3. Skid mounted radiator and cooling system rated for full load operation in 120 degrees F ambient as measured at the generator air inlet, based on 0.5 in H2O external static head. Radiator shall be sized based on a core temperature which is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment.

Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with a 50/50-ethylene glycol/water mixture by the equipment manufacturer. Rotating parts shall be guarded against accidental contact.

E. ENGINE ACCESSORY AND FEATURES

The engine generator set shall include the engine accessories as follows

1. An electric starter(s) capable of three complete cranking cycles without overheating before overcrank shutdown (75 seconds).

2. Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil indicator.

3. Engine driven, mechanical, positive displacement, redundant fuel pumps. Primary and secondary fuel filters with replaceable spin-on canister elements.

4. Replaceable dry element air cleaner with restriction indicator.

5. Flexible fuel lines, supply and return. A means for hand priming the engine shall also be provided.

6. Engine mounted battery charging alternator, 45 ampere minimum, and solid-state voltage regulator.

F. BASE

The engine-generator set shall be mounted on a heavy duty steel base to maintain proper alignment between components. The engine-generator set shall incorporate a battery tray with battery hold down clamps within the base rails. Provisions for stub up of electrical and fuel connections shall be within the footprint of the generator set base rails.
Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.

G. GENERATOR SET AUXILIARY EQUIPMENT

1. Engine mounted thermostatically controlled, coolant and engine heater(s). The heater(s) shall be sized according to site conditions. The contractor shall provide a branch circuit to the heater. The heater shall be U. L. 499 listed and labeled.

   a. The coolant heater shall be installed on the engine with high temperature silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using quick disconnect couplers to isolate the heater for replacement of the heater element. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.

   b. The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.

   c. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100F (40C) in a 40F ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.

2. Exhaust muffler(s) shall be provided for each engine, size and type as recommended by the generator set manufacturer. The mufflers shall be critical grade. The supplier shall mount the mufflers so the engine does not support their weight.

   a. The equipment supplier shall provide stainless steel seamless flexible exhaust connections for installation as required for connection between the engine exhaust manifolds and exhaust line in compliance with applicable codes and standards.
b. The supplier shall provide an exhaust system condensation trap with manual drain valve to trap and drain off exhaust condensation and to prevent condensation from entering the engine.

c. The supplier shall provide a suitable rain cap at the stack outlet with all necessary flanges and fittings for proper installation.

d. The supplier shall install all exhaust components as shown on the drawings, if applicable, and as required to comply with NFPA 37 and local codes and regulations. Components shall be sized to assure full load operation without excessive back pressure when installed as shown on the drawings, if applicable. Make provisions as required for pipe expansion and contraction. Also, provide covering for all indoor exhaust piping with a proper insulation material in a manner not to interfere with flexible exhaust connections.

H. SYSTEM AUXILIARIES

1. Starting and Control Batteries: 12VDC or 24VDC starting batteries sized as recommended by the generator set manufacturer, shall be supplied for the generator set with battery cables and connectors. The batteries shall be capable of performing the crank/rest cycles at temperatures of 10 degree F.

2. Provide 10 amp battery charger for generator set starting batteries.

   a. Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.

   b. The charger shall be compliant with UL991 requirements for vibration resistance.

   c. The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; EN61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.

   d. The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.

   e. The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge
rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.

f. The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.

g. The charger shall include the following features:

1) Two-line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming.

2) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red).

3) AC input overcurrent, over voltage, and undervoltage protection.

4) DC output overcurrent protection.

5) Alarm output relay; individual form C contacts rated at 4 amps, 120 VAC, 30 VDC for remote indication of

6) Corrosion resistant aluminum enclosure.

3. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.

4. Grounding Pads: Two non-corrosive, stainless steel grounding pads shall be welded to the alternator. The pads shall be located diagonally opposite one another.

5. Remote Annunciator:

a. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems; and in addition shall provide indications for high battery voltage, low battery voltage, loss of normal
power to the charger. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator.

b. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2.

6. Exhaust Silencer Mounting: The engine-generator supplier shall mount a critical grade silencer inside the enclosure. The silencer and exhaust pipe shall be properly insulated with heat resistant material to prevent damage or impairment to the system or enclosure.

7. Ductwork: The engine-generator supplier shall install a galvanized air discharge duct, with flexible section between the engine radiator and the exhaust louver.

8. Fuel Tank: Provide a dual wall sub base fuel storage tank with capacity to run engine at rated load for 24 hours. The tank shall be constructed of corrosion resistant steel and shall be UL142 listed. The equipment, as installed, shall meet all local and regional requirements for above ground tanks.

a. The tank shall be made of steel. In applications utilizing daytanks incorporate an integral fuel pump with 20 foot lift. The pump control shall be provided with On/Off/Emergency Run Switch, Test/Reset Switch, AC Circuit Breaker, DC Circuit Breaker, and Indicator lamps:

Ready (green) - AC supply & DC control power available.
High Fuel (red) - Latching fault, indicates fuel level near overflow, shuts down pump, and closes N/O dry contacts.
Low Fuel (red) - Latching fault, indicates pump failure or operating float switch failure, Closes N/O dry contacts.
Low Fuel Shutdown (red) - Latching fault, indicates near empty tank, closes N/O contacts which may be used to shutdown generator set to avoid air in the injection system.
Overflow to basin (red) - Latching fault, indicates fuel in overflow/rupture basin, shuts down pump, closes N/O dry contacts.
Spare (red) - with N/O and N/C dry contacts
Pump Running (green)

b. Contacts for the noted conditions shall be provided, and rated not less than 2 amps at 30VDC and 0.5 amps at 120VAC.

I. LOAD BANKS

In order to comply with NFPA 110 for minimum loading during routine maintenance tests, all generator sets shall be equipped with a permanent load bank, either freestanding or radiator mounted, that is 50% the nameplate kW rating.

1. (Radiator Mounted)
   a. Operational ratings and limitations as follows:
      1) Capacity: _______ KW (400KW maximum), 1.0 power factor.
      2) Voltage: 480V AC, 3-phase, 3-wire.
      3) Frequency: 60 Hertz.
      4) Load Steps: KW step resolution.
      5) Duty Cycle: Continuous.
      6) Temp. Rating: 180°F max. air intake temp. 60°-100°F nominal air temp. rise.
      7) Airflow Required: Radiator air outflow.
      8) Altitude: 5500’ (higher, contact Simplex).

   b. Principle systems and components as follows:
      1) Load Elements: Tubular type, weatherproof, totally enclosed, UL listed.
      2) Load Control: Branch circuit magnetic contactors.
      3) Element Short Circuit Protection: Branch circuit fuses. Fuses are 200KAIC, 600V, current limiting.
      4) Power Wiring: 150°C, insulated, color coded.
      5) Power Connection: Barrier type power distribution block with line side compression terminals.
      6) Control Wiring: 16AWG, 105°C.
7) Overheat Protection: Sensor to detect high exhaust air temp above 300°F. Circuits to disconnect load bank on overtemp. Alarm contacts.

8) Enclosure: Type 1, Galvanized Steel Construction, Designed for permanent installation by mounting, (pick: Directly to engine radiator, Within radiator air outflow duct, On inside of wall over radiator air outlet, On outside of wall over radiator air outlet.

c. Load bank control: Local
   1) Manual
   2) Control panel with control power on-off push-buttons master load control switch, load step switches, overtemp indicator, normal operation indicator. Internal control circuit and input terminals to dump load bank off-line on opening of remote control contacts.

2. (Freestanding Load Bank)

   a. Scope
   1) This specification contains the minimum requirements for the design, manufacture and testing of a UL listed, air-cooled, outdoor weatherproof resistive load bank.
   2) The load bank is required for periodic exercising and testing of the (standby) emergency power source. The load bank shall be permanently mounted in a weatherproof enclosure, forced air cooled with locally mounted control panel.
   3) The equipment covered by this specification shall be designed with the latest applicable NEMA, NEC, and ANSI standards.

   b. Ratings
   1) The total capacity of the load bank shall be rated (_______) KW at (_____ ) Volts, 3-Phase, 3-Wire, 60 Hertz, (_______) Amps per Phase at unity Power Factor and (___) KW minimum load step resolution.
   2) The load bank shall be designed for continuous duty cycle operation with no limitations. The load bank shall operate in an ambient temperature of -28°C to 49°C (-20°F to 120°F).

   c. Material and Construction
   1) The load bank shall be outdoor weatherproof construction, suitable for installation on a concrete pad or structural base. All exterior fastenlers shall be stainless steel. The load bank shall include forklift channels in the base for lifting.
2) The load bank shall be constructed of heavy gauge aluminized steel per ASTM A463. Aluminized steel provides superior corrosion protection and extended service life, with a better tolerance to high heat exposure compared to the more common Galvanized steel.

3) The main input load bus, load step relays, fuses and blower/control relays shall be located within the load bank enclosure. A thermostatically controlled heater shall be located within the control section to provide protection to the control devices from the effects of moisture and condensation.

4) Airflow throughout the load bank shall be vertical (>500 kW) or horizontal (<500 kW).

d. Resistive Load Elements

1) Load elements shall be Avtron Helidyne™, helically wound chromium alloy rated to operate at approximately ½ of maximum continuous rating of wire. Elements must be fully supported across the entire length within the air stream by segmented ceramic insulators on stainless steel rods. Element supports shall be designed to prevent a short circuit to adjacent elements or to ground.

2) The overall tolerance of the load bank shall be –0% to +5% KW at rated voltage. A –5%, +5% rating allows the load bank to deliver less than rated KW and shall not be used. The load bank must deliver full rated KW at rated voltage.

e. Cooling

1) The load bank shall be cooled by integral TEFC or TEAO motor(s) which is direct coupled to the cooling fan blade. The fan motor must be electrically protected against overload using a motor overload device and short circuit protected using three (3) current limiting fuses with an interrupting rating of 200K A.I.C.

2) An integral control power transformer shall be provided to supply 120V, 1 phase, 60 Hz to the load banks control and motor starter circuitry. Transformer primary and secondary control circuits shall be fuse protected.

f. Protective Devices

1) A differential pressure switch(s) shall be provided to detect air loss. The switch(s) shall be electrically interlocked with the load application controls to prevent load from being applied if cooling air is not present.
2) An over-temperature switch shall be provided to sense the load bank exhaust in each vertical heater case assembly. The switch shall be electrically interlocked with the load application controls to remove load from being applied in the event of an over temperature condition.

3) To provide for major fault protection, branch fuses shall be provided on all three phases of switched load steps above 50KW. Branch fuses shall be current limiting type with an interrupting rating of 200K A.I.C.

4) The exterior of the load bank shall have appropriate warning/caution statements on access panels.

g. Control Panel

1) The control panel shall be a locally mounted panel housed in a NEMA 4 type enclosure. The control panel shall contain the following manual controls:
   a) Power ON/OFF switch.
   b) Blower START/STOP pushbuttons.
   c) Master load ON/OFF switch.
   d) Load step switches for ON/OFF application of individual load steps.

2) Control panel visual indicators shall be as follows:
   a) Power ON indication light.
   b) Blower ON light.
   c) Blower/Air FAILURE light.
   d) OVERTEMPERATURE light.

3) A standard remote load dump circuit shall be provided as part of the load bank control circuit. Provisions shall be provided to remove the load bank off-line from the operation of a remote normally closed set of auxiliary contacts from a transfer switch or other device. In the event of the remote contact opening, all load is removed.

h. Qualifications of Manufacturer.

1) The load bank shall be manufactured by a firm regularly engaged in the manufacture of load banks and who can demonstrate at least twenty-five (25) years experience with at least twenty-five (25) installations of load banks similar or equal to the ones specified herein.
2) The load bank shall be as manufactured by Simplex or Avtron, no substitutions.

J. Enclosure

1. An outdoor enclosure shall be provided for the engine-generator set. The enclosure shall be sized for the exact unit being installed and include all necessary auxiliary equipment needed for operation of the emergency standby system described herein.

2. Enclosure overall acoustical performance should be XX dB(A) @ XX feet.

3. The enclosure shall be of the welded and bolted design, with all fabricated steel parts conforming to ASTM 569, specification C-1018 and all structural steel conforming to ASTM A36. All parts are to be individually prepped and primed prior to assembly.

4. Roof: The roof shall be of the tapered design for moisture runoff, with 12 gauge steel roof members and 16 gauge steel roof panels. Lifting eyes shall be supplied. The exhaust outlet shall be supplied with a steel ring above the roof line to prevent moisture from entering the enclosure.

5. Walls: The wall shall be a minimum of 14 gauge steel.

6. Base: The base of the enclosure shall be designed for a drop-over installation, and shall include a means for fastening to a concrete slab. The drop-over style shall include a fabricated channel construction perimeter. Provide an alternate grate for a portable enclosure.

7. Louvers: The air openings shall include fixed louvers sized to allow proper air flow. The frames shall be manufactured of 14 gauge steel, the blades 14 gauge steel, and the fronts shall be covered with 14 gauge expanded steel screen.

8. Doors: Adequate doors shall be installed for sufficient access. Single doors shall be a minimum of 30" wide. Double doors shall be a minimum of 60" wide. Doors shall include stainless steel hinges with brass pins, rain rail moldings above all door openings, recessed, keyed, chromed handles with positive locking assemblies, and fully weather-stripped. Doors shall be removable and lockable and have panic hardware.

9. Paint: All seams shall be caulked with body sealer. Enclosure shall be metal prepped, primed with two coats of self-etching primer and finished with two coats of weather grade paint of a color matching owner’s requirement. Default color shall be Aggie Power Plant Tan (Sherman Williams SW 6114 Bagel).
PART 3 - OPERATION

3.01 Sequence of Operation

A. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control and a redundant signal over the required network connection.

B. The generator set shall complete a time delay start period as programmed into the control.

C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:

1. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.

2. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.

3. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.

D. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.

E. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.

F. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.

1. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.
PART 4 - EXECUTION

4.01 Testing and Quality Control

A. To provide proven reliability of the system, three series of tests shall be performed: Prototype Model Tests, Production Model Tests, and Field Tests. The manufacturer shall provide documentation demonstrating satisfactory prototype and production test results.

1. Factory Prototype Model Tests: The electrical generating system consisting of prime mover, generator, governor, coupling and all controls must have been tested as complete unit on representative engineering prototype model as required by NFPA 110-1985. The tests, being potentially damaging to the equipment tested, must not be performed on equipment to be sold, but on separate prototype models as specified by NFPA 110-1985, paragraph 3-2.1 through 3-2.1.2 and their accomplishment certified by means of documentation of the tests accompanying submittal data. These tests shall have included:

a. Maximum power level (maximum kW).

b. Maximum motor starting capacity (maximum KVA) and voltage dip recovery within seven (7) cycles of applied load.

c. Structural soundness (Short Circuit and Endurance Test).

d. Torsiograph Analysis: The manufacturer of the engine-generator set shall verify that the engine-generator combination, as configured, is free from harmful torsional stresses. The analysis shall include correlation of empirical data from test on a representative prototype unit. The empirical data must include spectrum analysis of the torsional transducer output within the critical speed range of the generator set. Results of this analysis shall be made available on submittal. Calculation based on engine and generator separately are not acceptable.

e. Engine-generator cooling air requirements.

f. Transient response and steady-state speed control and voltage regulation.

g. Generator temperature rise per NEMA MGF1-22.40.

h. Harmonic analysis and voltage wave form deviation per MIL-STD-705B, method 601.4.

i. Three-phase short-circuit test for mechanical and electrical strength, with system operating at rated volts, amps, power factor, and speed. The generator set must build up and perform normally without manual interventions of any kind such as resetting of circuit breakers or other tripping devices when the short circuit is removed.
j. Failure mode test for voltage regulator. With engine-generator set operating at no load, rated speed and voltage, the AC sensing circuit to the regulator must be disconnected for a period of at least one hour. The engine-generator set must be fully operative after the test, and without evidence of damage.

k. Endurance testing is required to detect and correct potential electrical and mechanical problems associated with typical operation.

2. Factory Production Model Tests:

   Before shipment of the equipment, the engine-generator set shall be tested under rated load and power factor for performance and proper functioning of control and interfacing circuits. Testing at unity power factor only is not acceptable, since kilowatt output is affected by the higher generator efficiency at unity power factor, and the KVAR for motor starting and regulation loads varies with power factor. Test shall include:

   b. Transient and voltage dip responses and steady state voltage and speed (frequency) checks.
   c. Fuel consumption (No load, 25% load, 50% load, 75% load, and Full load).
   d. Generator temperature rise by resistance method.
   e. The Engineer shall have the option of witnessing these tests. A summary of the test results shall be available for submittal.

3. On Site Field Acceptance System Testing:

   The manufacturer of the standby diesel engine generator shall furnish a service engineer or engineers, who is, or are, expert in the installation of the emergency system, and shall make the initial start and complete the field testing of the equipment at the Site. The following are requirements in performing the field test:

   a. The generator controls manufacturer shall provide services of an engineer at the site as requested during the test and during any additional period of time needed to correct any deficiencies to the satisfaction of the Owner and Engineer. Conduct run test at site using certified laboratory recording instruments and maintain hourly written records of tests. The records shall include ampere, voltage and frequency and the engine and generator temperatures.

   b. All tests shall be run consecutively. The engine generator supplier shall furnish all facilities and equipment, including electrical load for load tests, which shall be capable of being switched in 20 kW increments from zero to full load.
c. The on site testing shall be done only in the presence of the Electrical Engineer, and the Owner or his authorized representative.

d. Failure of any component or System shall require the component to be replaced or repaired. At the option of the Engineer, the entire system shall be retested.

e. Provide all necessary testing equipment, cabling for temporary connections and other equipment necessary to complete the testing procedures.

f. All testing of the equipment shall be conducted at a time scheduled by the Owner. The Owner shall be given two weeks notice before any testing is scheduled. The schedule must be approved by the Owner prior to testing.

g. The following tests and inspection shall be performed on the engine Generator Assembly at the site:

1) Inspect for physical damage.

2) Compare nameplate rating and connection specifications and single line diagram.

3) Inspect for proper anchorage and grounding. Verify cooling and fuel system integrity.

4) Initial equipment start-up and operation will completed by the manufacturer’s representative.

5) Protective relay devices shall be tested to determine proper operation.

6) Engine shutdown features shall be function tested under the following conditions:
   - Low oil pressure, Over-temperature, Over-speed, Other features as applicable

7) Perform voltage and frequency transients’ test for 100% and 50% load step addition and subtraction showing compliance with these specifications. Use an oscillograph chart recording instrument or manufacturer’s service software to record the test results.

8) Perform resistive load bank test at one hundred percent (100%) nameplate rating. Loading shall be:
   - 25% rated for 30 minutes
   - 50% rated for 30 minutes
   - 75% rated for 30 minutes
   - 100% rated for 4 hours
PART 5 - OTHER REQUIREMENTS

5.01 Training
A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the OWNER.

5.02 Warranty
A. The manufacturer shall warranty all products against defects in material and workmanship for a period of 5 years from the date of start up in accordance with manufacturer's standard published limited warranty.
B. The warranty shall be comprehensive. Warranty coverage shall include parts, labor. Travel expenses, and labor to remove/re-install equipment.
C. A warranty by a generator set manufacturer which places responsibility on the engine or generator manufacturer shall not be acceptable.

5.03 Service and Support
A. Submit an agreement for continued service and maintenance of the emergency system, for the Owner’s possible acceptance. Offer price, terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, for a one year period following the expiration of the warranty period, with option for renewal of agreement by Owner.
B. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
C. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
D. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

5.04 Diagnostic Software
A. Four copies of any or all necessary software required to diagnose and clear alarms and fault codes, read historical and performance data, etc. for both the generator controllers and the ATS, shall be provided to TAMU’s Utilities and Energy Services EPSS team prior to commissioning and will be verified as
running properly on UES laptop during commissioning. Upgrades required to
maintain the software’s functionality shall be provided free of charge for the life
of the asset or up to 30 years.

PART 6 - REVISIONS TO DESIGN STANDARD

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<tr>
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<tr>
<td>1</td>
<td>12/20/2017</td>
<td>2.01A</td>
<td>Stewart &amp; Stephenson added to list of acceptable product manufacturers</td>
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<td>2</td>
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Design Standard

Automatic Transfer Switches

Detailed specifications follow.

PART 1 - GENERAL

1.01 System
   A. Furnish the automatic transfer switches to automatically transfer between the normal and emergency power source

1.02 Applicable Standards
   A. The automatic transfer switches covered by these specifications shall be designed, tested, and assembled in strict accordance with NEC 70E and all applicable standards of ANSI, U.L., IEEE and NEMA.

1.03 Submittals
   A. Manufacturer shall submit shop drawings for review, which shall include the following, as a minimum:
      1. Descriptive literature
      2. Plan, elevation, side, and front view arrangement drawings, including overall dimension, weights and clearances, as well as mounting or anchoring requirements and conduit entrance locations.
      3. Schematic diagrams.
      4. Wiring diagrams.
      5. Accessory list.

PART 2 - PRODUCTS

2.01 Acceptable Manufacturers
   A. ASCO
   B. Russelectric
   C. Zenith

2.02 Construction
   A. General
      1. The automatic transfer switch shall be furnished as shown on the drawings. Voltage and continuous current ratings and number of poles shall be as shown.
      2. On 3 phase, 4 wire systems, utilizing ground fault protection, a true 4-pole switch shall be supplied with all four poles mounted on a common shaft.
The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.

3. The transfer switch shall be mounted in a NEMA 1 enclosure, unless otherwise indicated. Enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008.

4. The transfer switch shall be equipped with an internal welded steel pocket, housing an operations and maintenance manual.

5. The transfer switch shall be top and bottom accessible.

6. The main contacts shall be capable of being replaced without removing the main power cables.

7. The main contacts shall be visible for inspection without any major disassembly of the transfer switch.

8. All bolted bus connections shall have Belleville compression type washers.

9. When a solid neutral is required, a fully rated bus bar with required AL-CU neutral lugs shall be provided.

10. Control components and wiring shall be front accessible. All control wires shall be multiconductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.

11. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs.

12. The complete transfer switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be delivered with shipping unit.

B. Automatic Transfer Switch

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Minimum transfer time shall be 400 milliseconds.

2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable.

3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator
shall provide the same contact to contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. The external manual operator shall be safely operated from outside of the transfer switch enclosure while the enclosure door is closed.

C. Automatic Transfer Switch Controls

1. The transfer switch shall be equipped with a microprocessor based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with NiCad battery back-up.

2. The CPU shall be equipped with self diagnostics which perform periodic checks of the memory I/O and communication circuits, with a watchdog/power fail circuit.

3. The controller shall use industry standard open architecture communication protocol for high-speed serial communications via multidrop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further, with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.

4. The serial communication port shall allow interface to either the manufacturer’s or the owner’s furnished remote supervisory control.

5. The controller shall have password protection required to limit access to qualified and authorized personnel.

6. The controller shall include a 20 character, LCD display, with a keypad, which allows access to the system.

7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and emergency sources.

8. The controller shall be capable of storing the following records in memory for access either locally or remotely:
   a. Number of hours transfer switch is in the emergency position (total since record reset).
   b. Number of hours emergency power is available (total since record reset).
   c. Total transfer in either direction (total since record reset).
   d. Date, time, and description of the last four source failures.
   e. Date of the last exercise period.
   f. Date of record reset.
D. Sequence of Operation

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-9999 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant.

2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases.

3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay period of 0-9999 seconds (factory set at 300 seconds) shall delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source.

4. After retransfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

E. Automatic Transfer Switch Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.

2. Programmable three phase sensing of the emergency source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases set at 20%, and phase sequence monitoring.

3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds, if not otherwise specified.

4. Time delay to control contact transition time on transfer to either source. Programmable 0-9999 seconds, factory set at 3 seconds.

5. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.
6. Time delay on transfer to emergency, programmable 0-9999 seconds, factory set at 3 seconds.

7. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.

8. A remote type load test switch shall be included to simulate a normal power failure, remote switch initiated.

9. A time delay bypass on retransfer to normal shall be included. Keypad initiated.

10. Contact, rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.

11. Contact, rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions.

12. Light emitting diodes shall be mounted on the microprocessor panel to indicate: switch is in normal position, switch is in emergency position and controller is running.

13. A plant exerciser shall be provided with (10) 7-day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise generating plant programmable in one-minute increments. Also include selection of either "no load" (switch will not transfer) or "load" (switch will transfer) exercise period. Keypad initiated.

14. Provision to select either "no commit" or "commit" to transfer operation in the event of a normal power failure shall be included. In the "no commit position," the load will transfer to the emergency position unless normal power returns before the emergency source has reach 90% of it's rated values (switch will remain in normal). In the "commit position" the load will transfer to the emergency position after any normal power failure. Keypad initiated.

15. Two auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 amps) 15 amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, one closed on normal, the other closed on emergency. Both contacts will be wired to a terminal strip for ease of customer connections.

16. A three phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase to phase voltages simultaneously, for both the normal and emergency source.

17. A digital LCD frequency readout with 1% accuracy shall display frequency for both normal and emergency source.

18. An LCD readout shall display normal source and emergency source availability.
F. Specifiers Notes:

The following accessories shall be available by simple activation, via the keypad, if required.

1. Include (2) time delay contacts that open simultaneously just (milliseconds) prior to transfer in either direction. These contacts close after a time delay upon transfer. Programmable 0-9999 seconds after transfer.

2. A block transfer function shall be included, energized from a 24VDC signal from the generator control switchgear, to allow transfer to emergency.

3. A load-shed function shall be included, energized from a 24VDC signal from the generator control switchgear, to disconnect the load from the emergency source when an overload condition occurs.

4. A peak shave function shall be included, energized from a 24VDC signal from the generator control switchgear. This function will start the emergency generator and transfer the ATS to the emergency source reducing the utility supply to the building. After the peak shave signal is removed, the transfer switch will retransfer to the normal supply, bypassing the retransfer time delay.

G. Approval

1. As a condition of approval, the manufacturer of the automatic transfer switches shall verify that their switches are listed by Underwriters Laboratories, Inc., Standard UL-1008 with 3 cycle short circuit closing and withstand as follows:

RMS Symmetrical Amperes 480 VAC

<table>
<thead>
<tr>
<th>Amperes</th>
<th>Closing and Withstand</th>
<th>Fuse Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 400</td>
<td>42,000</td>
<td>200,000</td>
</tr>
<tr>
<td>600 – 800</td>
<td>65,000</td>
<td>200,000</td>
</tr>
<tr>
<td>1000 – 1200</td>
<td>85,000</td>
<td>200,000</td>
</tr>
<tr>
<td>1600 – 4000</td>
<td>100,000</td>
<td>200,000</td>
</tr>
</tbody>
</table>

2. During the 3 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle tests shall be performed without the use of current limiting fuses. The test shall verify that contacts separation has not occurred, and there is contact continuity across all phases. Test procedures shall be in accordance with UL-1008, and testing shall be certified by Underwriters' Laboratories, Inc.

3. When conducting temperature rise tests to UL-1008, the manufacture shall include post-endurance temperature rise tests to verify the ability of the
transfer switch to carry full rated current after completing the overload and endurance tests.

4. The microprocessor controller shall meet the following requirements:
   a. Storage conditions - 25 degrees C to 85 degrees C.
   b. Operation conditions - 20 degrees C to 70 degrees C ambient.
   c. Humidity 0 to 99% relative humidity, noncondensing.
   d. Capable of withstanding infinite power interruptions.

5. Manufacturer shall provide copies of test reports upon request.

H. Manufacturer
   1. The transfer switch manufacturer shall employ a nationwide factory-direct, field service organization, available on a 24-hour a day, 365 days a year, call basis.
   2. The manufacture shall include an 800-telephone number, for field service contact, affixed to each enclosure.
   3. The manufacturer shall maintain records of each transfer switch, by serial number, for a minimum 20 years.

PART 3 - EXECUTION

3.01 Installation
   A. Automatic Transfer Switches shall be provided with adequate lifting means for ease of installation of wall or floor mounted enclosures.
   B. Provide access and working space as indicated or as required.

3.02 Adjustments
   A. Tighten assembled bolted connections with appropriate tools to manufacturer's torque recommendations prior to first energization.
Design Standard

Exterior Lighting and Installation

This standard was revised on November 28, 2018, and the latest changes are underlined. Please refer to Part 5 of this standard for full revision history.

General Exterior Campus Lighting Guidelines

Examine all available lighting source technologies to determine the appropriate source for the application, lowest life cycle cost and energy requirements for any given project. High performance HID, Compact Fluorescent, Induction, and LED technologies all have appropriate applications, based on energy efficiency, lighting level requirements, color of light, maintenance, cost, and other project criteria. Any deviation from the campus standards must be approved through Utilities & Energy Services (UES).

- All on/off control circuits for exterior lighting shall utilize photocells; the use of timers to control these circuits is unacceptable. \(^1\)
- All fixtures must be dark-sky compliant as required by state law.
- All Bollard lighting, Pole mounted pedestrian lighting, Pole mounted street lighting and Pole mounted parking lot lighting shall have dedicated raceways not to be shared with convenience outlet circuits, building mounted exterior lighting circuits, irrigation systems etc. \(^6\)
- All pole bases shall be minimum 12 inches above final grade. \(^7\)
- Wire shall be XXHWor XXHW-2. \(^8\)
- Photo cell control with Hand / Off / Auto over-ride. \(^9\)
- All terminations shall be made with Gel Tap splice with closure. NSI easy-splice gel tap splice kit provides a method for connecting, insulating, and environmentally sealing low-voltage splices. The splice kit is designed for underground and overhead environments and is useful for street lighting applications. The hinged splice closure can be installed over the connector in seconds by snapping the cover shut. Qualified to ANSI CI 19.1 -1986 for underground splicing. Rated -40 to 90 degrees C, UV resistant. \(^10\)

**Typical Design Lighting Level:** TAMU follows the lighting level chart below as a guide, refer to IESNA, TXDOT, and local codes requirements for additional information.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Ways Parking Lots</td>
<td>1.0</td>
<td>-</td>
<td>0.1</td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Roadways</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>-</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>3:1</td>
</tr>
<tr>
<td>Collector</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>4:1</td>
</tr>
<tr>
<td>Local</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
<td>6:1</td>
</tr>
</tbody>
</table>
PART 1  Pedestrian & General Area Lighting (Primary Campus Standard)

1.01  FIXTURE
   A. Gardco Round Form 10 or Kim CC/CCS
   B. Finish:  Pearl Mouse Grey RAL7048
   C. Distribution Type specific for location or Type 2 open area.

1.02  POLES
   A. Gardco or Sterner
   B. Finish:  Bronze Anodized Hiawatha Metal #311
   C. All pedestrian lighting applications shall have poles at least ten feet tall. Ten foot pole mounted fixtures are preferred, Fifteen foot poles are an acceptable alternative if site lighting needs require the additional height.

1.03  LAMPS
   A. Light Emitting Diodes (LED)
   B. All LEDs must have a color of 4000K

1.04  LIGHTING CONTROL
   A. NEMA 7-Pin Twist Lock Photocell Receptacle
   B. The use of timeclocks to control exterior lighting circuits is prohibited.  

<table>
<thead>
<tr>
<th>Pedestrian Light Poles</th>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>10’ Sterner</td>
<td>Tapered</td>
<td>RTA10-4.5x3.0-0.125-10-C-LBZ#311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10’ Gardco</td>
<td>Tapered</td>
<td>TAMU-TRA-HB-10-D1-BRA#311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15’ Sterner</td>
<td>Tapered</td>
<td>RTA15-4.5x3.2-0.125-10-C-LBZ#311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15’ Gardco</td>
<td>Tapered</td>
<td>TAMU-TRA-HB-15-D1-BRA#311</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:  D1-Light Duty Pole – engineer to specify correct relative strength based on site wind load factors.

<table>
<thead>
<tr>
<th>Pedestrian Light Fixtures</th>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>66W Kim</td>
<td>CC/CCS LED</td>
<td>FM/CCS17PXE35/60L4K277/CCRAL7048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70W Phillips Gardco</td>
<td>Form 10 LED</td>
<td>CP17L-P22-X-70LA-NW-UNIV-OC-RAL7048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66W Kim</td>
<td>CC/CCS Wall LED</td>
<td>1W/CCS17AXE35/60L4K277/CCRAL7048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70W Phillips Gardco</td>
<td>Form 10 Wall LED</td>
<td>CW17L-1-X-70LA-NW-UNIV-OC-RAL7048</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:  Fixtures must come with a 7 pin NEMA Photocell receptacle.

Note:  X denotes distribution type
PART 2  Historical Pedestrian & Heritage Area Lighting (standard per noted locations)

Historic District Lighting Areas include New Main Roadway and Military Walk.

2.01 FIXTURE
A. Lumec Zenith Series or Beacon Mediterranean Series.
B. Roman Bronze finish of decorative cast 356 aluminum.
C. Hood: spun aluminum with disk to block the up light out from hood.

2.02 POLES
A. Lumec
B. Shaft: 12 fluted round cast 356 aluminum tapered shaft, .250” wall thickness
C. Base: round fluted cast 356 Aluminum, .357” avg. wall thickness, double fuse double fuse holders, and a cast-in anchor plate

2.03 LAMPS
A. Light Emitting Diodes (LED)
B. All LEDs must have a color of 4000K

2.04 LIGHTING CONTROL
A. NEMA 7-Pin Twist Lock Photocell Receptacle
B. The use of timeclocks to control exterior lighting circuits is prohibited. ³

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixture</td>
<td>Lumec</td>
<td>Zenith</td>
<td>Z47A-65W42LED4K-R-AC-RLE5-XXX-SFZ4-SCUS542M65SM</td>
</tr>
<tr>
<td>12’ Pole</td>
<td>Lumec</td>
<td>RTA</td>
<td>RTA50F-12-SCUS542M65SM</td>
</tr>
<tr>
<td>Fixture</td>
<td>Beacon</td>
<td>Mediterranean</td>
<td>T1/AC/NC/24ND-55/4K/UNIV/DIR5/PCR-TL/DBT</td>
</tr>
</tbody>
</table>

XXX denotes system voltages
D1-Light Duty Pole – engineer to specify correct relative strength based on site wind load factors.
Note: Fixtures must come with a 7 pin NEMA Photocell receptacle
PART 3  
Parking & Roadway Lighting

3.01  FIXTURE
A. Fixture: CREE OSQ or Phillips Gardco EcoForm
B. Finish: Pearl Mouse Grey RAL7048 or Platinum Bronze
C. Distribution Type specific for location or Type 3 open area

3.02  POLES
A. Gardco, Sterner or Kim
B. Finish: Bronze Anodized Hiawatha Metal #311
C. Parking lighting applications for small and medium sized parking areas and the perimeter of large parking areas shall have a cutoff fixture.

3.03  LAMPS
A. Light Emitting Diodes (LED)
B. All LEDs must have a color of 4000K

3.04  LIGHTING CONTROL
A. NEMA 7-Pin Twist Lock Photocell Receptacle
B. The use of timeclocks to control exterior lighting circuits is prohibited.  

<table>
<thead>
<tr>
<th>Roadway &amp; Parking Light Poles</th>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>20’</td>
<td>Gardco</td>
<td>Tapered</td>
<td>TAMU-TRA-CB-20M-D1-BRA#311</td>
<td></td>
</tr>
<tr>
<td>20’</td>
<td>Kim</td>
<td>Tapered</td>
<td>LTRA20-6156-1A-DBA311/BC/PC4RDB/96068/95518</td>
<td></td>
</tr>
<tr>
<td>30’</td>
<td>Sterner</td>
<td>Tapered</td>
<td>RTA30-8.0x4.5-0.188-10-L-VD-LBZ#311</td>
<td></td>
</tr>
<tr>
<td>30’</td>
<td>Gardco</td>
<td>Tapered</td>
<td>TAMU-TRA-CB-30L-D1-BRA#311-VDA</td>
<td></td>
</tr>
<tr>
<td>30’</td>
<td>Kim</td>
<td>Tapered</td>
<td>LTRA30-7156-1A-DBA311/BC-PC4RDB/96068/95518</td>
<td></td>
</tr>
</tbody>
</table>

Note: D1- Light Duty Pole – engineer to specify correct relative strength based on site wind load factors.

<table>
<thead>
<tr>
<th>Roadway &amp; Parking Light Fixtures</th>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>160W</td>
<td>Phillips Gardco</td>
<td>EcoForm</td>
<td>ECF-DIM-1-3-160LA-481A-NW-UNV-OC-RAL7048-PCR7</td>
<td></td>
</tr>
</tbody>
</table>

Note: X denotes distribution type.
Note: Fixtures must come with a 7 pin NEMA Photocell receptacle.
PART 4 Pedestrian Bollard Lighting

4.01 FIXTURE

A. Fixture: Gardco 830 Series LED Bollard with Demand Response

B. The Bollard can be specified with or without lighting capability in effort to provide a standardized bollard type, but have the flexibility of installing the luminaire type in only the locations that ground lighting is needed.

4.02 LIGHTING CONTROL

A. NEMA 7-Pin Twist Lock Photocell Receptacle

B. The use of timeclocks to control exterior lighting circuits is prohibited. 5

<table>
<thead>
<tr>
<th>Pedestrian Bollard Lighting</th>
<th>Equipment</th>
<th>Manufacture</th>
<th>Style</th>
<th>Catalog Number Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixture</td>
<td>Phillips Gardco</td>
<td>LED</td>
<td>TAMU-BRM830-42-DR-NW-360-277-SC/BRA#311</td>
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<tr>
<td>Pole</td>
<td>Phillips Gardco</td>
<td>Nonlit</td>
<td>TAMU-42-NONLIT-SC/BRA#311</td>
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<tr>
<td>Fixture</td>
<td>Kim</td>
<td>LED</td>
<td>VRB1-15L-3KUV-DBA311</td>
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<tr>
<td>Pole</td>
<td>Kim</td>
<td>Nonlit</td>
<td>VRBC-BR-C</td>
<td></td>
</tr>
</tbody>
</table>

Note: Engineer to review bollard specifications (height/coverage/voltage) to ensure specification meets actual bollard application.
<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>All on/off control circuits for exterior lighting shall utilize photocells</td>
</tr>
<tr>
<td>2,3,4,5</td>
<td>11/28/2018</td>
<td>1.04B, 2.04B, 3.04B, 4.02B</td>
<td>The use of timeclocks to control exterior lighting circuits is prohibited</td>
</tr>
<tr>
<td>6</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>Lighting shall have dedicated raceways</td>
</tr>
<tr>
<td>7</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>All pole bases shall be minimum 12 inches above final grade</td>
</tr>
<tr>
<td>8</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>Wire shall be XXHWor XXHW-2</td>
</tr>
<tr>
<td>9</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>Photo cell control with Hand / Off / Auto over-ride</td>
</tr>
<tr>
<td>10</td>
<td>11/28/2018</td>
<td>1st page of standard</td>
<td>All terminations shall be made with Gel Tap splice with closure</td>
</tr>
</tbody>
</table>
IES Roadway Luminaire Classifications (Types I, II, III, IV and V) Summary:

The Illuminating Engineering Society of North America (IESNA) defines roadway and area lighting fixtures by their photometric properties and distance to the half maximum candela trace and the maximum candela value.

The definitions of the IES classifications follow:

The lateral classification describes the lateral light distribution with regards to the lighted area width described as multiples of the mounting height (MH). The width of the half-maximum candela trace within the longitudinal distribution range (Short, Medium or Long) is used. The boundaries for each classification in terms of Longitudinal Roadway Lines (LRL, running along the roadway) are as follows:

- **Type I** - Half-maximum candela trace falls between 1 MH LRL on the House side and 1 MH LRL on the Street side.
- **Type II** - Half-maximum candela trace on the Street side is beyond the 1 MH LRL but not beyond the 1.75 MH LRL.
- **Type III** - Half-maximum candela trace on the Street side is beyond the 1.75 MH LRL but not beyond the 2.75 MH LRL.
- **Type IV** - Half-maximum candela trace on the Street side is beyond the 2.75 MH LRL.
- **Type V** - Has circular symmetry being essentially the same at all lateral angles around the luminaire.

Informally, there is also a Type V-S, similar to Type V, but square in shape.

This image is from the IESNA Lighting Handbook, 9th Edition, © 2000, In this example, the luminaire is a Type III -- Medium distribution.
Pedestrian Sterner Tapered Pole

### Ordering Example

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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</thead>
<tbody>
<tr>
<td>RTA20</td>
<td>6.0 x 4.5</td>
<td>0.188</td>
<td>A28</td>
<td>B</td>
<td>DF</td>
<td>BK</td>
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</table>

### Ordering Sequence

<table>
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<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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</thead>
<tbody>
<tr>
<td>RTA10</td>
<td>Sea Pole Data Table Below</td>
<td>0.135</td>
<td>B</td>
<td>10</td>
<td>SN</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note:** 11/32" applies to both arms & pole main flanges. 22" (903.8) style base available 20" max. 41/4" Arm (2 arms) 3/4" Arm (1 arm) See below for hole drilling information: 3/4" Arm (2 arms) See below for hole drilling information: 3/4" Arm (1 arm) See below for hole drilling information: 3/4" Arm (1 arm) 2 arms. 1 arm.

### Pole Data

<table>
<thead>
<tr>
<th>Pole Code No.</th>
<th>Diameter (Tapered)</th>
<th>Wall Thickness</th>
<th>Flange Height</th>
<th>Flange Pattern</th>
<th>Base Type</th>
<th>Base Code</th>
<th>Base Diameter</th>
<th>Base Height</th>
<th>Overall Diameter</th>
<th>Overall Height</th>
<th>Overall Weight</th>
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<tbody>
<tr>
<td>RTA10</td>
<td>4.0 x 5.50</td>
<td>0.033</td>
<td>11.0</td>
<td>T, T</td>
<td>L</td>
<td>11.0</td>
<td>36.0</td>
<td>4.0</td>
<td>51.0</td>
<td>51.0</td>
<td>15.0</td>
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<tr>
<td>RTA15</td>
<td>4.0 x 5.50</td>
<td>0.030</td>
<td>11.0</td>
<td>T, T</td>
<td>L</td>
<td>11.0</td>
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<td>51.0</td>
<td>51.0</td>
<td>15.0</td>
</tr>
<tr>
<td>RTA20</td>
<td>4.0 x 5.50</td>
<td>0.030</td>
<td>11.0</td>
<td>T, T</td>
<td>L</td>
<td>11.0</td>
<td>36.0</td>
<td>4.0</td>
<td>51.0</td>
<td>51.0</td>
<td>15.0</td>
</tr>
<tr>
<td>RTA25</td>
<td>4.0 x 5.50</td>
<td>0.030</td>
<td>11.0</td>
<td>T, T</td>
<td>L</td>
<td>11.0</td>
<td>36.0</td>
<td>4.0</td>
<td>51.0</td>
<td>51.0</td>
<td>15.0</td>
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</tbody>
</table>

**Note:** This is a tentative list for ordering purposes. For more information, please refer to the Sterner Lighting website or contact the supplier directly.
## Tapered Round Aluminum - Hinged Base

The Philips Gardco TRA tapered round aluminum pole consists of a one-piece design fabricated aluminum tubing circumferentially welded to a structural quality hot rolled carbon steel plate. The poles are finished with either Architectural Class I anodizing or electrostatically applied TGIC polyester powdercoat. All poles include anchor bolts, hand hole, ground lug and top cap.

### Data Sheets

<table>
<thead>
<tr>
<th>PREFIX</th>
<th>BASE</th>
<th>HEIGHT</th>
<th>DRILLING</th>
<th>FINISH</th>
<th>OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRA</td>
<td>CB</td>
<td>10</td>
<td>D1</td>
<td>BRA#311</td>
<td></td>
</tr>
</tbody>
</table>

Enter the order code into the appropriate box above. Note: Gardco reserves the right to modify configurations. Not all combinations and configurations are viable. Refer to notes below for exclusions and limitations. For questions or concerns, please contact the factory.

### Dimensions

<table>
<thead>
<tr>
<th>BASE</th>
<th>Height</th>
<th>Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Cast Base</td>
<td>25'LH</td>
<td>1-way</td>
</tr>
<tr>
<td>Hinged Base</td>
<td>20'MH</td>
<td>1-way</td>
</tr>
</tbody>
</table>

### Notes

- **BRP**: Bronze Paint
- **BLP**: Black Paint
- **WP**: White Paint
- **NP**: Natural Aluminum Paint
- **BRA**: Bronze Anodized #311
- **BLA**: Black Anodized
- **NA**: Natural Anodized
- **OC**: Optional Color Paint
- **SC**: Special Color Paint

### Additional Information

- **Nipples and Couplings**: Indicate sizes (1/2", 3/4", 1", 1 1/4", 1 1/2") indicate height above base and orientation to hand hole. See Pole Orientation Information on Page 4.
- **NL**: Nipple - External thread
- **CL**: Coupling - Internal thread
- **Single Mount Bollard Brackets**: Indicate height above base and orientation to hand hole. See Pole Orientation Information on Page 4.

### Product Options

- **Motion Response**: Provision for Gardco HID Motion Response System
- **Minimum Pole Height**: 8 ft. Includes a 1/2" coupling placed 18" to the hand hole, 12" above the pole base.
- **MSM**: Motion Sensor Mounting Provision for LED Luminaires available with Motion Response
- **Minimum Pole Height**: 8 ft. Includes a special hand hole with 1/2" coupling placed in the lower part, 18" to the hand hole, 15" above the pole base.
The Philips Gardco TRA tapered round aluminum pole consists of a one-piece design fabricated aluminum tubing circumferentially welded to a structural quality hot rolled carbon steel plate. The poles are finished with either Architectural Class I anodizing or electrostatically applied TGIC polyester powdercoat. All poles include anchor bolts, hand holes, ground lug and top cap.

### Tapered Round Aluminum - Hinged Base

**Options**

- **BRA**
  - Bronze Anodized
- **BLA**
  - Black Anodized
- **NP**
  - Natural Aluminum

**Nipple and Couplings**


### Dimensions

- **HB**
  - Fixed Cast Base
- **Hinged Base**

### DRILLING

- **D1**
  - 1 Way
- **D2**
  - 2 Way
- **D2@90**
  - 2 Way at 90°
- **D3**
  - 3 Way
- **D3@120**
  - 3 Way at 120°
- **D4**
  - 4 Way
- **T2**
  - 2 3/8" OD Taperon
- **T4**
  - 4" OD Taperon

**Motion Response Provisions**

- **GMR**
  - Provision for Gardco HID Motion Response System
- **MSM**
  - Motion Sensor Mounting Provision for LED Luminaires available with Motion Response

**Specifications**

- **Motion Response Provisions**
  - Provision for Gardco HID Motion Response System
  - Minimum pole height is 16' includes a 1/2" coupling placed 180° to the hand hole, 12" above the pole base.
  - Minimum pole height is 16' includes a special hand hole with 1/2" coupling placed in the cover plate, 16" above the pole base.
CC/CCS17
17\degree Post Top Mounted, Curvilinear, PicoEmitter™ LED

Specifications

17\degree Diameter
60 Light Emitting Diodes
Total System Watts = 64W

Housing: Spun aluminum; (Rollformed linear reveals; CC: Three equally spaced reveals, \( \frac{1}{2} \) wide, separated by \( \frac{1}{2} \) ribs, \( \frac{3}{4} \) deep.

CCS: One \( \frac{1}{2} \) groove, \( \frac{3}{4} \) deep.) Sidewalls have a maximum \( \frac{1}{2} \) of tapers, and are free of welds or fasteners. A rollformed aluminum flange is hemmed into the bottom providing support for the reflector module. An internal aluminum casting provides for mounting of the electrical module and support for the housing hinge.

Lens Frame and Yoke: One-piece cast aluminum lens frame is attached to the housing by a zinc plated cold rolled steel hinge with a stainless steel pin. Closure of the housing is by a single self-retained stainless steel screw. A stainless steel self-locking stop arm is provided to hold the housing in the open position while servicing. A \( \frac{1}{4} \) thick clear flat tempered glass lens is fully gasketed by a one-piece extruded and vulcanized silicone gasket. Lens is retained in the frame by removable zinc plated steel clips. Lens frame is supported at four points two aluminum U-shaped tubular arms cradled in a cast aluminum hub. Arms are welded to the lens frame, and welded to the hub along their longitudinal axis. Hub contains a field-splice compartment, a cast aluminum cover and one of the following pole attachment means: FM - Flush Mounting or PT - Pole Tenon Mounting (see page 2 for complete descriptions).

Electronic Module: All electrical components are UL and CSA recognized, mounted on a single plate and factory premounted with quick-disconnect plugs. Module includes a driver, LifeShield\textsuperscript{TM} temperature control device and surge protector. Electrical module attaches to housing with no-tool hinges and latches, accessible by opening the lens frame only. Driver is rated for 40°F starting and has a 0-10V dimming interface for multi-level illumination options.

Optical Module: Precision, replaceable PicoEmitters are positioned to achieve directional control toward desired task. The entire EmitterDeck\textsuperscript{TM} mounting assembly fastens to the housing as one-piece module.

Finish/Color: TGIC thermoset polyester powder coat paint; 2.5 mill nominal thickness. Standard colors are Black, Dark Bronze, Light Gray, Stealth Gray, Platinum Silver, or White. Custom colors are available.


Warranty: Kim Lighting warrants Curvilinear LED products (“Product”) sold by Kim Lighting to be free from defects in material and workmanship for (i) a period of five (5) years for metal parts, (ii) a period of ten (10) years for exterior housing paint finishes), (iii) a period of six (6) years for LED Light Engines (PicoEmitter reflectors) and, (iv) a period of five (5) years for LED power components (LED Driver, LifeShield temperature control device, surge protector), from the date of sale of such goods to the buyer as specified in Kim Lighting shipment documents for each product.

CAUTION: Fixtures must be grounded in accordance with national, state and/or local electrical codes. Failure to do so may result in serious personal injury.

© 2013 KIM LIGHTING • 19005 EAST GALE AVENUE, CITY OF INDUSTRY, CA 91745-1785 • TEL: 626/969-5666 • FAX: 626/969-3719
## CC/CCS17

### Exterior Lighting and Installation

**17” Post Top Mounted, Curvilinear, PicoEmitter™ LED**

**Version 3.0.2018**

---

### Standard Features

#### Mounting

<table>
<thead>
<tr>
<th>Housing:</th>
<th>CC</th>
<th>CCS</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Source:</th>
<th>xK = 60/1L ED.A</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Color Temperature:</th>
<th>Voltage:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3K = 3000K</td>
<td>120V = 120V</td>
</tr>
<tr>
<td>4K = 4200K</td>
<td>208V = 208V</td>
</tr>
<tr>
<td>5K = 5000K</td>
<td>240V = 240V</td>
</tr>
<tr>
<td>2K = 5000K - Amber</td>
<td>277V = 277V</td>
</tr>
</tbody>
</table>

| E35 = 350mA |

#### Distribution:

- Type I Full Cutoff
- Type II Full Cutoff
- Type III Full Cutoff
- Type IV Full Cutoff
- Type V Square Full Cutoff
- Type L Left Full Cutoff
- Type R Right Full Cutoff

#### Light Distribution:

- Type I: Forward Throw
- Type II: Square
- Type III: Right
- Type IV: Left

---

### Electrical Module

Cat. Nos. for Electrical Modules available:

- G60L

<table>
<thead>
<tr>
<th>Color:</th>
<th>Black</th>
<th>Dark Bronze</th>
<th>Light Gray</th>
<th>Stealth Gray</th>
<th>Platinum Silver</th>
<th>White</th>
<th>Custom Color</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Cat. No.:</th>
<th>BL</th>
<th>DB</th>
<th>LG</th>
<th>SG</th>
<th>PS</th>
<th>WH</th>
<th>CC</th>
</tr>
</thead>
</table>

**Due to current unavailability of 347V and 480V drivers, specification of these voltages may feature an integral step-down transformer.**

---

### Finish

- TGIC powder coat

**Color:**

- Black
- Dark Bronze
- Light Gray
- Stealth Gray
- Platinum Silver
- White
- Custom Color

**Cat. No.:**

- BL
- DB
- LG
- SG
- PS
- WH
- CC

**Custom colors subject to additional charges, minimum quantities and extended lead times. Consult representative, Custom color description: RAL7048**

---

### 0-10V Dimming Interface

- Driver has a 0-10V dimming interface with a dimming range of 10-100%. Is compatible with most control systems including Hubbell Building Automation (HBA)™.
- Approved dimmers include Lutron Diva AVTV, Lutron Nova NTVF and NTVFV. **Note:** Not compatible with current sourcing dimmers. Controls compatible via Gray and Purple dimming lead.

---

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Form 10 Round LED

The Philips Gardco post top mounted Round Form 10 LED products are cutoff luminaires featuring LED arrays. Round Form 10 LED luminaires provide performance excellence and advanced Philips Gardco LED thermal management technology. High-performance Class 1 LED systems offer the potential for energy savings up to 50% when compared to HID systems. Housings are one-piece stainless spun aluminum and finished with either Architectural Class 1 anodizing or high-heat resistant, electrophoretically applied TEOC polyester powdercoat or polyesterume. Optional toe glow rings at post tops are available in (4) colors and are illuminated by the primary source. Luminaries provide full cutoff performance.

CP17L-P22-70LA-NW-UNIV-OC-RAL3003

Enter the order code in the diagram box above. Note: Philips Gardco reserves the right to alter a configuration. Not all combinations and configurations are valid. Refer to notes below for exclusions and limitations. For questions or concerns, please consult the factory.

### PREFIX

<table>
<thead>
<tr>
<th>CP17L</th>
<th>CP17L-DIM</th>
<th>MP17L</th>
<th>MP17L-DIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>17&quot; Cylindrical Luminaires LED - Constant Wattage</td>
<td>17&quot; Cylindrical Luminaires LED - 0-10V Dimming</td>
<td>17&quot; Semi-Spherical Luminaires LED - Constant Wattage</td>
<td>17&quot; Semi-Spherical Luminaires LED - 0-10V Dimming</td>
</tr>
</tbody>
</table>

### MOUNTING

- **FOLES**
  - **EROS**
    - **PIN OD**: 3.88" MAX:OD: 3.00"
    - **RAISSN4**
  - **CP/MP**: 17" PIN OD: 3.88" MAX:OD: 4.60"
  - **CP/MP 22**: 17" PIN OD: 3.50" MAX:OD: 4.90"

- **TENONS**
  - **TX**: 2.38" X 4"
  - **T3**: 3.76" X 4"
  - **T4**: 4" X 6"

### DISTRIBUTION

- **Type I**: 4
- **Type II**: 5
- **Type Y**: Depends on desired distribution. Normally Type 2

### LED WATTAGE AND LUMEN VALUES

<table>
<thead>
<tr>
<th>Code</th>
<th>Average System Watts</th>
<th>LED Current (mA)</th>
<th>LED Selection</th>
<th>Luminaire Initial/ Absolute Lumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>70LA</td>
<td>70</td>
<td>J50</td>
<td>CW (NW)</td>
<td>6,516 (6,715)</td>
</tr>
<tr>
<td>95LA</td>
<td>95</td>
<td>J50</td>
<td>CW (NW)</td>
<td>6,804 (6,914)</td>
</tr>
<tr>
<td>110A</td>
<td>110</td>
<td>J50</td>
<td>CW (NW)</td>
<td>7,458 (7,487)</td>
</tr>
<tr>
<td>160A</td>
<td>160</td>
<td>J50</td>
<td>CW (NW)</td>
<td>13,395 (13,400)</td>
</tr>
</tbody>
</table>

### Notes:

1. Wattage may vary by ±1-5% due to LED manufacturer for forward with qualification and ambient temperature. Wattage shown is average for 20-0 through 37°C input. Actual operating may vary by an additional ±10% due to actual input wattage.
2. LEDs are shunted with a RLA capacitor.
3. The external shield option tests are included for luminaries with the HG option.
4. For information contact Philips Gardco applications at philips.com (if applicable). Options may vary based on design specifications.

### Luminance Data:

- **Device Luminance**: Photometric tests performed in compliance with ENSA, UWA standard, exclude other test conditions.

1611 Clavis Baskar Road, Sunnyside, TX 78066
(800) 237-4795 (800) 793-1090 FAX: (800) 793-7805 sitelighting.com
© 2013 Koninklijke Philips Electronics N.V. All rights reserved.
### Form 10 Round LED

#### CP / MP Post Top Mount

**LED SELECTION**

<table>
<thead>
<tr>
<th>Color</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td>Cool White - 5700K - 75 CRI</td>
</tr>
<tr>
<td>NW</td>
<td>Neutral White - 4000K - 70 CRI</td>
</tr>
<tr>
<td>WW</td>
<td>Warm White - 3000K - 80 CRI</td>
</tr>
</tbody>
</table>

**VOLTAGE**

- **UNIV**: 120V through 277V, 50Hz or 60Hz
- **HYU**: 347V through 480V, 50Hz or 60Hz (High Voltage Universal)

**FINISH**

- BRP: Bronze Paint
- BLP: Black Paint
- WP: White Paint
- NP: Natural Aluminum Paint
- BRA: Bronze Anodized
- BLA: Black Anodized
- NA: Natural Anodized

**OPTIONS**

- P: Testing
- LF: In-Line Fuse/Pole Fusing
- PC*: Photocontrol and Receptacle
- PCR*: Photocontrol Receptacle only
- SPR: Surge Protection for 120V through 277V Input meeting ANSI C62.41.2
- SPR*: Surge Protection for 347V through 480V Input meeting ANSI C62.41.2

**DIMENSIONS AND EPA**

**MOUNTING ILLUSTRATIONS**

Refer to Table on Page 1 for mounting ordering information.

### Table: LED Styles and Data

<table>
<thead>
<tr>
<th>Style</th>
<th>Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Weight</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>17&quot;</td>
<td>17&quot;</td>
<td>8&quot;</td>
<td>10&quot;</td>
<td>18&quot;</td>
<td>7 lb</td>
<td>Single</td>
</tr>
<tr>
<td></td>
<td>22&quot;</td>
<td>22&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>25&quot;</td>
<td>10 lb</td>
<td>Single</td>
</tr>
<tr>
<td>MP</td>
<td>17&quot;</td>
<td>17&quot;</td>
<td>11&quot;</td>
<td>10&quot;</td>
<td>21&quot;</td>
<td>7 lb</td>
<td>Single</td>
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<tr>
<td></td>
<td>22&quot;</td>
<td>22&quot;</td>
<td>14&quot;</td>
<td>10&quot;</td>
<td>25&quot;</td>
<td>10 lb</td>
<td>Single</td>
</tr>
</tbody>
</table>

### Table: Height and Weight

<table>
<thead>
<tr>
<th>Style</th>
<th>Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Weight</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17&quot;</td>
<td>38.13 cm</td>
<td>35.40 cm</td>
<td>41.32 cm</td>
<td>87 mg</td>
<td>1.46 kg</td>
<td>Single</td>
</tr>
<tr>
<td></td>
<td>22&quot;</td>
<td>38.13 cm</td>
<td>35.40 cm</td>
<td>41.32 cm</td>
<td>87 mg</td>
<td>1.46 kg</td>
<td>Single</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td>53.34 cm</td>
<td>87 mg</td>
<td>1.46 kg</td>
<td>Single</td>
</tr>
</tbody>
</table>

*Note: All weights are approximate and may vary slightly due to manufacturing tolerances.*

---

**Contact Information**

1611 Clevis Barker Road, San Marcos, TX 78666
(866) 237-4738  (512) 753-1000  FAX: (512) 753-1855  site@lighting.com

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Philips Gardco reserves the right to change materials or modify the design of its products without notification as part of the company's continuing product improvement program.

Gardco 02/2012
Luminaire [Z47A-065]-6W42LED4K-R-AC-RLE5-209-SFZ4-SCUS542M5SM

Description of Components:

**Finial:** Decorative cast 356 aluminum, mechanically assembled.

**Hood:** Cast 356 aluminum ring with one clear borosilicate glass upright diffuser installed on the lower part of the hood, also complete with a disk to block the upright coming out from the hood, mechanically assembled on the luminaire.

**Access Mechanism:** Rotomatic, die-cast A360 aluminum quarter-turn mechanism with constant-pressure spring-loaded points. The mechanism shall offer tool-free access to the inside of the luminaire. An embedded memory-retentive gasket shall ensure weatherproofing. A red key on the unit shall indicate point of engagement.

**Light Engine:** EcoSwap Rotomatic tool-free system composed of 4 main components: LED lamp / Optical System / Heat Sink / Driver

Electrical components are RoHS compliant.

**Globe:** (AC), Made of one-piece seamless injected-moulded clear acrylic having a prismatic exterior surface. The globe is mechanically assembled on the access-mechanism.

**Lamp:** LED Module (Included), LED type Philips Lumileds LUXEON R. Composed of 42 high-performance white LEDs, 65w lamp wattage. Color temperature of 4000 Kelvin nominal, 70 CRI. Operating lifespan based on TM-21 extrapolation to get results after which 50% of LEDs still emits over 70% (L70) of its original lumen output. Use of metal core board ensures greater heat transfer and longer lifespan of the light engine.

**Optical System:** (RLE5), IES type Y (symmetrical). Composed of high-performance acrylic refractor lenses to achieve optimized distribution and get maximum spacing, target luminers will create a perfect lighting uniformity. Performance shall be tested per LM-63, LM-79 and TM-15 (IESNA) certifying its photometric performance. Painted color grey.
Heat Sink: Made of extruded aluminum optimising the LEDs efficiency and life. Product does not use any cooling device with moving parts (only passive cooling device).

Driver: High power factor of 90%. Electronic driver, operating range 50/60 Hz. Auto-adjusting to a voltage between 120 and 277 volt AC rated for both application line to line or line to neutral. Class II, THD of .20% max. Maximum ambient operating temperature from -40F(-40C) to 130F(55C) degrees. Certified in compliance to cULus requirement. Dry and damp location. Assembled on a unitized removable tray with Tyco quick disconnect plug resisting to 221F(105C) degrees.

The current supplying the LEDs will be reduced by the driver if the internal driver temperature exceeds 185F(85C), as a protection to the LEDs and the electrical components. Output is protected from short circuits, voltage overload and current overload. Automatic recovery after correction.

Surge Protector: Surge protector tested in accordance with ANSI/IEEE C62.45 per ANSI/IEEE C62.41.2 Scenario I Category C High Exposure 10kV/10kA waveforms for Line-Ground, Line-Neutral and Neutral-Ground, and in accordance with U.S. DOE (Department of Energy) MS56LC (Municipal Solid-State Street Lighting Consortium) model specification for LED roadway luminaires electrical immunity requirements for High Test Level 10kV / 10kA.

Fitter: (SFZ4), Cast 356 aluminum c/w 8 set screws 3/8-16 UNC. Slip-fits on a 4” (102mm) outside diameter x 4” (102mm) long lenon.

---

### Miscellaneous

**Description of Components:**

**Wiring:** Gauge (#14) TEW/AWM 1015 or 1230 wires, 6” (152mm) minimum exceeding from luminaire.

**Hardware:** All exposed screws shall be stainless steel with Ceramic primer-seal basecoat to reduce seizing of the parts. All seals and sealing devices are made and/or lined with EPDM and/or silicone and/or rubber.

**Finish:** (SCUS542M65SM) Special Color US542M65, smooth Protech U series Matt Smooth, Bronze “Roman”. In accordance with the AAMA 2603 standard. Application of polyester powder coat paint (4 mils/100 microns) with ± 1 mils/24 microns of tolerance. The Thermosetting resins provides a discoloration resistant finish in accordance with the ASTM D2244 standard, as well as luster retention in keeping with the ASTM D523 standard and humidity proof in accordance with the ASTM D2247 standard.

The surface treatment achieves a minimum of 2000 hours for salt spray resistant finish in accordance with testing performed and per ASTM B117 standard.

**Surface Finish:** The above mentioned product has been specified in a smooth finish. We wish to inform you that we cannot guarantee a finish without imperfections (e.g. apparent grinding marks and porosity). We strongly recommend the use of a textured finish which provides better uniformity of surface finish. No return of merchandise showing above mentioned imperfection will be granted.

**LED products manufacturing standard:** The electronic components sensitive to electrostatic discharge (ESD) such as light emitting diodes (LEDs) are assembled in compliance with IEC61340-5-1 and ANSI/ESD S20.20 standards so as to eliminate ESD events that could decrease the useful life of the product.

**Quality Control:** The manufacturer must provide a written confirmation of its ISO 9001-2008 and ISO 14001-2004 International Quality Standards Certification.

**Mechanical resistance:** In order to ensure the mechanical resistance of the poles, the reflected area should be calculated according to AASHTO standards and resists to a wind of 140 km/hr.

**Web site information details:** Click on any specific information details you need:
**Exterior Lighting and Installation**

**Pedestrian Poles and Fixture Datasheets**

**Version 3.0.2018**

**Page 123**

---

### Details

**A. MODEL**
- **T1** Mediterranean

**B. LENS OPTIONS**
- **AC** acrylic, clear
- **AF** acrylic, frosted

**C. CAGE**
- **C1** Mediterranean
- **C2** London
- **C3** Monaco
- **C4** Park Lane
- **C5** Brighton
- **NC** no cage

**D. HOUSING**
- **H1** Mediterranean
- **H2** London
- **H3** Monaco
- **H4** Park Lane
- **H5** Brighton

**E. SOURCE**
- **24NB-55** 55 Watts - LED array
- **36NB-90** 80 Watts - LED array
- **48NB-110** 110 Watts - LED array

**F. CCT - COLOR TEMP**
- **3K** 3000K
- **4K** 4000K
- **5K** 5000K

**G. VOLTAGE**
- **UNV** 120-277V
- **347** 347V
- **480** 480V

---

**Examples**

Shown with standard Mediterranean configuration:
- **Top:** T1
- **Cage:** C1
- **Housing:** H1

Below displays several examples of the over 20 custom configurations available:

---

**H. OPTICS**
- **DR2** type II
- **DR3** type III
- **DR4** type IV
- **DR5** type V

**I. ELECTRICAL OPTIONS**
- **PEC** photocell, button
- **PCR-TL** photocell, twist-lock
- **PCR-SC** photocell, shorting cap

**J. COLOR**
- **BBT** basic black textured
- **BMT** black matte textured
- **WHT** white textured
- **MBT** metallic bronze textured
- **BZT** bronze textured
- **DBT** dark bronze textured
- **GYS** gray smooth
- **DPS** dark platinum smooth
- **GNT** green textured
- **MST** metallic silver textured
- **MTT** metallic titanium textured
- **OWI** old world iron

**RAL**

---

---

ORDERING
**Housing:** All cast aluminum parts shall be low copper alloy A386. All extruded aluminum parts shall be alloy 6061-T6, 6063-T5 or equal.

**Construction:** The upper chamber fillet shall be topped by a decorative cast aluminum finish/cap and mechanically fastened to the optical chamber. The cast multi-sided cage shall accommodate UV stabilized acrylic or polycarbonate lenses (side panels) which shall be sealed for weather tight operation. The electrical chamber/fitter shall be aluminum, decorative fitter designed to accommodate the ballast assembly and shall mount to 3 3/4" O.D. x 3" H tenon and secured by three stainless steel set screws.

**Fasteners:** All fasteners shall be Corrosion Resistant. When tamper resistant fasteners are required, sparrow HD (snake eye) style shall be provided (special tool required, available at additional cost).

**Finish:** Finish shall be a Beacco V polyester powder-coat electro-statically applied and thermocured. Beacco V finish shall consist of 5 stage iron phosphate chemical pretreatment regimen, a polymer primer sealer, oven dry off, and top coated with a thermoset super TSG polyester powder coat finish. The finish shall meet the AMMA 605.2 performance specification which includes passing a 3000 hour salt spray test for corrosion resistance and resists crazing or loss of adhesion per ASTM D652 and resists surface impacts of up to 150 inch-pound.

**Beaco Optical System:** Each luminaire is supplied with an optical one piece cartridge system consisting of an LED engine, LED lamps, optics, gasket and stainless steel bezel. The cartridge is held together with internal brass standoffs soldered to the board so that it can be field replaced as a one piece optical system. Turned silicon and polycarbonate foam gasket ensures a weatherproof seal around each individual LED and allows the luminaire to be rated for high-pressure hose down applications. The optical cartridge is sealed to the extruded housing with fasteners and a heat sink to ensure thermal conductivity. The optics are held in place without the use of adhesives and the complete assembly is gasketed for high pressure hose down cleaning. The cartridge assembly is available in various lighting distributions using a specially designed acrylic optical lens over each LED.

**Power Supply/Driver Requirements:** U.L. UL1310, Class 2 and UL482 compliant

**Color Rendering Index (CRI):** Luminaire shall have a minimum CRI of 57 at 5000K.

**Operating Environment:** Shall be able to operate normally in ambient temperatures from -40°C to 40°C

**Lifeshield Circuit:** Thermal circuit shall protect the luminaire from excessive temperature by interfacing with its 0-10V dimmable drivers to reduce drive current as necessary. The factory-set temperature limits shall be designed to ensure maximum hours of operation to assure L70 rated lumen maintenance. The device shall activate at a specific, factory-set temperature, and progressively reduce power over a finite temperature range in recognition of the effect of reduced current on the internal temperature and longevity of the LEDs and other components. A luminaire equipped with the device may be reliably operated in any ambient temperature up to 59°C (139°F). The thermal circuit will allow higher maximum Wattages than would be permissible on an unregulated luminaire (if some variation in light output is permissible), without risk of premature LED failure. Operation shall be smooth and undetectable to the eye. Thermal circuit shall directly measure the temperature at the LED solder point.

Thermal circuit shall consist of surface mounted components mounted on the LED engine (printed circuit board). For maximum simplicity and reliability, the device shall have no dedicated enclosure, circuit board, wiring harness, gaskets, or hardware. Device shall have no moving parts, and shall operate entirely at low voltage (NEC Class 2). The device shall be located in an area of the luminaire that is protected from the elements.

Thermal circuit shall be designed to “fail on”, allowing the luminaire to revert to full power in the event of an interruption of its power supply, or faulty wiring connection to the drivers.

Device shall be able to co-exist with other 0-10V control devices (occupancy sensors, external dimmers, etc.). The device will effectively control the address point temperature as needed; otherwise it will allow the other control device(s) to function unperturbed.

**Surge Protector:** The on-board surge protector shall be a U.I. recognized component for the United States and Canada and have a surge current rating of 20,000 Amps using the industry standard 8/20 microsecond wave. The LSP shall have a clamping voltage of 106V and surge rating of 4500. The case shall be a high-temperature, flame resistant plastic enclosure.

**Electrical:** Luminaire are equipped with LED driver(s) that accept 90 through 365 VAC, 50 Hz to 60 Hz (UNIV). Power factor is .92 at full load. All electrical components are rated at 56,000 hours at full load and 25°C ambient conditions per ML-217P Notice 2. All driver components supplied are component-to-component wiring within the luminaire will carry no more than 93% of rated current and is listed by U.L. for use at 600VAC at 50°C or higher. Plug disconnects are listed by U.L. for use at 600 VAC, 15A or higher.

**Agency Certification:** The luminaire shall bear an NFPA label and be marked suitable for wet locations.

**Limited Warranty:** Beacon luminaires feature a 5-year limited warranty. Beacon LED luminaires with LED arrays feature a 5 year limited warranty covering the LED arrays. LED drivers are covered by a 5 year limited warranty. PF sensors carry a 5 year limited warranty from the sensor manufacturer. See Warranty Information on www.beaconproducts.com for complete details and exclusions.

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Due to our continued efforts to improve our products, product specifications are subject to change without notice.
Description of Components:

Pole Shaft: Shall be made from a mandrel-formed aluminum tapered shaft, 12 fluted round, having a 0.125" (3.2mm) wall thickness, welded to both the bottom and top of the anchor plate.

Base Cover: Two piece round base cover made from cast 356 aluminum, mechanically fastened with stainless steel screws.

Pole Options: One HEY-AA double fuse holder to accept two KTKR1 fuses (provided by other).

Note: A tenon will be provided when the luminaire or bracket does not fit directly on pole shaft. Tenon not shown on the drawing.

IMPORTANT: Philips Lumelec strongly recommends the installation of the complete lighting assembly with all of its accessories upon the anchoring of the pole. This will ensure that the structural integrity of the product is maintained throughout its lifetime.

Pole Weight: 28 lbs (12.7 kg)
CC/CCS17
17" Arm Mounted, Curvilinear, PicoEmitter™ LED
revision 11/21/14 • kl_cc17awled_spec.pdf

Specifications

17" Diameter
60 Light Emitting Diodes
Total System Watts = 64W

Housing: Spun aluminum. (Rollformed linear reveals; CC: Three equally spaced reveals, ½" wide, separated by ½" ribs, ¾" deep.
CCS: One ¼" groove, ½" deep.) Sidewalls have a maximum of 1" of taper, and are free of welds or fasteners. A rollformed aluminum flange is hemmed into the bottom providing support for the reflector module. An internal aluminum casting provides for mounting of the electrical module plus reinforcing for side-arm mounting of the fixture.

Lens Frame Assembly: One-piece cast aluminum lens frame is attached to the housing by a zinc plated cold rolled steel hinge with a stainless steel pin. Closure is by one self-retained stainless steel screw. A stainless steel self-locking stop arm is provided to hold the lens frame in the open position while servicing. A ¾" thick clear flat tempered glass lens is fully gasketed by a one-piece extruded and vulcanized silicone gasket. Lens is retained in the frame by removable zinc plated steel clips.

Standard Arm Mounting: Arm is one-piece extruded aluminum with internal bolt guides and fully radiused top and bottom. Luminaire-to-pole attachment is by internal draw bolts, and includes a pole reinforcing plate with wire strain relief. Arm is circular cut to mate with specified round pole.

Electronic Module: All electrical components are UL and CSA recognized, mounted on a single plate and factory prewired with quick-disconnect plugs. Module includes a driver, LifeShield™ temperature control device and surge protector. Electrical module attaches to housing with key hole slots, accessible by opening the lens frame and removing optical module. Driver is rated for 40°F starting and has a 0-10V dimming interface for multi-level illumination options.

Optical Module: Precision, replaceable PicoEmitters are positioned to achieve directional control toward desired task. The entire PicoEmitter™ Deck™ mounting assembly fastens to the housing as a one-piece module.

Finish/Color: TGIC thermoset polyester powder coat paint. 2.5 mil nominal thickness. Standard colors are Black, Dark Bronze, Light Gray, Stealth Gray™, Platinum Silver, or White. Custom colors are available.


Warranty: Kim Lighting warrants Curvilinear LED products ("Products") sold by Kim Lighting to be free from defects in material and workmanship for (i) a period of five (5) years for metal parts, (ii) a period of ten (10) years for exterior housing paint finish, (iii) a period of six (6) years for LED Light Engines (PicoEmitter reflectors) and, (iv) a period of five (5) years for LED power components (LED Driver, LifeShield™ temperature control device, surge protector), from the date of sale of such goods to the buyer as specified in Kim Lighting shipment documents for each product.

CAUTION: Fixtures must be grounded in accordance with national, state and/or local electrical codes. Failure to do so may result in serious injury.

Kim Lighting reserves the right to change specifications without notice.

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Exterior Lighting and Installation
Pedestrian Poles and Fixture Datasheets
Version 3.0.2018
Page 126
## Standard Features

### Mounting
3Y configuration is available for round poles only.

### Fixture
Cat. No. designates CC/CCS fixture and light distribution.

### Electrical Module
Cat. Nos. for Electrical Modules available:

<table>
<thead>
<tr>
<th>Source</th>
<th>Color Temperature</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>60 = 60 LEDs</td>
<td>120V</td>
</tr>
<tr>
<td></td>
<td>3K = 3000K</td>
<td>208V</td>
</tr>
<tr>
<td></td>
<td>4K = 4200K</td>
<td>240V</td>
</tr>
<tr>
<td></td>
<td>5K = 5100K</td>
<td>347V</td>
</tr>
<tr>
<td></td>
<td>2K = 5000K - Amber</td>
<td>480V</td>
</tr>
</tbody>
</table>

1. Due to current unavailability of 347V and 480V drivers, specification of these voltages may feature an integral step-down transformer.

### Optional Features
- Polycarbonate Lens
  - Cat. No. L17F
  - No Option
  - Clear UV stabilized polycarbonate replaces standard flat glass lens, gasketed and integral with lens frame.
  - CAUTION: Use only when vandalism is anticipated to be high. Useful life is limited by UV discoloration from sunlight.
Form 10 Round LED

The Philips Gardco wall mounted Round Form 10 LED products are cutoff luminaires featuring LED arrays. Round Form 10 LED luminaires provide performance excellence and advanced Philips Gardco LED thermal management technology. High performance Class 1 LED systems offer the potential for energy savings up to 50% when compared to HID systems. Housings are one-piece seamless spun aluminum and finished with either Architectural Class 1 anodized, black, or satin black powder coat or powdercoat. Luminaires provide full cutoff performance.

**DISTRIBUTION**

<table>
<thead>
<tr>
<th>finishing</th>
<th>options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LED WATTAGE AND LUMEN VALUES**

<table>
<thead>
<tr>
<th>Ordering Code</th>
<th>Average System Watts</th>
<th>LED Current (mA)</th>
<th>LED Selection</th>
<th>Luminous Initial (Absolute) Luminous*</th>
<th>Basis of Lumen Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>70LA</td>
<td>70</td>
<td>350</td>
<td>CW</td>
<td>66417, 6737, 6530, 6000, 6400</td>
<td>Photometric tests performed in compliance with IESNA LM-79, unless otherwise indicated.</td>
</tr>
<tr>
<td>85LA</td>
<td>85</td>
<td>350</td>
<td>CW</td>
<td>59326, 6124, 5903, 5074</td>
<td>Notes:</td>
</tr>
<tr>
<td>110LA</td>
<td>110</td>
<td>350</td>
<td>CW</td>
<td>7406, 7671, 7411, 6924</td>
<td>1. Wattage may vary by ±5% due to LED luminous forward with pincushion and plumbosol variations. Watts shown is for luminaire with aluminum reflector. Actual wattage may vary by more than 5% due to actual input voltage.</td>
</tr>
<tr>
<td>150LA</td>
<td>150</td>
<td>350</td>
<td>CW</td>
<td>95330, 9700, 9364, 8524</td>
<td>2. Luminous flux is for luminaire without the HI-1000 shroud. Luminous flux is for luminaire with the HI-1000 shroud.</td>
</tr>
<tr>
<td>200LA</td>
<td>200</td>
<td>350</td>
<td>CW</td>
<td>8911, 9120, 8510, 7603</td>
<td>3. LED arrays feature LEDs that provide 150 to 300 lumens per watt when operated at 350 volts. Lumen values based on tests performed in compliance with IESNA LM-79.</td>
</tr>
</tbody>
</table>

**LED SELECTION**

- **CW** Cool White - 5000K - 75 CRI
- **NW** Neutral White - 4000K - 70 CRI
- **WW** Warm White - 3000K - 80 CRI

**VOLTAGE**

- **UNIV** 120V through 277V, 50Hz or 60Hz
- **HVU** 347V through 480V, 50Hz or 60Hz (High Voltage Universal)
Form 10 Round LED
CW / MW Wall Mount

FINISH
BRP  Bronze Paint
BLP  Black Paint
WP  White Paint
NP  Natural Aluminum Paint
BRA  Bronze Anodized
BLA  Black Anodized
NA  Natural Anodized

OPTIONS
F  Fitting
PC  Photocontrol and Receptacle
PCR  Photocontrol Receptacle only
SPR  Surge Protection for 120V through 277V Input meeting ANSI C42.41.2
SPRF  Surge Protection for 480V Input meeting ANSI C42.41.2

DIMENSIONS AND EPA

---

1611 Clarks Barker Road, San Marcos, TX 78666
(800) 377-4758  (512) 753-1000  FAX: (512) 753-7855 sitallighting.com
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Philips Gardco reserves the right to change materials or modify the design of its product without notification as part of the company's continuing product improvement program.
G290-02/1912
LTRA
Round Aluminum Tapered Pole
revision 5/6/13 • LTRA_spec.pdf

Specifications

Pole Construction: Tapered by spinning and coldworking a seamless one-piece extruded tube of aluminum alloy 6063-T6. After tapering, shaft is welded to a cast aluminum anchor base of alloy A356, heat-treated to T6 temper, and rotary sand finished. Poles above 39° include a flush field joint approximately 26½ above base, with both sections taper spun.

Bolt Covers: Cast aluminum anchor bolt covers included.

Pole Cap: A flush-sided cast aluminum pole cap is provided for side arm mounted luminaires.

Handhole: Reinforced handhole with a gasketed cover and grounding provisions provided, 16° up from base. Cover mounts flush.

Anchor Bolts: Four galvanized anchor bolts provided complete with eight nuts, eight flat washers, and a presswood template.

Vibration Dampener: Poles 20° and above include a mechanically fastened internal pendulum vibration dampener.

Strength: Poles will withstand wind loads as listed in chart (see page 2) when luminaires are mounted per fixture installation instructions.

Finish: Standard thermostet polyester powder coat paint over anodized zincum conversion coating. Standard colors are Black, Dark Bronze, Light Gray, Stealth Gray™, Platinum Silver, and White. Custom colors are available.

CAUTION: Installation of poles without luminaires will compromise pole strength. Any accessories attached to pole, or other modifications, will compromise pole strength and may result in pole failure.

Maintenance: A regularly scheduled maintenance program must be established to ensure the protective paint coating is intact, corrosion or structural damage has not occurred, and anchor bolt nuts are tight. Failure to do so could lead to pole collapse and serious personal injury.
### Standard Features

**NOTE:** All allowable pole and fixture EPA are derived from the AASHTO standard. Responsibility lies with the specifier for correct pole selection based on local codes and standards for the job location. (See page 4).

<table>
<thead>
<tr>
<th>Pole Catalog Number</th>
<th>Pole X Y Z</th>
<th>Allowable Pole EPA</th>
<th>Wind Map Steady Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTRA16-6156 16' 6&quot; x 156 4&quot;</td>
<td>21.00 19.36 17.93 14.70 12.26 10.30 8.67 7.36</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA16-6188 16' 6&quot; x 188 4&quot;</td>
<td>26.32 23.36 21.64 17.77 14.83 12.49 10.56 9.01</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA20-5156 20' 5&quot; x 156 3&quot;</td>
<td>9.67 8.51 7.98 6.45 5.30 4.42 3.73 3.18</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA20-5188 20' 5&quot; x 188 3&quot;</td>
<td>12.01 10.59 9.89 8.03 6.63 5.55 4.70 4.03</td>
<td>100</td>
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<tr>
<td>LTRA20-6156 20' 6&quot; x 156 4&quot;</td>
<td>15.75 13.94 12.96 10.58 8.77 7.30 6.04 5.03</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA20-6188 20' 6&quot; x 188 4&quot;</td>
<td>19.23 17.04 15.82 12.94 10.76 8.99 7.50 6.30</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA25-6156 25' 6&quot; x 156 4&quot;</td>
<td>10.73 9.44 8.85 7.15 5.88 4.79 3.84 3.06</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA25-6188 25' 6&quot; x 188 4&quot;</td>
<td>13.39 11.82 11.04 8.96 7.39 6.08 4.95 4.03</td>
<td>100</td>
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<tr>
<td>LTRA25-7156 25' 7&quot; x 156 4&quot;</td>
<td>16.32 14.43 13.44 10.55 8.85 7.19 5.88 4.81</td>
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<tr>
<td>LTRA25-8156 25' 8&quot; x 156 4&quot;</td>
<td>23.70 20.13 18.00 14.90 12.90 10.90 8.17 6.27</td>
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<tr>
<td>LTRA30-6156 30' 6&quot; x 156 4&quot;</td>
<td>11.54 10.47 9.81 7.93 6.26 4.93 3.87 3.02</td>
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<tr>
<td>LTRA30-8156 30' 8&quot; x 156 4&quot;</td>
<td>17.06 15.09 13.96 11.00 8.75 6.99 5.60 4.48</td>
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<tr>
<td>LTRA30-9188 30' 9&quot; x 188 4&quot;</td>
<td>21.03 18.62 17.31 13.69 11.01 8.92 7.26 5.92</td>
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<td></td>
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<tr>
<td>LTRA35-8250 35' 8&quot; x 250 4&quot;</td>
<td>28.43 25.23 23.30 18.72 15.23 12.52 10.36 8.63</td>
<td>100</td>
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<tr>
<td>LTRA35-8156 35' 8&quot; x 156 4&quot;</td>
<td>13.01 11.45 10.63 8.17 6.30 4.84 3.69 2.75</td>
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<tr>
<td>LTRA35-8188 35' 8&quot; x 188 4&quot;</td>
<td>16.30 14.38 13.33 10.40 8.17 6.44 5.06 3.95</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA35-8250 35' 8&quot; x 250 4&quot;</td>
<td>22.44 19.86 18.37 14.57 11.68 9.42 7.64 6.20</td>
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<td></td>
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<tr>
<td>LTRA35-10188 35' 10&quot; x 188 6&quot;</td>
<td>26.03 24.51 22.20 17.56 14.03 11.29 9.11 7.35</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA39-8188 39' 8&quot; x 188 4&quot;</td>
<td>13.29 11.68 10.85 8.28 6.33 4.81 3.60 2.63</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA39-8250 39' 8&quot; x 250 4&quot;</td>
<td>18.68 16.49 15.28 11.94 9.40 7.43 5.86 4.60</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA39-10188 39' 10&quot; x 188 6&quot;</td>
<td>23.51 20.43 18.40 14.33 11.23 8.82 6.91 5.37</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA39-10250 39' 10&quot; x 250 6&quot;</td>
<td>32.23 28.20 25.56 20.25 16.20 13.06 10.56 8.55</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LTRA48-10250 48' 10&quot; x 250 6&quot;</td>
<td>22.78 19.65 17.39 13.46 10.31 7.87 5.93 4.36</td>
<td>100</td>
<td></td>
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<tr>
<td>LTRA50-10250 50' 10&quot; x 250 6&quot;</td>
<td>15.95 13.44 9.65 6.85 4.72 3.07 1.75</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

48' and 50' poles are 2-piece assemblies.

### Anchor Base and Bolt Detail

<table>
<thead>
<tr>
<th>Pole Height</th>
<th>Y Pole Diameter</th>
<th>Bolt Circle Dia</th>
<th>Anchor Bolt Projection</th>
<th>Anchor Bolt Size</th>
<th>Base Size</th>
<th>Conduit Opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>20'</td>
<td>5&quot;</td>
<td>9/16&quot;</td>
<td>3/4&quot; x 30&quot; + 4&quot;</td>
<td>9 1/2&quot; sq.</td>
<td>41/2&quot; Dia</td>
<td></td>
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<tr>
<td>16-25'</td>
<td>6&quot;</td>
<td>9/16&quot;</td>
<td>3/4&quot; x 30&quot; + 4&quot;</td>
<td>10 1/4&quot; sq.</td>
<td>5&quot; Dia</td>
<td></td>
</tr>
<tr>
<td>25' - 39'</td>
<td>7&quot;</td>
<td>11/16&quot;</td>
<td>1&quot; x 36&quot; + 4&quot;</td>
<td>10 1/2&quot; sq.</td>
<td>61/2&quot; Dia</td>
<td></td>
</tr>
<tr>
<td>35' - 48'</td>
<td>10&quot;</td>
<td>11/16&quot;</td>
<td>1&quot; x 36&quot; + 4&quot;</td>
<td>11 1/2&quot; sq.</td>
<td>7 1/2&quot; Dia</td>
<td></td>
</tr>
<tr>
<td>50'</td>
<td>10&quot;</td>
<td>11/16&quot;</td>
<td>1&quot; x 36&quot; + 4&quot;</td>
<td>14 1/2&quot; sq.</td>
<td>9 1/2&quot; Dia</td>
<td></td>
</tr>
</tbody>
</table>

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Roadway / Parking Poles and Fixture Datasheets Page 132
## Standard Features

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<tr>
<th>Mounting</th>
<th>Plan Views:</th>
<th>Side Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[<img src="" alt="Images of mounts and pole views" />]</td>
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</tr>
<tr>
<td>Mounting¹</td>
<td>☐ FM ☐ A ☐ SA ☐ B ☐ SB ☐ L ☐ SL ☐ T ☐ ST ☐ Y ☐ SY ☐ C ☐ SC</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Allowable Pole EPA for jobsite wind conditions must be equal to or greater than fixture mount EPA. Please refer to Kim luminaire catalog for specific fixture.

See luminaire drilling requirements in luminaire catalog.

### Structural Luminares Only - Examples
- ☐ TS: Single Tension for small and large Structural - LTRA20-5156B-TS
- ☐ TD: Double Tension for small and large Structural - LTRA20-5156B-TD
- ☐ TR: Truss for small and large Structural - LTRA20-5156B-TR
- ☐ XTS: Single Tension for 1000W Structural - LTRA20-5156B-XTS
- ☐ XTD: Double Tension for 1000W Structural - LTRA20-5156B-XTD
- ☐ XTR: Truss for 1000W Structural - LTRA20-5156B-XTR

### Finish

<table>
<thead>
<tr>
<th>Color:</th>
<th>Black</th>
<th>Dark Bronze</th>
<th>Light Gray</th>
<th>Stealth Gray²</th>
<th>Platinum Silver</th>
<th>White</th>
<th>Custom Color²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat. No.:</td>
<td>☐ BL</td>
<td>☐ DB</td>
<td>☐ LG</td>
<td>☐ SG</td>
<td>☐ PS</td>
<td>☐ WH</td>
<td>☐ CC</td>
</tr>
</tbody>
</table>

²Custom color subject to additional charges, minimum quantities and extended lead times. Consult representative. Custom color description: [DBA31](#)
## Tapered Round Aluminum - Cast Base

The Philips Gardco TRA tapered round aluminum pole consists of a one-piece design fabricated aluminum tubing circumferentially welded to a cast aluminum base. The poles are finished with either Architectural Class 1 anodizing or electrochemically applied Tafco polyester powdercoat. All poles include anchor bolts, hand hole, ground lug and top cap.

### TRA-CB-30L-D1-BRA311-VDA

### OPTIONS

<table>
<thead>
<tr>
<th>FINISH</th>
<th>OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRP</td>
<td>Duplex Receptacle</td>
</tr>
<tr>
<td>BLP</td>
<td>Ground Fault Receptacle</td>
</tr>
<tr>
<td>WP</td>
<td>Vibration Damper</td>
</tr>
<tr>
<td>NP</td>
<td>Brass Anodized</td>
</tr>
<tr>
<td>BR</td>
<td>Natural Aluminum Paint</td>
</tr>
<tr>
<td>BCA</td>
<td>Special Color Paint</td>
</tr>
</tbody>
</table>

### Notes:

- 

**1.** Refers to relative strength based on wind load factor. L-Guide; M = Medium; H = Heavy.

**2.** Indicates size (1/4", 3/16", 1/2", 1 1/2", 2") indicates height above base and orientation to hand hole. See Pole Orientation Information on Page 4.

**3.** Indicate height above base and orientation to hand hole. See Pole Orientation Information on Page 4.

**4.** Minimum Pole Height is 18". Includes a 1/2" coupling bored 1/8" to the hand hole, 12" above the base hole.

**5.** Motion Response Provisions:

- **GMR:** Gardco HID Motion Response System
- **MSM:** Motion Sensor Mounting Provision for LED Luminaires available with Motion Response

**6.** Philips Gardco reserves the right to change materials or modify the design of its product without notification as part of the company's continuing product improvement program.
POLE DATA

<table>
<thead>
<tr>
<th>CATALOG NUMBER</th>
<th>POLE SIZE</th>
<th>MAXIMUM LUMINAIRE LOADING</th>
<th>ANCHOR BOLT DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACTUAL HEIGHT</td>
<td>POLE SHAFT SIZE</td>
<td>WALL THICKNESS</td>
</tr>
<tr>
<td>TRA-CB-8</td>
<td>7’ 6”</td>
<td>3 x 4</td>
<td>.125</td>
</tr>
<tr>
<td>TRA-CB-10</td>
<td>9’ 8”</td>
<td>3 x 4</td>
<td>.125</td>
</tr>
<tr>
<td>TRA-CB-12L</td>
<td>11’ 8”</td>
<td>3 x 3</td>
<td>.125</td>
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<tr>
<td>TRA-CB-12M</td>
<td>11’ 8”</td>
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<td>.125</td>
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<tr>
<td>TRA-CB-14L</td>
<td>13’ 8”</td>
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<td>.125</td>
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<td>TRA-CB-16M</td>
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</tr>
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<td>TRA-CB-20L</td>
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<td>.125</td>
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<td>TRA-CB-20M</td>
<td>19’ 8”</td>
<td>3 x 5</td>
<td>.125</td>
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<td>TRA-CB-25H</td>
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<tr>
<td>TRA-CB-28L</td>
<td>27’ 8”</td>
<td>4 x 7</td>
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<tr>
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<tr>
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<td>TRA-CB-37L</td>
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<td>TRA-CB-37H</td>
<td>38’ 8”</td>
<td>4 x 8</td>
<td>.156</td>
</tr>
</tbody>
</table>

2. Warning: Additional wind loading, in terms of EPA, from banners, cameras, floodlights and other accessories attached to the pole, must be added to the luminaire(s) EPA before selecting the pole with the appropriate wind load capability.

3. Factory supplied template must be used when setting anchor bolts. Philips Gardco will not honor any claim for incorrect anchorage placement resulting from failure to use factory supplied templates.

4. Includes (VDA) Vibration Damper standard.

DIMENSIONS

NOTE: Factory supplied template must be used when setting anchor bolts. Philips Gardco will not honor any claim for incorrect anchorage placement resulting from failure to use factory supplied templates.
**OSQ Series**

**LED Area/Flood Luminaires – Medium**

**Product Description**
The OSQ Area/Flood luminaires blend extreme optical control, advanced thermal management, and modern, clean aesthetics. Built to last, the housing is rugged cast aluminum with an integral, weathertight LED driver compartment. Versatile mounting configurations offer simple installation. Its slim, low-profile design minimizes wind load requirements and blends seamlessly into the site providing even, quality illumination. If input power designer is a suitable upgrade for HID applications up to 250 Watt. \*J Input power designer is a suitable upgrade for HID applications up to 400 Watt.

**Applications:** Parking lots, walkways, campuses, car dealerships, office complexes, and internal roadways.

**Performance Summary**
- Utilizes BetaLED® Technology
- NanoOptic® Precision Delivery Grid™ optic
- Made in the U.S. of U.S. and imported parts
- CRI: Minimum 70 CRI (4000K & 5700K); 80 CRI (3000K)
- CCT: 3000K (+/- 300K), 4000K (+/- 300K), 5700K (+/- 500K)
- Limited Warranty: 10 years on luminaire/10 years on Colorfast DeltaGuard® finish

**Accessories**
- Field-installed
- Reflectors:
  - OSQ BL500F: Front facing optics
  - OSQ BL503R: Rotated optics

**Ordering Information**
- Fully assembled luminaires are composed of two components that must be ordered separately:

**Mount (Luminaire must be ordered separately)**

<table>
<thead>
<tr>
<th>Mount (Luminaire)</th>
<th>Color Options:</th>
<th>ISD, THD, PBD, CSD, RSD, XSD, YSD, ZSD, WSD, MSD</th>
<th>Option:</th>
<th>THD, PBD, CSD, RSD, XSD, YSD, ZSD, WSD, MSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSQ-AA Adjustable Arm</td>
<td>7W Silver, BK Black, PB Platinum Bronze, WW White</td>
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<td>OSQ-AA (Fixed Arm)</td>
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</tr>
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</table>

**Fixtures:**
- Mounting Arm: CREE OSQ-DA-PB

**Reprints:**
- www.cree.com/lighting
- US: 1-800-426-4554
- Canada: 1-800-447-1234
- www.cree.com/canada

**UL Listed**
- UL 924
- DLC Listed

**Version:** V4.02/2014

**Utilities & Energy Services**
- Texas A&M University
**Exterior Lighting and Installation**

**Roadway / Parking Poles and Fixture Datasheets**

**Version 3.0.2018**

**Page 137**

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**EcoForm**

EcoForm combines economy with performance in an LED area luminaire. Capable of delivering up to 20,000 lumens or more in a compact, low profile housing, EcoForm offers a new level of customer value. EcoForm features an innovative retrofit arm kit, simplifying site conversions to LED by eliminating the need to drill additional holes in most existing poles. Integral control systems, including motion response and wireless controls are available for further energy savings during off peak hours.

### Ordering guide

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Controls</th>
<th>Mounting</th>
<th>Optics</th>
<th>LED Wattage</th>
<th>Color Temp</th>
<th>Voltage</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECF</td>
<td>Standard</td>
<td>1</td>
<td>2</td>
<td>530 mA</td>
<td>CW</td>
<td>120</td>
<td>UNV</td>
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<td>ECF</td>
<td>-</td>
<td></td>
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<tr>
<td>ECF</td>
<td>EcoForm</td>
<td>-</td>
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<tr>
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<td>2</td>
<td>2</td>
<td>55L-325A</td>
<td>Cool White</td>
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<td>3</td>
<td>70L-4853</td>
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<td>DIM-0W Dimming</td>
<td>1</td>
<td>2</td>
<td>105L-327A</td>
<td>Neutral White</td>
<td>277</td>
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<td>APD-MRI</td>
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<tr>
<td>EFC</td>
<td>LimeLight Wireless Controls</td>
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<tr>
<td>EFC</td>
<td>LLC2-2 circuits for 2-12</td>
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<tr>
<td>EFC</td>
<td>LLC3-4 circuits for 12-24</td>
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<td>EFC</td>
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<td>EFC</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

---

1. Available in 120V - 277V Voltages only (UNV, 120, 208, 240 & 277).
2. MR16 and ADP-MRO Luminaires require one motion sensor per pole, ordered separately. See page 2 for accessories. Available in 120V or 277V only.
3. EFC-MRI requires a built-in sensor when used with Terminal Block (TBD) Option.
4. Contact factory for lead times on warm white finish:
5. LL3/LLC3/LLC4 3子 Wire Luminaires are not compatible with PC/PC/PCS/PCS/PCS Options. See page 2 for accessory options.
6. Not compatible with Type A (1) Optics.
7. Not compatible with 120V - 277V (UNV) Voltage. Voltage must be specified.
12. Works with 3-pin or 5-pin NEMA photocells/dimmer devices and auxiliary connections are not connected (for future use only).
13. EcoForm is compatible with DAP, MRG, ADP-MRI, ADP-MRO, dimmable. It will not be connected to NEMA receptacle.
ECF  EcoForm
Site & Area

EcoForm Accessories (order separately)

FS1R-100
MR hand held programmer
For use with "MRR" motion response when field programming is required. If desired, only one is needed per job.

MS-A-120V
120V Input Area Motion Sensor
For MR50 (Motion Response) or APD-MRIO (Automatic Profile Dimming with Motion Response Override)

MS-A-277V
277V Input Area Motion Sensor
For MR50 (Motion Response) or APD-MRIO (Automatic Profile Dimming with Motion Response Override)

Note: Motion Sensors are ordered separately, with one (1) motion sensor required per pole location for MR50 or APD-MRIO luminaires. See Luminaire Configuration Information on page 5 for more details. Aera motion sensor color is Arctic White. MRI and APD-MRI luminaires include an integral motion sensor.

EcoForm Drill Template (standard arm mount)

LED Wattage and Lumen Values (standard EcoForm luminaire)

<table>
<thead>
<tr>
<th>Order Code (standard units)</th>
<th>Array Quantity</th>
<th>Total LEDs</th>
<th>LED Current (mA)</th>
<th>Average System Watts¹</th>
<th>LED Selection</th>
<th>Initial Lumens²</th>
</tr>
</thead>
<tbody>
<tr>
<td>55LA-3253</td>
<td>2</td>
<td>32</td>
<td>530</td>
<td>52</td>
<td>NW</td>
<td>5,994 (s)</td>
</tr>
<tr>
<td>75LA-4853</td>
<td>3</td>
<td>48</td>
<td>530</td>
<td>77</td>
<td>NW</td>
<td>8,899 (s)</td>
</tr>
<tr>
<td>100LA-6452</td>
<td>4</td>
<td>64</td>
<td>530</td>
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<td>NW</td>
<td>11,700 (s)</td>
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<tr>
<td>70LA-3270</td>
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<td>32</td>
<td>700</td>
<td>69</td>
<td>NW</td>
<td>7,385 (s)</td>
</tr>
<tr>
<td>105LA-4870</td>
<td>3</td>
<td>48</td>
<td>700</td>
<td>104</td>
<td>NW</td>
<td>10,965 (s)</td>
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<tr>
<td>125LA-6470</td>
<td>4</td>
<td>64</td>
<td>700</td>
<td>139</td>
<td>NW</td>
<td>14,657 (s)</td>
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<td>105LA-3212</td>
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<td>1050</td>
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<td>NW</td>
<td>10,199 (s)</td>
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<tr>
<td>160LA-481A</td>
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<td>158</td>
<td>NW</td>
<td>15,144 (s)</td>
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<tr>
<td>215LA-641B</td>
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<td>64</td>
<td>1050</td>
<td>211</td>
<td>NW</td>
<td>20,243 (s)</td>
</tr>
</tbody>
</table>

1. System input wattage may vary based on input voltage, by up to ±10%, and based on manufacturer forward voltage, by up to ±8%.
2. Lumen values based on photometric tests performed in compliance with IESNA LM-79.
3. Data is scaled based on tests of similar, but not identical, luminaires.

Dimensions – Standard EcoForm luminaire

Top View

Side View

End View

EPA (ft²/µp): Single = 0.2 / 0.019, Twin (2)x180° = 0.5 / 0.046, 3/4@90° = 0.5 / 0.046

Approximate Luminaire Weight: 20 Lbs (9.07 Kg)
ECF EcoForm

Site & Area

**Dimensions** -- EcoForm with Retrofit Arm Mount (RAM)

*Top View*

*Side View*

*End View*

**EPA (ft³/m²)**

<table>
<thead>
<tr>
<th>Single</th>
<th>Twin (2@180)</th>
<th>3/4@90</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 / 0.028</td>
<td>0.6 / 0.056</td>
<td>0.7 / 0.065</td>
</tr>
</tbody>
</table>

*Approximate Luminaire Weight: 21 Lbs (9.53 Kg)*

**Dimensions** -- EcoForm with Mast Arm Fitter (MA)

*Top View*

*Side View*

*End View*

**EPA (ft³/m²)**

<table>
<thead>
<tr>
<th>Single</th>
<th>Twin (2@180)</th>
<th>3/4@90</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.51 / 0.047</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Approximate Luminaire Weight: 21.5 Lbs (9.77 Kg)*

**Dimensions** -- EcoForm with Wall Mount (WS)

*Top View*

*Side View*

*End View*

*Approximate Luminaire Weight: 23.36 Lbs (10.6 Kg)*

**Dimensions** -- EcoForm with LimeLight Luminaire mounted controller

*Top View*

*Side View*

*End View*
Bollard Fixture Datasheets

Gardco Bollard

LED BOLLARD

BRM830/831/833 Dome Top Louver
BRM834/835/837 Bevel Top Louver

Featuring
Motion Response

Gardco's dome top and bevel top LED Louver Bollards provide uniform illumination, superior spacings, and solid vandalism resistance. Rugged, extruded and cast construction with silicone seals and gasketing ensure years of trouble-free service. The BRM830 and BRM834 are complete assemblies with an aluminum base. BRM831 and BRM835 have only units that are custom architectural elements. BRM833 and BRM837 luminaires include a concrete base assembly. Gardco's advanced stack-louver LED technology and Motion Response provide maximized light output and maximum energy savings.

PREFIX

<table>
<thead>
<tr>
<th>HEIGHT</th>
<th>LED CONTROL</th>
<th>LED SELECTION</th>
<th>LIGHTED COVERAGE</th>
<th>VOLTAGE</th>
<th>FINISH</th>
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</thead>
<tbody>
<tr>
<td>BRM830</td>
<td>42</td>
<td>DR</td>
<td>380</td>
<td>347</td>
<td>SC/BRM831</td>
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<tr>
<td>BRM831</td>
<td>42</td>
<td>DR</td>
<td>380</td>
<td>347</td>
<td>SC/BRM831</td>
</tr>
<tr>
<td>BRM833</td>
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<td>DR</td>
<td>380</td>
<td>347</td>
<td>SC/BRM831</td>
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<td>BRM834</td>
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<td>DR</td>
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<td>SC/BRM831</td>
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<td>DR</td>
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<td>SC/BRM831</td>
</tr>
<tr>
<td>BRM838</td>
<td>42</td>
<td>DR</td>
<td>380</td>
<td>347</td>
<td>SC/BRM831</td>
</tr>
</tbody>
</table>

Enter the order code into the appropriate box above. Note: Gardco reserves the right to change a configuration. Not all combinations and configurations are valid. Refer to notes below for exclusions and limitations. For questions or concerns, please contact the factory.

LED CONTROL

<table>
<thead>
<tr>
<th>MR</th>
<th>Motion Response</th>
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<tbody>
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<td>CWL</td>
<td>Constant Wattage Full Light Output</td>
</tr>
<tr>
<td>WW</td>
<td>180° lighted louvers (Provides reduced backside light.)</td>
</tr>
<tr>
<td>WW</td>
<td>180° lighted louvers (Provides reduced backside light.)</td>
</tr>
<tr>
<td>WW</td>
<td>180° lighted louvers (Provides reduced backside light.)</td>
</tr>
<tr>
<td>WW</td>
<td>180° lighted louvers (Provides reduced backside light.)</td>
</tr>
</tbody>
</table>

VOLTAGE

| UNIV | 120V through 277V, 50Hz to 60Hz input. |
| 247V | 347V |

FINISH

| BRP | Bronze Paint |
| BLP | Black Paint |
| WP | White Paint |
| NP | Natural Aluminum Paint |
| BGP | Beige Paint |
| VP | Verde Green Paint |
| LGP | Light Green Paint |
| DGP | Dark Green Paint |
| LSP | Light Sandstone Paint |
| DSP | Dark Sandstone Paint |
| RBP | Red Brick Paint |

Optional Color Paint
Special WWW designation as ex-OC-WWW.02.05.13

Options

| SPR | Surge Protection for 120V through 277V Input meeting ANSI C42.41.2 |
| SPRH | Surge Protection for 347V through 480V Input meeting ANSI C42.41.2 |

Philips

GARDCO
UNLIT GARDCO BOLLARD

LED BOLLARD

BRM830/831/833 Dome Top Louver
BRM834/835/837 Bevel Top Louver

Featuring
Motion Response

Gardco's dome top and bevel top LED Louver Bollards provide uniform illumination, superior spacings and solid vandal resistance. Rugged extruded and cast construction with silicone seals and gasketing assure years of trouble free service. The BRM830 and BRM834 are complete assemblies with an aluminum base. BRM831 and BRM835 head only units affix to custom architectural elements. BRM833 and BRM837 luminaires include a concrete base assembly. Gardco's advanced stack-louver LED technology and Motion Response provide maximized light output and maximum energy savings.

PREFIX | HEIGHT
--- | ---
Dome Top | Bevel Top
BRM830 | BRM834
BRM831 | BRM835
BRM833 | BRM837
BRM833B | BRM837B
BRM833G | BRM837G

LED CONTROL

Motion Response
LEDs stay on Low Level (8 watts) when no motion is present. LEDs increase to full light output (41 watts) when motion detected.

CWL
Constant Wattage Full Light Output
Full light output only (41 watts). No motion sensor included.

LED SELECTION

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td>6,500K, 5 SCR</td>
</tr>
<tr>
<td>NW</td>
<td>4,300K, 5 SCR</td>
</tr>
<tr>
<td>WW</td>
<td>3,000K, 5 SCR</td>
</tr>
</tbody>
</table>

Solid Colors

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>Amber</td>
</tr>
<tr>
<td>LR</td>
<td>Red</td>
</tr>
<tr>
<td>LG</td>
<td>Green</td>
</tr>
<tr>
<td>LB</td>
<td>Blue</td>
</tr>
</tbody>
</table>

LIGHTED COVERAGE

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>360</td>
<td>360° lighted louvers</td>
</tr>
<tr>
<td>180</td>
<td>180° lighted louvers (Provide reduced backside light)</td>
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</table>

VOLTAGE

UNIV
120V through 277V, 50Hz to 60Hz input

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>34V</td>
<td>347V</td>
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OPTIONS

<table>
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<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPR</td>
<td>Surge Protection for 120V through 277V Input meeting ANSI C62.41.2</td>
</tr>
<tr>
<td>SPRH</td>
<td>Surge Protection for 347V through 480V Input meeting ANSI C62.41.2</td>
</tr>
</tbody>
</table>

PHILIPS GARDCO
**Specifications**

**VRB-LED Models**
10 - 20 Diodes

**VRB1:** Single Function Luminaire (Aluminum Shaft)
Maximum Weight: 30 lb

---

**Domed Top Cap:** One-piece die-cast aluminum secured to louvers by concealed allen screws in keyhole slots. For relamping access, allen screws shall not require complete removal.

**Louvers:** Aluminum die-cast with vertical support ribs at 90° intervals. Horizontal louvers blades shall have a 1 1/4" depth, a 65° upward pitch and provide light source cutoff above horizontal. Louver assembly shall be secured to shaft by four internal tie rods.

**Lamp Enclosure:** One-piece tempered molded glass with internal flutes and full gasketing at bottom edge.

**Fixture Head:** Allows flow-through ventilation around and above the lamp enclosure.

**Shaft:** One-piece extruded aluminum, .125" wall thickness with a heavy cast aluminum twist-lock anchor base concealed within the shaft. Concealed set screws shall lock shaft onto the cast anchor base.

**Electronic Module:** All electrical components are either UL or ETL recognized, mounted on a single plate and factory prewired with quick disconnect plugs. Driver is rated for -40°F starting and has a 0-10V dimming interface for multi-level illumination options.

**Optical Module:** Each LED equipped with a directional optic for maximum beam angle projecting through louvers or stacking. LED boards to be mounted to an anodized interlocking heat sink extrusion. (Type I) Two 5-LED boards for a total of 10-LED. (Type III) three 5-LED boards for a total of 15-LED. (Type V) four 5-LED boards for a total of 20-LED. Available in 3500K and 5100K color temperatures.

**Anchor Bolts:** Four 3/8" x 10" x 2" zinc plated L-hooks, each with two nuts, washers and a rigid pressed board template.

**Finish:** TGIC thermoset polyester powder coat paint, 2.5 mil nominal thickness, applied over a titanium-zirconium conversion coating; 2500 hour salt spray test endurance rating. Standard colors are Black, Dark Bronze, Light Gray, Stealth Gray™, Platinum Silver, or White. Custom colors are available.

**CAUTION:** Fixtures must be grounded in accordance with national, state and/or local codes. Failure to do so may result in serious personal injury.

---

### Listings and Ratings

<table>
<thead>
<tr>
<th>UL or ETL to UL Standards 1586 &amp; 6750</th>
<th>25C Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP46 Rated</td>
<td>FS = Fully Shielded</td>
</tr>
</tbody>
</table>

*Suitable for wet locations.

*Dark Sky Legislation Compliant

KIM LIGHTING RESERVES THE RIGHT TO CHANGE SPECIFICATIONS WITHOUT NOTICE.
## Standard and Optional Features

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Cat. No. VRB1 Single Function, Aluminum Shaft, Domed Top</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical Module</strong></td>
<td><strong>LED - Light Emitting Diode</strong></td>
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<tr>
<td><strong>Source:</strong></td>
<td><strong>Color Temperature:</strong></td>
</tr>
<tr>
<td>□ 10L - 10 LED (IES Type I)</td>
<td>□ 3K - 3500K</td>
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<tr>
<td>□ 15L - 15 LED (IES Type III)</td>
<td></td>
</tr>
<tr>
<td>□ 20L - 20 LED (IES Type V)</td>
<td>□ 5K - 5100K</td>
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### FIXTURE | TOTAL SYSTEM WATTS | VOLT | OPERATING AMPS |
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</thead>
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<tr>
<td>VRB1 - 10 LED</td>
<td>12</td>
<td>120 / 208 / 240 / 277</td>
<td>.10 / .05 / .05 / .04</td>
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<tr>
<td>VRB1 - 15 LED</td>
<td>18</td>
<td>120 / 208 / 240 / 277</td>
<td>.15 / .09 / .08 / .07</td>
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<tr>
<td>VRB1 - 20 LED</td>
<td>24</td>
<td>120 / 208 / 240 / 277</td>
<td>.20 / .12 / .10 / .09</td>
</tr>
</tbody>
</table>

### Finish

TGIC thermoset polyester powder coat paint applied over a tittanated zirconium conversion coating on fixture and shaft.

- **Color:** Back | Dark Bronze | Light Gray | Stealth Gray | Platinum Silver | White | Custom Color²
- **Cat. No.:** □ BL | □ DBA 311 | □ LG | □ SG | □ PS | □ WH | □ CC

**NOTE:** Black and Dark Bronze colors will produce slightly less louver brightness than Light Gray or White.

²Custom colors subject to additional charges, minimum quantities and extended lead times. Consult representative. Custom color description:
VRBC Round Bollard
Unlighted Concrete

Specifications

VRBC - Unlighted Concrete Bollard
Maximum weight: 150 lb

Material: Cement shall conform to current specifications for “Portland Cement,” ASTM C150, Type I or II. Aggregates shall meet current requirements of “Specifications for Concrete Aggregates,” ASTM C33. Water shall be clean and free from deleterious amounts of silt, oil, acids, alkalies or organic materials. Wire for reinforcement shall conform to ASTM A185. Steel for lugs and plates shall conform to ASTM A36, or A283 grade D.

Surface: Medium sand-blasted with anti-graffiti sealer. Available colors are Charcoal, Brown, Natural Gray or White, integral in concrete mix.

Cure and Strength: Allows for completion of the hydration process, and result in a 28 day compressive strength of not less than 4,500 psi.

Manufacture: Fiberglass molds used to insure uniform parts. Mold parting lines may be slightly visible in finished parts.

Anchorage: Four steel mounting tabs for installation on four ¾” x 10’ + 2’ zinc electroplated L-hook anchor bolts. Each anchor bolt is supplied with two nuts, two washers, and a rigid pressed board template.

Shipment: Palletized with adequate hold-downs to prevent load movement in transit.

Concrete Finish:

- BR-C Brown
- CH-C Charcoal
- NG-C Natural Gray
- WH-C White

*Shaft surface color is integral in concrete mix.

NOTE: No fixture, electrical elements, or conduit openings. Flat top not available.
Design Standard

General Overhead Electrical Distribution

Detailed specifications follow.

PART 1 MATERIALS

1.1 All poles shall use S&C brand cutouts.
1.2 All materials shall be hot-dipped galvanized including nuts, bolts, and others.
1.3 Rebuilds (refurbished poles) are prohibited.

PART 2 GROUNDING

2.1 All poles shall be butt wrap grounded and ground-rod attached.

PART 3 PLAIN POLES

3.1 All Poles, regardless of length, shall be of Class 2 (C-2) designation.
3.2 Poles shall be used only at the discretion of the University. Overhead distribution is generally being replaced by underground lines.
3.3 All Poles shall be creosote pressure treated.

PART 4 RISER POLES

4.1 Any primary or secondary riser poll shall have no other equipment mounted onto it including transformers.
4.2 All riser poles shall have riser brackets.
4.3 Any primary or secondary riser shall have a OZ bushing.
4.4 A spare conduit for a riser pole will be installed with cap.

PART 5 DEAD END POLE

5.1 One guy-strain insulator shall be used in each respective guy.
5.2 Conductor size shall depend on anchor size.
5.3 Clearance shall be 20 feet wide and clear of all potential obstructions.
PART 6  OVERHEAD POLES WITH TRANSFORMERS

6.1  Transformer mounted poles shall not have a device arm installed. Single transformer installations may be bolt-mounted. However, any transformer bank cluster consisting of two or more transformers shall utilize an aluminum-form transformer bank rack.
GROUNDED WIRE TO HAVE MINIMUM CONDUCTIVITY OF NO 6 SOLID COPPER OR EQUIVALENT.

STAPLES ON GROUND WIRE SHALL BE 2' APART EXCEPT FOR A DISTANCE OF 8' ABOVE GROUND AND 8' FROM TOP OF POLE WHERE THEY SHALL BE 6' APART.

40' CLASS 2 POLE

FINISHED GRADE

5" X 8' GROUND ROD

WALL WRAP

GROUND( EARTH )

15KV PIN INSULATOR

8' CROSSARM

WOOD CROSSARM BRACE

15" TYP

44" TYP

44" TYP

RIDGE PIN
Design Standard

High Density Polyethylene (HDPE) Piping Installations

This standard was revised on August 18, 2017, and the latest changes are underlined. Please refer to Part 4 of this standard for full revision history.

PART 1  GENERAL

Texas A&M University requires the use of Extra High Molecular Weight Plus (EHMW Plus) High Density Polyethylene (HDPE) pipe due to its additional performance against abrasion, higher pressure and elevated temperatures. This pipe is manufactured with the PE4710 resin. For chilled water and domestic cold water a minimum of SDR 17 is required. For heating water and domestic hot water a minimum of SDR 11 is required. For sanitary sewer a minimum of SDR 26 is required (SDR 17 is recommended under mall and paver areas). For heating water, all pipe shall be “DOW 2499 Water” per the specification in Appendix A (attached).

The following standards and practices shall be adhered to:
Polyethylene fabricated fittings shall be manufactured from polyethylene pipe, sheet stock or molded fittings meeting the material requirements of this specification and all appropriate requirements of AWWA C-901 or AWWA C-906.

Polyethylene fittings, including custom fabrications, shall have the same internal pressure rating as the mating pipe. At the point of fusion, the wall thickness and outside diameter of the fitting shall be in accordance with AWWA C-901 or AWWA C-906 for the same pipe size.

For campus buildings served by TAMU central thermal distribution systems, supply and return lines typically have piping with identical size and material for each system - chilled water (CHW), heating hot water (HHW), and domestic hot water (DHW). Because these thermal distribution lines are identical in size and appearance for each thermal system, there is the potential for cross-connection between supply and return. To avoid possible cross-connection of supply and return lines, design engineers shall require field verification in construction documents and contractors shall field verify the configuration of supply and return lines, using an appropriate temperature sensing device and adequate system flow, before making building connections. Any discrepancy between construction documents and field verification should be promptly reported to the project A/E and the Owner’s representative before completing piping installation, so proper piping configuration can be verified.

An isolation valve shall be installed on any lateral feeding a building so that the building can be isolated without bringing down adjacent buildings. The valve shall be a direct buried gate valve. ¹

Detailed specifications follow.

¹
PART 2 JOINING

2.01 Heat Fusion

A. Pipe and fittings shall be joined by one of the following types of thermal fusion per the Manufacturer’s recommended procedures: Butt fusion, Saddle fusion or Socket fusion.

B. All fusion joints shall be prepared using a data logging system. Each joint shall be uniquely identified with a permanent marker. The data log shall include:

1. Operators initials.
2. Date and time of fusing.
3. Pre-heat temperature and duration (if used).
4. Fusing pressures, temperatures, and duration.
5. Ambient air temperature.
6. Geo-reference for location of fused joint. This geo-reference shall be updated after the completion of laying the pipe.

C. Upon request, the Manufacturer shall provide fusion training by authorized personnel or an authorized Representative. The Contractor shall be responsible for ensuring that personnel have received proper training per the Manufacturer’s recommended procedure. Records of training shall be maintained by the Contractor and should not exceed 12 months from date of construction.

D. Butt fusions performed between pipe ends or pipe ends and fitting outlets shall be within the following allowable wall mismatches:

1. 2 DR difference for pipe and fitting diameters 6"IPS and smaller.
2. 1 DR difference for above 6" through 18".
3. No difference for diameters above 18".

The difference in DR’s is determined from the following DR values: 7.3, 9, 11, 13.5, 17, 21, 26 and 32.5

2.02 Other Methods of Joining

A. Polyethylene pipe and fittings may be joined together or to other materials through the use of electrofusion fittings, flange adapters with back-up rings, mechanical couplings designed for connecting polyethylene pipe and fittings to itself or to another material, or MJ adapters. The Manufacturer of the joining device shall be consulted for proper installation procedures.
2.03 Third Party Certification

A. The performance requirements of the pipe and fittings shall comply with the most current version of AWWA C-901 or AWWA C-906. The Manufacturer shall be listed with NSF-61 certification and include the third party certification within the print line of the product.

PART 3 INSTALLATION

3.01 Marking

A. Pipe and tubing shall be permanently marked in accordance with all applicable standards per this specification. Marking shall be heat stamped indent print and shall remain legible under normal handling and installation practices.

B. Fittings shall be marked on the body or hub. Marking shall be in accordance with the applicable standard depending upon the fitting type. Mechanical fittings shall be marked with size, body material designation code, pressure rating and the Manufacturer’s name or trademark.

3.02 Thermal lines shall be insulated in accordance with the Underground Piping Systems Design Standard. All uninsulated lines shall have the following bedding materials:

- Under paved areas – 6” of bedding sand and 6” sand cover with remaining to be 2% stabilized sand to subgrade.

  Note: Avoid direct contact between HDPE pipe and stabilized sand.

- Under non-paved areas – 6” bedding sand with remainder of back fill to be select fill.

3.03 Pipe, tubing and fittings shall be homogenous throughout, and free of visible cracks, holes, foreign inclusions, blisters, dents or other injurious defects. The pipe, tubing and fittings shall be as uniform as commercially practicable in color, opacity, density and other physical properties.

3.04 TESTING

A. The Contractor shall be responsible for field set-up and performance of the fusion equipment and the fusion procedure used by the operator. Upon request, the Contractor shall verify the fusion quality by making and testing per the Manufacturer’s recommended qualification procedure. The Contractor shall be responsible for the necessary adjustments to the set-up, equipment, operation, and fusion procedure. Fusions that fail the qualification procedure shall be remade.

B. Hydrostatic testing shall be conducted in accordance with the Manufacturer’s recommended testing procedures. Hydrostatic testing shall be performed prior to installation of the insulation and backfill. At no time shall the pipe be covered prior to the completion of the hydrostatic testing. Hydrostatic test pressures for main campus shall be 100 psi for chilled and heating water piping, 125 psi for domestic cold and hot water lines. Acceptance shall be zero pressure drop after 2 hours.
C. Low pressure pneumatic testing may be conducted on gravity sewer lines in accordance with ASTM F1417. Other methods of pneumatic testing are not recommended.

D. A detectable “Caution-Buried Water Line” tape shall be placed 18” to 24” above each line.

PART 4 REVISIONS TO DESIGN STANDARD

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/12/2017</td>
<td>Part 1</td>
<td>Isolation valve added to standard</td>
</tr>
<tr>
<td>2</td>
<td>8/18/2017</td>
<td>Part 2</td>
<td>Section 2.01B added to standard. Previous sections 2.01B and 2.01C moved to 2.01C and 2.01D, respectively.</td>
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</table>
APPENDIX A
INTREPID 2499 NT TECHNICAL INFORMATION
INTREPID™ 2499 NT
Bimodal Polyethylene Resin

Overview
INTREPID™ 2499 NT Bimodal Polyethylene Resin is a Polyethylene resin produced using UNIPOL II process technology. This product is intended for use in industrial piping systems where extreme conditions such as high temperatures, aggressive chemicals, hydrocarbons, or highly oxidative conditions exist. Suitable uses include oil and gas field pipelines, gas distribution pipelines, and other industrial applications.

Industrial Standards Compliance:
- ASTM D 3530: cell classification PE445574A
- Plastics Pipe Institute (PPI): TR-4
  - Natural Pipe INTREPID™ 2499 NT Bimodal Polyethylene Resin
    - ASTM PE4710 pipe grade - 1600psi HDB @ 73 °F (23°C)
    - ASTM PE4710 pipe grade - 800psi HDB @ 180 °F (82.2°C)

Additive
- Antblock: No
- Slip: No
- Processing Aid: Yes

<table>
<thead>
<tr>
<th>Physical</th>
<th>Nominal Value (English)</th>
<th>Nominal Value (SI)</th>
<th>Test Method</th>
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</thead>
<tbody>
<tr>
<td>Density (Natural)</td>
<td>0.950 g/cm³</td>
<td>0.950 g/cm³</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Melt Mass-Flow Rate</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>190°C/2.16 kg</td>
<td>0.10 g/10 min</td>
<td>0.10 g/10 min</td>
<td>ASTM D1238</td>
</tr>
<tr>
<td>190°C/21.6 kg</td>
<td>7.0 g/10 min</td>
<td>7.0 g/10 min</td>
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<tr>
<td>Mechanical</td>
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<tr>
<td>Tensile Strength (Yield)</td>
<td>&gt; 3500 psi</td>
<td>&gt; 24.1 MPa</td>
<td>ASTM D638 1</td>
</tr>
<tr>
<td>Tensile Elongation (Break)</td>
<td>&gt; 500 %</td>
<td>&gt; 500 %</td>
<td>ASTM D638 1</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>152000 psi</td>
<td>1050 MPa</td>
<td>ASTM D790B 2, 3</td>
</tr>
<tr>
<td>Resistance to Rapid Crack Propagation, P&lt;sub&gt;c&lt;/sub&gt; - S&lt;sub&gt;-4&lt;/sub&gt; 32°F (0°C)</td>
<td>&gt; 174 psi</td>
<td>&gt; 12.0 bar</td>
<td>ISO 13477 3</td>
</tr>
<tr>
<td>Resistance to Rapid Crack Propagation, T&lt;sub&gt;c&lt;/sub&gt; - S&lt;sub&gt;-4&lt;/sub&gt; @ 145 psi (10 bar)</td>
<td>&lt; 2 °F</td>
<td>&lt; -17 °C</td>
<td>ISO 13477 3</td>
</tr>
<tr>
<td>Slow Crack Growth PENT - @ 2.4 MPa</td>
<td></td>
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<td></td>
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<tr>
<td>176°F (80°C)</td>
<td>&gt; 10000 hr</td>
<td>&gt; 10000 hr</td>
<td>ASTM F1473 1</td>
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<tr>
<td>194°F (90°C)</td>
<td>&gt; 10000 hr</td>
<td>&gt; 10000 hr</td>
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<tr>
<td>Impact</td>
<td></td>
<td></td>
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<tr>
<td>Notched Izod Impact (73°F (23°C))</td>
<td>9.1 ft lb/in</td>
<td>480 J/m</td>
<td>ASTM D256 A 1</td>
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<tr>
<td>Thermal</td>
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<tr>
<td>Brittleness Temperature</td>
<td>&lt; -103 °F</td>
<td>&lt; -75.0 °C</td>
<td>ASTM D746 A 1</td>
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<tr>
<td>Melting Temperature (DSC)</td>
<td>259 °F</td>
<td>132 °C</td>
<td>Dow Method</td>
</tr>
<tr>
<td>Thermal Stability</td>
<td>&gt; 428 °F</td>
<td>&gt; 220 °C</td>
<td>ASTM D3350</td>
</tr>
</tbody>
</table>

Extrusion Notes
Fabrication Conditions:
- Screw Type: High quality HDPE barrier with mixing
- Melt Temperature Range: 380-450°F (193-232°C)

Notes
These are typical properties only and are not to be construed as specifications. Users should confirm results by their own tests.

1 Compression molded parts prepared according to ASTM D 1928 Procedure C. Properties will vary with changes in molding conditions and aging time.

2 Method I (3 point load)

3 Pipe diameter of 10 inch IPS (25.4 cm) and Standard Diameter Ratio (SDR) 11.
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Additional Information

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<th>North America</th>
<th>Europe/Middle East</th>
<th>South Africa</th>
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</thead>
<tbody>
<tr>
<td>U.S. &amp; Canada:</td>
<td>1-800-441-4369</td>
<td>+800-99-5078</td>
</tr>
<tr>
<td></td>
<td>1-998-832-1426</td>
<td></td>
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<td>Mexico:</td>
<td>+1-800-441-4369</td>
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www.dowplastics.com

This document is intended for use within Europe, Latin America, North America

Published: 2012-07-11

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Design Standard

Hydronic Piping in Buildings

This standard was revised on January 18, 2019, and the latest changes are underlined. Please refer to Part 4 of this standard for full revision history.

Detailed specifications follow.

PART 1 - GENERAL

1.01 Above ground hydronic piping 2 inches and less in diameter shall be as follows:

A. Copper

1. Pipe: ASTM B88, hard drawn copper, Type L.\(^1\)

B. PEX-A

1. Pipe: ASTM F876 and ASTM F877, cross-linked polyethylene.
3. Manufacturer: Uponor or approved equal.

C. Polypropylene

1. Pipe: ASTM F2389 polypropylene pipe and fittings.
2. Pipe shall have certification from NSF to meet NSF 14 and 61, and be listed with ICC.
3. Joints: Socket fusion, electrofusion, or butt fusion as applicable.
4. Manufacturer: Aquatherm, Niron.

1.02 Above ground hydronic piping 2.5 to 10 inches in diameter shall be as follows:

A. Carbon Steel

1. Pipe: ASTM A53, Grade B Type E or S, standard weight black steel pipe.

B. Polypropylene

1. Pipe: ASTM F2389 polypropylene pipe and fittings.
2. Pipe shall have certification from NSF to meet NSF 14 and 61, and be listed with ICC.
3. Joints: Socket fusion, electrofusion, or butt fusion as applicable.
4. Manufacturer: Aquatherm, Niron.

1.03 For condensate drain piping, provide one of the following:
A. Copper piping as specified above.
B. PEX-A piping as specified above.
C. Polypropylene as specified above.

1.04 For PEX-A and polypropylene applications, piping shall be terminated at the control valve at the AHU. Piping from the control valve to the coil shall be copper.

1.05 Isolation Valves
A. Provide the piping systems with line size shutoff valves located at risers, at main branch connections at each floor, at branch takeoffs serving equipment and at each heating and cooling coil. Valves shall be provided on both supply and return lines.
B. At air handling units where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge, thermometer and a balancing valve with memory stop and valves for isolation of each coil.

1.06 Provide insulation with minimum thickness and conductivity values in compliance with ASHRAE Standard 90.1-2010, Table 6.8.3A & B. Consider additional insulation to ensure compliance with requirements of Building Energy Efficiency Analysis Design Standard.

1.07 All hydronic piping systems (CHW and HHW) shall have automatic air venting at the highest point in the system.

1.08 Stainless steel fine wire mesh strainers shall be installed at all pumps and air handling units to mitigate problems with particulate matter.

1.09 The methodology for initial flushing and treatment of hydronic systems contained in Appendix A, or equivalent approved in advance by UES, is required for any new hydronic system (chilled water or heating hot water) prior to start up.

1.10 The methodology contained in Appendix B, or equivalent approved in advance by UES, is required for any hydronic system (chilled water or heating hot water) shutdown or layup of more than 30 days duration.

1.11 Di-electric insulating flanges shall be provided at all connections between copper and steel piping and maintained for the life of the piping system.
PART 2 - PEX-A AND POLYPROPYLENE PIPE REQUIREMENTS

2.01 Standard Grade hydrostatic pressure ratings from Plastic Pipe Institute in accordance with TR-3 as listed in TR-4. The following three standard-grade hydrostatic ratings are required:

A. 200 Degrees F at 80 psi
B. 180 Degrees F at 100 psi
C. 73.4 Degrees F at 160 psi

2.02 Certification of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 when wrapped with standard pipe insulation, field installed.

2.03 Where installed in systems with pumps in excess of 7.5 HP, piping shall be protected from excessive heat generated by operating the pump at shut-off conditions. Where the possibility exists that the pump will operate with no flow, the protection method shall be a temperature relief valve or comparable level of protection, set to a maximum temperature of 185° F.

PART 3 - FLUSHING AND TREATMENT

3.01 All new metallic, hydronic piping systems shall be flushed and treated before the building piping system is connected to the central hydronic piping system.

3.02 Flushing and treatment shall be initiated by the university’s project manager for the piping project (FP&C or SSC) upon completion of the installation.

3.03 Flushing and treatment shall be done in accordance with the specification in Appendix A.

3.04 Flushing and treatment shall be witnessed by representatives of the mechanical contractor, SSC and UES.

3.05 The chemical treatment firm shall complete the report in Appendix A. It shall be signed by the chemical treatment firm and all witnesses. The signed report shall be submitted to the UES Technical Services manager before the building system is connected to the central system.

3.06 Installation contractor shall cover the flushing and treatment costs for the building hydronic piping systems.

3.07 SUEZ FerroQuest (FQ) 7101 or approved equal is the chemical to be used for flushing. University Project Manager shall notify UES (darryl.petersen@tamu.edu) one week prior to flushing and treatment.

3.08 After witnessing and verifying satisfactory completion of flushing and treatment, UES will open valve connecting the building to the campus hydronic systems.
<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
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<tbody>
<tr>
<td>1</td>
<td>6/1/2017</td>
<td>Part 1.01 A1</td>
<td>“Type K” pipe changed to “Type L”.</td>
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<tr>
<td>2</td>
<td>1/18/2019</td>
<td>Part 3.07</td>
<td>FQ7101 is approved chemical to be used for flushing</td>
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<tr>
<td>3</td>
<td>1/18/19</td>
<td>Part 3.08</td>
<td>Witness and verification of flushing and treatment is needed before reconnection</td>
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<tr>
<td>4</td>
<td>1/18/19</td>
<td>Appendix A, Section 1.2</td>
<td>Recommended doses for pipe cleaning procedure</td>
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</table>
APPENDIX A

FLUSHING FOR CLOSED HYDRONIC SYSTEMS
SECTION 232500 - FLUSHING FOR CLOSED HYDRONIC SYSTEMS

PART 1 – METALLIC PIPING SYSTEMS

1.1 After the mechanical contractor has prepared the building and the piping to be flushed after it has been tested. Provide a complete water flushing and cleaning of the closed loop chilled and hot water systems as specified herein. Systems must be commissioned as clean and meet the water treatment specifications.

1.2 All chilled, and hot water piping and related equipment shall be thoroughly flushed out with pre-cleaning chemicals designed to remove deposits such as pipe dope, oils, loose rust, mill scale and other extraneous materials. Recommended dosages of pre-cleaning chemical products shall be furnished by water treatment supplier, added and circulated throughout the water systems. The water systems shall then be drained, refilled and flushed thoroughly until no foreign matter is observed and total alkalinity of the rinse water is equal to or better than that of the make-up water. Recommended dosages of pre-cleaning chemicals are listed in the Ferroquest (FQ) Preoperational pipe cleaning procedure.

1.3 All temporary connections required for cleaning, purging, and circulating shall be included. Provide suitable pipe bypasses at each coil and heat exchanger during this cleaning operation.

1.4 Flushing & Cleaning – a third party flushing company should be used. Permanent facility pumps should not be used for circulating the cleaning water. However, if its impractical to use temporary pumps, the permanent facility pump may be used provided that the pump is unconditionally warranted for two years, parts and labor, after the date of substantial completion by the mechanical contractor. A documented flush plan may be required at the discretion of the engineer. All operators should be aware of and abide by the Safety and PPE regulations of the project site. Operation should be manned continuously during the flushing process.

1.5 Self-Contained Flush Unit Requirements – Should contain a pump or pumps connected that will meet or exceed the volume required to flush and purge the system at the required velocity rate through the largest pipe. A pump curve will be submitted along with other important documentation for the related equipment on the unit. This will include, at minimum, filtration, flow meter(s), pressure gauges, and unit description or picture.

1.6 Pre Flush - Bypass loops should be installed at all equipment components. Strainers can be removed when a self-contained purge unit is used in conjunction with on board filtration. Flush ports should be identified along with the type of high pressure hose or piping that will be used to connect to the system. The water source should be identified and must be adequate to fill and make up water in a timely manner to the system during the flush process.

1.7 Clear Water Flush – Fill the piping system with clean potable water. The first flush is a clear-water flush intended to circulate water through the system and force loose debris to low point drains and the flush cart filtration system. This flush should be at minimum velocity throughout the system of 5 to 7 ft/sec. Filtration should be 25 micron.

1.8 Cleaning & Passivation - The second flush cycle is a combined flushing cycle where cleaning and passivation chemicals are introduced into the system to clean the oils and treat the inside...
wall of the piping system. This process will be monitored by the chemical treatment company to meet the chemical specifications of the water. The cleaning velocity should be between 3 to 5 ft/sec and the circulation time will be based on the chemical testing but will typically be up to 48 hours.

1.9 Treatment – After cleaning and before adding chemical initial charge, system must be flushed to meet these minimum requirements:

A. Conductivity no higher than 20 mmho above domestic water level
B. No foam
C. Copper level less than 0.5 ppm
D. Iron level less than 1.0 ppm
E. pH 9.4 or less
F. Less than 1 ppm phosphates (ortho-phosphate PO4)

1.10 Final Clear Water Flush – The system will be continuously flushed while discharging chemicals into the sanitary system as approved locally. As the existing treated water is being discharged a fresh water make-up source will be utilized to ensure air is not introduced into the system. Continue to drain the system while adding domestic water to dilute the treated water. The chemical treatment company will monitor the outgoing water composition and compare the composition with the incoming water. Flush with fresh water until the conductivity is reduced to that of the make-up water and iron level is 1.0 ppm or less. The final system water should be approved by the chemical treatment company. Filtration should be 5 micron.

1.11 Final Chemical Fill – Once the chemical treatment company has determined the system has been brought back to the correct composition, the chemical treatment company will inject the final chemicals into the system. Once the system is filled with the final chemicals it is important that the water is not to be left stagnant. Chemical treatment shall be comparable to existing treatment program.

1.12 Verify satisfactory completion of clean pipe and a final flushing and chemical treatment report should be signed by field personnel and submitted.
2.1 After the mechanical contractor has prepared the piping to be flushed after it has been tested. Provide a complete water flushing and cleaning of the polypropylene piping as specified herein. Systems must be commissioned as clean and meet the water treatment specifications.

2.2 All polypropylene piping and related equipment shall be thoroughly flushed out with high volume and velocity water designed to remove deposits such as pipe shavings, dirt, debris and any other and other extraneous materials.

2.3 All temporary connections required for cleaning, purging, and circulating shall be included. Provide suitable pipe bypasses at any equipment or building feeds during this cleaning operation.

2.4 Flushing & Cleaning – a third party flushing company should be used. Permanent facility pumps should not be used for circulating the cleaning water. However, if its impractical to use temporary pumps, the permanent facility pump may be used provided that the pump is unconditionally warranted for two years, parts and labor, after the date of substantial completion by the mechanical contractor. A documented flush plan may be required at the discretion of the engineer. All operators should be aware of and abide by the Safety and PPE regulations of the project site. Operation should be manned continuously during the flushing process.

2.5 Self-Contained Flush Unit Requirements – Should contain a pump or pumps connected that will meet or exceed the volume required to flush and purge the system at the required velocity rate through the largest pipe. A pump curve will be submitted along with other important documentation for the related equipment on the unit. This will include, at minimum, filtration, flow meter(s), pressure gauges, and unit description or picture.

2.6 Pre Flush - Bypass loops should be installed at all equipment components. Strainers should be removed when a self-contained purge unit is used in conjunction with on board filtration. Flush ports should be identified along with the type of high pressure hose or piping that will be used to connect to the system. The water source should be identified and must be adequate to fill and make up water in a timely manner to the system during the flush process.

2.7 Clear Water Flush – Fill the piping system with clean potable water. The flush intended to circulate water through the system and force loose debris to low point drains and the flush cart filtration system. This flush should be at minimum velocity throughout the system of 5 to 7 ft/sec. Filtration should be 25 micron. Minimum duration should be calculated using a formula of 1 hour per 1000 linear feet of pipe and until system water is comparable to make up water source.

2.8 Final Chemical Fill – Once the chemical treatment company has determined the system has been brought back to the correct composition, the chemical treatment company will inject the final chemicals into the system. Once the system is filled with the final chemicals it is important that the water is not to be left stagnant. Chemical treatment shall be comparable to existing treatment program.

2.9 Verify satisfactory completion of clean pipe and a final flushing and chemical treatment report should be signed by field personnel and submitted.
Flush & Cleaning Hydronic Pipe Field Completion Report

Project Name _________________________

Date of Report: __________
Project Location: ______________________
Prime Contractor: ______________________
Mechanical Firm: ______________________
Chemical Treatment Firm: ______________________
Lead Flushing Technician On-Site During Process: ______________________

Project Type:
- Chilled Water Flush ______________________
- Condenser Water Flush ______________________
- Hot Water Flush ______________________
- Geothermal Piping F&P ______________________
- Other: ______________________

Scope Summary:
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Start Time and Date: ________________  End Time and Date: ________________

________________________
Mechanical Representative

________________________
Chemical Representative

________________________
FP&C / SSC Representative

________________________
UES Representative
APPENDIX B

GE LAY-UP OF BUILDING HHW & CHW SYSTEMS
Lay-Up of Building HHW Systems

If any part or all of a heating hot water system will be taken out of service for a period of time, precautions must be taken to prevent severe corrosion damage, both traditional and microbiologically induced. Freeze protection of coils is briefly covered under this document but may also be a factor. All equipment must be taken into consideration, including heat exchangers and water loops that may be normally isolated.

Preparation

If equipment has become fouled during operation, then a cleaning should be completed first. Depending on the nature of the deposit and the metallurgy, a scale cleaning or iron based corrosion by-product type cleaning may be appropriate.

Wet Layup Method

Drain the system and refill with enough water to adequately circulate. Charge with a molybdate based product such as GE Betz CorrShield* MD4107 at 1250-2000 ppm or 10-17 lbs./1,000 gal and also add additional copper protection such as GE Betz Inhibitor AZ8104 at 100 -140 ppm or 1-1.5 lbs per 1,000 gallons of system volume.

Also add a high dose of a broad-spectrum biocide such as Spectrus* NX1100 at 100-200 ppm  (0.83-1.7 lbs./1,000 gal).

Continuous circulation without load is preferred, but if not practical, circulate weekly and test monthly for microbiological activity and chemical residual.

Special Considerations with Freezing Conditions

In the unlikely event that building HHW system will be down and not recirculating during freezing conditions, layup of air coils with propylene glycol may be necessary, in this case a 35% solution of propylene coil is added to the coil system. It is essential if glycol in the coil is used, that it be COMPLETELY DRAINED and flushed with city water. All residual glycol must be removed before interconnecting this system with the larger UES system.

An alternate is to blow warm return air through the coil. Consult UES if you want to consider this as an option.
Lay-Up of Building Chilled Water Systems

If any part or all of a chilled water system will be taken out of service for a period of time, precautions must be taken to prevent severe corrosion damage, both traditional and microbiologically induced. Freeze protection of coils is briefly covered under this document but may also be a factor. All equipment must be taken into consideration, including heat exchangers and water loops that may be normally isolated.

Preparation

If equipment has become fouled during operation, then a cleaning should be completed first. Depending on the nature of the deposit and the metallurgy, a scale cleaning or iron based corrosion by-product type cleaning may be appropriate.

Wet Layup Method

Drain the system and refill with enough water to adequately circulate. Charge with a molybdate based product such as GE Betz CorrShield* MD4107 at 1250-2000 ppm or 10-17 lbs./1,000 gal and also add additional copper protection such as GE Betz Inhibitor AZ8104 at 100 -140 ppm or 1-1.5 lbs per 1,000 gallons of system volume.

Also add a high dose of a broad-spectrum biocide such as Spectrus* NX1100 at 100-200 ppm (0.83-1.7 lbs./1,000 gal).

Continuous circulation without load is preferred, but if not practical, circulate weekly and test monthly for microbiological activity and chemical residual.

Special Considerations with Freezing Conditions

In the event that building chilled water system will be down and not recirculating during freezing conditions, layup of air coils with propylene glycol may be necessary, in this case a 35% solution of propylene coil is added to the coil system. It is essential if glycol in the coil is used, that it be COMPLETELY DRAINED and flushed with city water. All residual glycol must be removed before interconnecting this system with the larger UES system.

An alternate is to blow warm return air through the coil. Consult UES if you want to consider this as an option.
Design Standard

Interconnection of Building Hydronic Systems to Campus Thermal Utility Infrastructure

This standard defines requirements for connection of new facilities to existing thermal utility infrastructure as well as minimum clearances required between new facilities and existing infrastructure. For the purposes of this standard, thermal utility infrastructure includes underground chilled water and heating hot water lines owned and operated by Texas A&M University.

For campus buildings served by TAMU central thermal distribution systems, supply and return lines typically have piping with identical size and material for each system - chilled water (CHW), heating hot water (HHW), and domestic hot water (DHW). Because these thermal distribution lines are identical in size and appearance for each thermal system, there is the potential for cross-connection between supply and return. To avoid possible cross-connection of supply and return lines, design engineers shall require field verification in construction documents and contractors shall field verify the configuration of supply and return lines, using an appropriate temperature sensing device and adequate system flow, before making building connections. Any discrepancy between construction documents and field verification should be promptly reported to the project A/E and the Owner's representative before completing piping installation, so proper piping configuration can be verified.

Detailed specifications follow.

PART 1 - GENERAL

1.01 THERMAL UTILITY INFRASTRUCTURE PROCESS CONDITIONS


B. The campus thermal distribution system static pressure will be set at 45 psig (104 ft.) and 50 psig (116 ft.) for West Campus and Main Campus, respectively. All buildings connected to the West and Main campus thermal distribution system shall assume these maximum static pressure values with direct connection. When the building hydronic system exceeds these static pressure values, an indirect connection is required.

PART 2 - CONNECTIONS TO EXISTING THERMAL UTILITY INFRASTRUCTURE

2.01 All new buildings to be constructed on the Texas A&M University Campus shall connect to existing thermal utility infrastructure. Any exceptions to this requirement must be approved in writing by the Utilities & Energy Services Department at Texas A&M before completion of the schematic design phase of the project.
2.02 The project is responsible for bearing all costs associated with the design and installation of thermal utility infrastructure connections.

2.03 Design and installation shall comply with the requirements of all applicable Utilities and Energy Services Design Standards. The complete set of design standards can be found at the following link: https://utilities.tamu.edu/design-standards/

2.04 BUILDING INTERCONNECTION

A. Direct Connection to Thermal Utility Infrastructure
   1. The building hydronic system will direct connect to the thermal utility infrastructure.
   2. The expansion and contraction of the volume of water in the building will be accounted for at the thermal utility plants. Expansion tanks shall not be permitted for building systems that are directly connected to the thermal utility infrastructure.
   3. Existing buildings with aging equipment, piping, and HVAC systems designed for less than utility infrastructure process conditions shall not be direct connected to thermal utility infrastructure.
   4. Direct Connection Building Hydronic Pumps:
      a. Each building will have one set of variable speed building hydronic pumps.
      b. The building hydronic pump speed will vary to provide the required hydronic differential pressure to ensure adequate building flows.

B. Direct Connection to Thermal Utility Infrastructure with Pressure Sustaining Valve
   1. The campus thermal distribution system static pressure will be set at 45 psig (104 ft) and 50 psig (116 ft) for West and Main campus, respectively. All buildings connected to the West and Main campus thermal utility infrastructure shall assume these maximum static pressure values with direct connection. When the building hydronic system exceeds these static pressure values, a direct connection with pressure sustaining valves is required.
   2. The pressure sustaining valve setpoint shall be set by the building hydronic system designer to maintain a static pressure equal to the highest hydronic coil within the building plus 5 psig.
   3. The building hydronic system designer shall ensure that the static pressure is maintained in the highest hydronic coil and piping at all times.
4. Refer to Figure 1 Interconnection of Building Hydronic Systems to Campus Thermal Utility Infrastructure.

C. Indirect Connection to Thermal Utility Infrastructure

1. The building hydronic system will indirectly connect to the thermal utility infrastructure by way of a heat exchanger. A plate and frame heat exchanger will be utilized to pressure isolate the building hydronic system from the thermal utility infrastructure when:
   a. The building’s hydronic system pressure exceeds 45 psig (104 ft.) and 50 psig (116 ft.) for buildings on the West Campus and Main Campus, respectively, or
   b. The building’s HVAC system are designed with less than the thermal utility infrastructure process conditions, or
   c. The building’s hydronic piping system is aged and/or deteriorated such that it may cause piping leaks or thermal utility infrastructure contamination, or
   d. The building is owned or operated by a third party.

2. Plate and Frame Heat Exchanger:
   a. Select to maximize the thermal utility infrastructure temperature differential.
   b. The plate and frame heat exchanger shall be ASME stamped.

3. The building hydronic system will require provisions for expansion and contraction.

4. The building hydronic system will require provisions for makeup water including back-flow prevention and metering.

5. The interconnection of the building systems with the campus thermal utility infrastructure will require special attention to cleaning, pressure testing, filling, and flushing (Refer to Cleaning, Flushing, and Water Treatment).

6. Indirect Connection Building Hydronic Pumps:
   a. Each building will have one set of variable speed building hydronic pumps and one set of variable speed heat exchanger pumps.
   b. The building hydronic pump speed will vary to provide the required hydronic differential pressure to ensure adequate building hydronic flows.
   c. The heat exchanger pumps will be sized to meet the requirements of the heat exchanger and building hydronic system.

D. Common Requirements for all Building Interconnections

1. Installation shall comply with Texas A&M University’s Building Design Standards and Utilities & Energy Services’ Design Standards.
2. All buildings hydronic systems will be designed for variable flow, without bypass, to obtain maximum delta-T from the thermal utility infrastructure.


4. Building and Heat Exchanger Hydronic Pumps:
   a. Pumps shall be variable speed, centrifugal double-suction horizontal or vertical split case, single-stage, and direct-coupled.
   b. Pumps shall be provided with sufficient turn-down to account for minimum flow conditions.

5. Strainers:
   a. Construction and Start-up strainers shall be specified at a minimum of 40 mesh and are required on each pump.
   b. Permanent duty strainers shall not exceed 20 mesh.
   c. Permanent strainers shall be installed to protect pumps and plate and frame heat exchangers.

6. Air Removal:
   a. An air and dirt separator shall be provided for each building distribution system.
   b. Automatic air vents will be required at all high points in each system.
   c. Air vents shall have manual isolation valves to permit replacing a failed vent without shutting down the system.

7. Cleaning, Flushing, and Water Treatment:
   a. The engineer of record, in association with the commissioning agent (if applicable) and coordinated with Utilities and Energy Services, shall develop an inspection, flush, and startup plan.
   b. Each contractor shall flush, fill, and treat their system before being connected to the thermal utility infrastructure.
   c. The initial filling of the building hydronic system from the thermal utility infrastructure shall be done in a manner to prevent damage to the Thermal Utility Plant equipment and/or contaminate or introduce air to thermal utility infrastructure.
   d. Each contractor shall install all bypasses necessary for flushing. The contractor shall also remove all bypasses to a permanent configuration when flushing is complete.
   e. For initial building hydronic start-up, the system shall be pumped by building hydronic pumps for flushing.
   f. After start-up, all thermal utility infrastructure water chemistry and make-up shall be controlled at the Thermal Utility Plants for direct connections. Alternatively, for indirect connections, the building hydronic chemistry and makeup shall be controlled by the building facilities staff.
g. Utilities & Energy Services will sign-off on the water chemistry before any valves are opened to the thermal utility infrastructure.


E. Commissioning

1. Definition by ASHRAE as a systematic process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.

2. Building commissioning shall be provided:
   a. To ensure that the building hydronic systems are designed and function in accordance with this Standard.
   b. Initial filling of the building system shall be metered to obtain a total building system hydronic volume. Document and submit this total water volume to the project’s Commissioning Agent.
   c. By an independent third party hired by the University.

PART 3 - MINIMUM CLEARANCE REQUIREMENTS

3.01 No structures or facilities are to be built or placed underneath or on top of existing thermal utility lines or easements.

3.02 The project is required to maintain a minimum clearance of 8 feet from the closest point of any existing underground thermal utility infrastructure.

3.03 The project shall bear all costs associated with thermal utility infrastructure modifications required to maintain minimum clearances defined above.

3.04 Assistance in locating existing thermal utility infrastructure on a proposed project site can be obtained from the Technical Services group at Utilities and Energy Services at 979-862-4604.
APPENDIX A

INTERCONNECTION OF BUILDING HYDRONIC SYSTEMS TO CAMPUS THERMAL UTILITY INFRASTRUCTURE
Appendix A
Interconnection of Building Hydronic Systems to Campus Thermal Utility Infrastructure

CAMPUS DIRECT CONNECTION TO BUILDING HYDRONIC SYSTEMS

NOTES:
1. AIR/DIRT SEPARATOR. REFER TO DETAILS.
2. BUILDING PUMPS. REFER TO DETAILS.
3. PRESSURE SUSTAINING VALVE. THE CAMPUS THERMAL DISTRIBUTION SYSTEM STATIC PRESSURE WILL BE SET AT 45 psig (194 kP) AND 50 psig (350 kP) FOR WEST AND MAIN CAMPUS RESPECTIVELY. ALL BUILDING CONNECTED TO THE WEST AND MAIN CAMPUS THERMAL UTILITY INFRASTRUCTURE SHALL ASSUME THESE MAXIMUM STATIC PRESSURE VALUES WITH DIRECT CONNECTION. WHEN THE BUILDING HYDRONIC SYSTEM EXCEEDS THESE STATIC PRESSURE VALUES, A DIRECT CONNECTION WITH PRESSURE SUSTAINING VALVE IS REQUIRED.

CAMPUS INDIRECT CONNECTION TO BUILDING HYDRONIC SYSTEMS

NOTES:
1. AIR/DIRT SEPARATOR. REFER TO DETAILS.
2. BUILDING PUMPS. REFER TO DETAILS.
3. HEAT EXCHANGER PUMPS. REFER TO DETAILS.
4. THE BUILDING HYDRONIC SYSTEM WILL INDIRECTLY CONNECT TO THE THERMAL UTILITY INFRASTRUCTURE BY WAY OF A HEAT EXCHANGER. A PLATE AND FRAME HEAT EXCHANGER WILL BE UTILIZED TO PRESSURE ISOLATE THE BUILDING HYDRONIC SYSTEM FROM THE THERMAL UTILITY INFRASTRUCTURE. WHEN:
   A. THE BUILDING'S HYDRONIC SYSTEM PRESSURE EXCEEDS 45 psig (194 kP) AND 50 psig (350 kP) FOR BUILDINGS ON THE WEST CAMPUS AND MAIN CAMPUS, RESPECTIVELY, OR
   B. THE BUILDING'S HYDRONIC SYSTEM IS DESIGNED FOR LESS THAN THE THERMAL UTILITY INFRASTRUCTURE PROCESS CONDITIONS, OR
   C. THE BUILDING'S HYDRONIC PIPING SYSTEM IS AGED AND/OR DETERIORATED SUCH THAT IT MAY CAUSE PIPING LEAKS OR THERMAL UTILITY INFRASTRUCTURE CONTAMINATION.
Appendix A
Interconnection of Building Hydronic Systems to Campus Thermal Utility Infrastructure

TYPICAL BUILDING HYDRONIC RISER DIAGRAM
SCALE: NONE

NOTES:
1. AUTOMATIC AIR VENTS PIPED TO FLOOR DRAINS. REFER TO DETAILS.
2. WATER PIPING CONNECTIONS TO COILS IN AIR HANDLING UNITS. REFER TO DETAILS.
APPENDIX B

BUILDING HYDRONIC SYSTEM DETAILS
Appendix B
Building Hydronic System Details

AUTOMATIC AIR VENT (AV) DETAIL

NOTES:
1. PROVIDE HOSE ADAPTER FITTING AND HOSE CONNECTIN VACUUM BREAKER FOR VENTS LOCATED IN FINISHED SPACES OR WHERE INDICATED.
2. EXTEND VENT TO DRAIN WITH MINIMUM OF 2" AIR GAP IN ACCORDANCE WITH LOCAL PLUMBING CODE IN MECHANICAL ROOMS AND UNFINISHED AREAS.

AIR/DIRT SEPARATOR DETAIL

NOTES:
1. PROVIDE VALVE TYPES AS SPECIFIED FOR FLUID SERVICE.
2. PROVIDE LOCKABLE VALVE. LOCK VALVE IN OPEN POSITION.
3. PROVIDE SPIROVENT DIRT OR APPROVED EQUAL.
INLINE PIPE MOUNTED PUMP PIPING DETAIL
NO SCALE

NOTES:

1. PROVIDE VALVE TYPES AS INDICATED IN SPECIFICATION FOR FLUID SERVICES BEING PUMPED.

2. SUPPORT PUMP AS REQUIRED BY MANUFACTURER AND SPECIFIED. PUMP SUPPORT SHALL ELIMINATE STRESS ON PUMP COMPONENTS AND SHALL ALLOW FOR PIPE EXPANSION.
WATER PIPING CONNECTIONS TO COILS IN AIR HANDLING UNITS

NOTES:

1. PROVIDE VALVE TYPES AS SPECIFIED FOR FLUID SERVICE INDICATED.
2. DRAINS AND VENTS SHALL NOT BE COMBINED TOGETHER.
BASE MOUNTED END SUCTION PUMP PIPING DETAIL
NO SCALE

NOTES:

1. PROVIDE VALVE TYPES AS INDICATED IN SPECIFICATION FOR FLUID SERVICES BEING PUMPED.

2. AT CONTRACTOR’S OPTION PROVIDE 5 DIAMETERS STRAIGHT SUCTION PIPE IN LIEU OF SUCTION DIFFUSER.

3. IF SUCTION DIFFUSER DOES NOT INCLUDE SUPPORT ON SUCTION DIFFUSER, PROVIDE ADDITIONAL PIPE SUPPORT.
DOUBLE SUCTION SPLIT CASE PUMP PIPING DETAIL

NOTES:
1. PROVIDE VALVE TYPES AS INDICATED IN SPECIFICATION FOR FLUID SERVICES BEING PUMPED.
Design Standard

Interior Lighting

The lighting and day lighting systems of a building represent one of the most important aspects of building aesthetics. The performance of these systems has a direct effect on the functionality and energy efficiency of the illuminated spaces.

Detailed specifications follow.

PART 1 - GENERAL

1.01 Design all lighting systems in accordance with applicable codes and standards.


1.03 Illuminate all spaces in accordance with the User’s requirements and within the footcandle limits specified in the latest edition of the Illuminating Engineering Society of North America (IESNA) *Lighting Handbook*.

1.04 Design lighting systems to limit glare, minimize uniformity ratios, and provide CRIs appropriate to the functionality of the space. Refer to the IESNA *Lighting Handbook* for guidance.

1.05 Do not exceed a lumen depreciation of 5.0% in the calculation of design footcandles.

1.06 Design lighting systems to minimize the maintenance required.

1.07 Do not specify incandescent lighting.

1.08 The specification of custom-designed luminaires is discouraged because of the special maintenance required.

1.09 Select a combination of direct/indirect energy-efficient fluorescent or LED luminaires to light general interior spaces. Specify luminaires to be either recessed type or pendant mounted.

1.10 Specify T8 linear, low-mercury fluorescent lamps with efficacies above 95 lumens/watt and a color temperature of either 3500K or 4100K for use throughout the building. Confirm the type with Utilities & Energy Services, if applicable. (28w T8)
1.11 Specify T5 linear, low-mercury fluorescent lamps with efficacies above 90 lumens/watt and a color temperature of either 3500K or 4100K for use throughout the building. Confirm the type with Utilities & Energy Services, if applicable.

1.12 All lamps shall have a color-rendering index (CRI) greater than or equal to 80. Minimum rated lamp life must be 20,000 hours.

1.13 All compact fluorescents lamps (CFL) must have a minimum efficacy of 60 lumens/watt and maximum lumen depreciation of 15%. Minimum rated lamp life must be 10,000 hours. Lamp color and CRI must be consistent with linear fluorescent lamps. No CFLs below 13W shall be used.

1.14 All ceramic metal halide lamps used in interior finished spaces shall have a color rendering index (CRI) greater than 75.

1.15 All ballasts shall be UL-rated and CMB-certified, rapid-start electronic type with the following characteristics:

A. Sound ratings: “A” for 430mA lamps, “B” for 800mA lamps, and “C” for 1500mA lamps.

B. Operate at less than 10% total harmonic distortion (THD).

1.16 Instant-start ballasts shall not be used. Electronic program start ballasts are acceptable.

1.17 Where dimming is required, use fluorescent fixtures and electronic ballasts that are capable for dimming to 10% (minimum) of full light output. LEDs may also be used.

PART 2 - CLASSROOM AREAS

2.01 Widely varying illumination levels are necessary for various project types. Fluorescent fixtures shall be wired so that separate switches control banks of lights in rows (width wise) running from front to back of room.

2.02 The front row of lights can be turned off when the overhead or video project is used.

2.03 The next row of lights can be turned off during slide/filmstrip viewing, leaving the last switch to turn off last row of lights for opaque projection and 16mm projection. Thus, ambient light levels can be maintained as high as possible for visual comfort and note taking without compromising the quality of the project image. Directionality and resultant glare on screens, TV monitors must be considered.

2.04 Lighting controls must be easily accessed by presenter and should be positioned at both the front and rear of room.
PART 3 - SWITCHING

3.01 Provide multiple switching of interior lighting as required for flexibility and economy of operation.

3.02 Any exterior lights and site lighting will be controlled by the energy management system with a hand off auto switch override or by photocell.

PART 4 – OCCUPANCY SENSORS

4.01 Occupancy sensors are to be ceiling mounted dual technology occupancy or vacancy switches. Sensor Switch CM PDT9 with relay or Sensor Switch CM10 with relay or equivalent are acceptable. Sensors are to be set for 5 minutes with a 10 minute lamp maximizer setting.

4.02 Sensors must be tied into the VAV’s TEC to control room conditioning.

4.03 Room temperature is to be programmed for day occupied (70F heating and 75F cooling), day unoccupied (65F heating and 80F cooling), and night unoccupied (60F heating and 85F cooling).

4.04 VAV CFM shall go to 0 CFM during unoccupied periods.

4.05 AHUs shall shut down when all associated VAVs are in unoccupied mode (0 CFM).

4.06 Lab ACH to be programmed to 8 ACH during occupied and 4 ACH during unoccupied.
Design Standard

Laboratory Control Systems (LCS)

Detailed specifications follow.

PART 1 - GENERAL

1.01 DESCRIPTION

A. When a construction project includes Fume Hoods, the engineer will design a Variable Air Volume (VAV) laboratory airflow control system, (LCS). Constant Air Volume Systems (CAV) are not acceptable. The VAV LCS shall be furnished and installed to comply with the engineer’s design of airflow into and out of laboratory rooms and fume hoods. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain a constant average face velocity into the fume hood when the sash is open. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). Air Changes per Hour (ACH) will be engineered, and balanced, to provide 8 ACH when occupied, and 4 ACH when unoccupied, (with fume hood sash closed). The laboratory will have dual technology, ceiling mounted, occupancy sensors installed that control general lighting in the room, as well as connect to the LCS, in order to manage the Air Changes per Hour during occupied and unoccupied periods.

1.02 RELATED WORK

A. The LCS shall be included within the scope and responsibilities of the projects Building Automation System (BAS) Contractor.

1.03 ACCEPTABLE BAS Contractors and Laboratory Control Systems

A. The following are acceptable BAS Contractors and Laboratory Control Systems
   1. Siemens Building Technologies with Siemens Laboratory Control Systems
   2. Johnson Controls Metasys and TSI Laboratory Control Systems

B. The above vendors will supply a LCS that will use varying LCS products, methods and technologies to meet the engineers design. The BAS contractor will be responsible for providing the LCS to meet the engineers design.
1.04 WARRANTY PERIOD

A. Warranty shall be for a period of twenty-four months (starting from the date of final acceptance) whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the Owner.

1.05 SHOP DRAWINGS:

The BAS contractor shall provide to the engineer and owner in an electronic and paper format:
1. Schematic flow diagrams.
2. Power, signal, and control wiring diagrams.
3. Details of control panel faces.
4. Equipment schedule.
5. Valve schedule.
6. Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
7. Control System Software: Schematic diagrams, written descriptions, and points list.
8. Sequences of operation.
10. Samples of Graphic Display screen types and associated menus.
11. Operation and maintenance data.

PART 2 - SYSTEM PERFORMANCE REQUIREMENTS AND COMPONENTS

2.01 Fume Hood Monitor/Controller

1. A fume hood monitor shall be provided. This same monitor shall generate an exhaust airflow control signal for the appropriate airflow control device in order to provide a constant average face velocity.
2. Audible and visual alarms shall be provided for both flow alarm and emergency exhaust conditions.
3. The fume hood monitor shall indicate the average face velocity for the fume hood, and have indicator lights to indicate normal, warning and alarm status. The fume hood monitor shall have an audible alarm and alarm silence button

2.02 AIRFLOW CONTROL DEVICE

A. The airflow control device shall be pressure independent over its specified operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.
B. Each fume hood exhaust terminal will have a factory mounted, removable, air flow transmitter with output of 4-20 mA proportional to velocity pressure. The air flow transmitter will have an accuracy of at least ±.5% of the transmitter range.

C. The laboratory general exhaust valve (GE) shall meet one of the following requirements:

   Actuation:
   1. For electrically-actuated VAV boxes the actuator shall be mounted to the VAV box. Loss of main power shall cause the actuator to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position, or last position. This position shall be maintained constantly without external influence, regardless of external conditions on the actuator (within product specifications).

2.03 LABORATORY CONTROL UNIT

A. Each Laboratory Control Unit (LCU) shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each LCU shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of LCUs as a minimum:
   1. VAV Fume Hood, temperature general exhaust and supply controllers.
   2. Laboratory Room Controllers.

B. A laboratory control unit shall control the supply and/or general exhaust and laboratory exhaust airflow control devices to maintain proper room pressurization polarity (positive or negative). Each individual laboratory shall have a dedicated laboratory control unit.

C. The control unit shall be electronic. The inputs shall accept linear feedback signals from fume hood, canopy, snorkel, biosafety cabinet, and office supply airflow control devices. The output signals shall control supply, general exhaust/return airflow control devices and/or variable frequency drives with signals that are linearly proportional to the desired supply or exhaust airflows.

D. The control unit shall maintain a constant design offset between the sum of the room’s total exhaust and make-up/supply airflows. This offset shall be field adjustable and represents the volume of air which will enter (or exit) the room from the corridor or adjacent spaces.

E. The control unit shall provide linear signals that are proportional to all airflow sources, sash sensors, and flow alarms. The signals shall be available for hard wired connection to the facility’s direct digital control (DDC) system, or through an integrated control unit that interfaces directly into the facility’s DDC system.
F. Refer to the DDC Control specification for the required input/output summary for the necessary points to be monitored and or controlled.

G. The LCU shall be equipped with a dynamic auto-zero module to automatically recalibrate the flow sensors every 24 hours without reducing flow through the boxes.

H. Each laboratory shall have a dedicated 120 Vac line connection to power the laboratory's airflow control system power supply.

2.04 INTERFACE TO BUILDING AUTOMATION SYSTEM

A. The laboratory airflow control system shall fully interface with the project Building Automation System (BAS). The LCS system shall include all necessary devices and software to monitor and control all items indicated in on the Contract Documents. All points shall be able to be monitored and adjusted thru the BAS

PART 3 - EXECUTION

3.01 INSTALLATION

A. The Building Automation System (BAS) contractor shall install sensors, interface boxes, presence and motion sensors, and fume hood monitor on the fume hood. Sash interface boxes with interface cards shall be mounted in an accessible location.

B. The BAS contractor shall install the laboratory control unit (if panel-mounted) and wall-mounted power supply (as required) in an accessible location in the designated laboratory room.

C. The BAS contractor shall terminate and connect devices as required. In addition, integrated laboratory control unit connectors shall be furnished by the BAS.

D. The laboratory control unit or power supply shall be from a dedicated, single phase 120 vac power circuit.

PART 4 - SYSTEM START-UP AND TRAINING

A. System start-up shall be provided by a factory authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination flow sensing equipment as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust, or return).
B. The balancing contractor shall be responsible for final verification and reporting of all airflows. All balancing shall be coordinated with the commissioning efforts of the BAS system.

C. The BAS contractor shall furnish a minimum of eight hours of owner training, by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves, and general troubleshooting procedures.

D. Operation and Maintenance manuals, including as-built wiring diagrams and component lists shall be provided.
Design Standard

Medium-Voltage Electrical Service & Distribution

This standard was revised on May 16, 2017, and the latest changes are underlined. Please refer to Part 4 of this standard for full revision history.

PART 1 - OPERATING CHARACTERISTICS

1.01 The medium-voltage electrical service and distribution system that serves Texas A&M is owned by the university and is operated as an electric utility system in the manner by which power is distributed and utilized at the point of delivery. The operating characteristics, grounding, load connections, utilization voltages, and short-circuit current available at the point of service vary. This information is summarized in the following table:

<table>
<thead>
<tr>
<th>Item</th>
<th>Information / Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Voltage</td>
<td>12.47 kV, 3-phase, 4-wire, delta / low-resistance-grounded wye, 60Hz</td>
</tr>
<tr>
<td>Grounding</td>
<td>Low-resistance-grounded wye</td>
</tr>
<tr>
<td>Load Connections</td>
<td>ΔY Delta-Y</td>
</tr>
<tr>
<td>Elec. Utility Co. / Provider</td>
<td>TAMU Utilities &amp; Energy Services</td>
</tr>
</tbody>
</table>

PART 2 - DESIGN GUIDANCE

2.01 Confirm the available short-circuit current at the point of service or connection to the existing utility source from the manager of UES Electrical Services.

Note: For projects that require one or more medium-voltage transformers to supply low-voltage power to a building or facility, it is generally acceptable to assume for design purposes, in the calculation of maximum short-circuit current, that the utility source has an infinite bus impedance relative to the secondary windings of each medium-voltage transformer supplied from it. Refer to IEEE 242, Section 2.7 for additional information and guidance on the calculation of short-circuit values.

2.02 Medium-voltage distribution circuits in the well-developed areas of a campus generally consist of multiple single-conductor insulated copper conductors routed in a multi-duct underground ductbank/manhole system with radial and
looped circuits switched manually via sectionalizing switchgear (underground or above ground medium voltage switches).

2.03 The switchgear supply power from the campus utility distribution system “grid” to the primary windings of one or more medium-voltage transformers located within the project site through an extension of the underground ductbank/manhole system.

2.04 Major loads in such areas may have dedicated radial feeders from utility substations. Distribution circuits in less developed areas typically provide electrical services to individual buildings and other permanent structures radially from aerial conductors; however, the installation of permanent overhead distribution is not permitted for new construction at any campus. Any new proposed aerial lines will require UES approval and depending on location, approval by the Council for the Built Environment.

2.05 The portion of the utility distribution system supplying a typical TAMU project originates at the point of service or connection to the existing campus-owned utility supply line via switchgear and terminates at the primary windings of the medium-voltage transformer(s) that serve(s) the project load at a lower utilization voltage.

2.06 Depending on the magnitude of the load and the level of reliable normal power required for the project, one or both of the switches positions may be used to supply the building or buildings from one or two service transformers.

2.07 Smaller buildings that do not require more than an average level of service reliability are usually served by a single transformer via one radial feeder from the switchgear, in which case the other switch may be reserved as a spare to supply temporary backup power to the building.

2.08 Buildings that require two service transformers, either because of a high demand load and/or a requirement for a high level of service reliability, are most often served by two radial feeders that each emanate from one of the two switch positions.

2.09 Additional alternatives for supplying one or more buildings from the utility distribution system are possible because TAMU standards require that all medium-voltage transformers be provided with loop/dual-feed primary bushings.

2.10 Unless noted otherwise in the project-specific Program of Requirements (POR), any modifications necessary to extend or upgrade the campus utility distribution system to supply electrical service to a new project or project site must be fully funded by that project. Therefore, all utility distribution system components including cables, duct banks, manholes, switchgear, service
transformers, equipment pads, and similar construction items necessary to support or contain utility system components must be furnished and installed by the Construction Contractor selected for each project.

PART 3 - MINIMUM CLEARANCE REQUIREMENTS

3.01 No structures or facilities are to be built or placed underneath existing or new overhead utility lines or on top of existing or new electrical manholes and duct banks.¹

3.02 The project is required to maintain a minimum clearance of 20 feet from the closest point of any existing underground or overhead electric utility infrastructure. Ten feet of clearance is required in front of transformer and switch doors.¹

3.03 The project shall bear all costs associated with electric utility infrastructure modifications required to maintain minimum clearances defined above.¹

3.04 Assistance in locating existing electric utility infrastructure on a proposed project site can be obtained from the Technical Services group at Utilities and Energy Services at 979-862-4604.¹

3.05 Written approval from Utilities and Energy Services is required for any waiver from these minimum clearance requirements.¹

PART 4 - REVISION HISTORY

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/16/2017</td>
<td>Part 3</td>
<td>Minimum clearance requirements added to standard.</td>
</tr>
</tbody>
</table>
Design Standard

Medium Voltage Power Systems

Detailed specifications follow.

PART 1 MEDIUM-VOLTAGE CABLE

1.1 Shielded MV105 Cable

A. Provide medium-voltage shielded power cables that are NTRL-listed as Type MV105 for use in raceways, trays, underground ductbanks, manholes, vaults, and within switchgear and equipment of sufficient interior dimensions to allow for the proper bending & and termination of shielded cables.

B. Comply with the NEC®, IEEE C2™, ICEA S-93-639 / NEMA WC-74, and UL 1072.

C. Select voltage ratings for power cables and terminations based on the operating voltage of the medium-voltage distribution system as follows:

<table>
<thead>
<tr>
<th>Distribution System Operating Voltage</th>
<th>Power Cable Nominal Voltage Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,160 volts</td>
<td>5kV</td>
</tr>
<tr>
<td>5,000 volts to 15,000 volts</td>
<td>15kV</td>
</tr>
<tr>
<td>25,000 volts</td>
<td>25kV</td>
</tr>
<tr>
<td>35,000 volts</td>
<td>35kV</td>
</tr>
</tbody>
</table>

D. Specification

1. Conductor: Single uncoated annealed copper conductor with Class B stranding. Aluminum conductors may be allowed in some circumstances with prior UES approval. If aluminum is approved standard sizes below shall be increased to meet equal or greater ampacity.

2. Strand Screen: Extruded semi-conducting ethylene-propylene rubber (EPR).

3. Insulation: 133% EPR 140 mils thick for 5kV & 220 mils for 15kV.

4. Insulation Screen: Extruded semi-conducting thermoset (TS) EPR.

5. Shielding: Copper tape 5 mils thick helically applied with a minimum of 12.5% overlap.

6. Jacket: Sun Resistant PVC

7. Continuous Operating Temperature: 90°C

Note: Operating temperature is limited to 90°C because PVC power ducts are listed for 90°C conductors.

8. Emergency Temperature Rating: 105°C

9. Short-Circuit Rating: 250°C

10. Conductor Sizes (for 15kV copper conductor only): AWG Nos. 1, 1/0, 4/0, &
1.2 Non-shielded MV105 Power Cable
   A. Use non-shielded medium-voltage power cables only for short jumpers within switchgear or transformer enclosures where it is not feasible to install shielded cables due to inadequate space for bending or terminating shielded cables.
   B. Use non-shielded medium-voltage transformer cable with 133% EPR / 140 mils thick for 5kV and 133% EPR / 220 mils thick for 15kV insulation, Sun Resistant PVC Jacket.
   C. Conductor AWG Sizes (for 15kV only): 1, 1/0, 4/0, & 500kcmil.
   D. Obtain approval from the Owner for each installation of non-shielded medium-voltage cable.
   E. Acceptable Manufacturers:
      1. General Cable Prysm
      2. Okonite
      3. Southwire

1.3 Medium-Voltage Cable Terminations
   A. Terminating materials must be compatible with the cable supplied.
   B. Submit proof of the acceptability by the cable manufacturer of any splicing or terminating materials.
   C. Separable Insulated Connectors: Specify pre-molded EPDM-type, submersible, fully shielded, separable insulated connectors for use with MV105 power cable as specified above. Connector system components shall comply with IEEE Std 386, *Separable Insulated Connector Systems for Power Distribution Systems Above 600V*
   D. Match voltage-class ratings of cable at 5kV, 15kV, or 25kV voltage-class. Provide 200A-rated load break elbow connectors for outdoor terminations at medium-voltage transformers and switchgear with switch-ways rated at 200A continuous, and 600A-rated dead break elbow connectors for terminations at medium-voltage switchgear with switch-ways rated at 600A continuous.
   E. Indoor Terminators: Silicone rubber, cold shrink, tubular or skirted.
   F. Outdoor Terminator: Silicone rubber, cold shrink, skirted.
   G. Acceptable Manufacturers:
      1. Elastimold
      2. RTE
      3. 3M

1.4 Medium-Voltage Cable Testing
   A. Upon completion of the installation, the Owner shall secure and pay for the services of a qualified, independent testing firm to conduct a test of all medium-voltage cable, including
terminations, as part of the electrical acceptance test project phase.

B. The testing firm shall perform a high-potential proof test using a non-destructible DC testing device such as a “Kenotron” Westinghouse “High-Pot Tester”, or approved equal, capable of generating approximately 100,000 VDC under normal leakage conditions of acceptable cable.

C. All cables shall be tested in place with all splices and pothead terminations made up but not connected to switchgear or any other equipment, load device, or dead-end seal. Cables with dead-end seals shall be temporarily opened and then re-sealed.

D. In case of failure during the test, the Contractor shall locate the faulty splice, termination, or cable section and notify the Owner before making any repairs.

E. The testing firm shall submit to the Project A/E five copies of all test reports for review by the Engineer-of-Record. Should the test reports indicate, in the opinion of the Owner, that the condition of the new cable is unsatisfactory, the Contractor shall make all repairs and/or replacements to the satisfaction of and no additional cost to the Owner.

F. Additional tests using the same testing firm shall also be made at the Contractor’s expense on all repaired sections.

G. The Owner will not accept any cable installations until satisfactory certified proof test reports are obtained.

PART 2 RACEWAY SYSTEMS FOR MEDIUM-VOLTAGE CABLES

2.1 Design Guidance

A. Perform calculations to determine pulling tensions and sidewall pressures for all duct or conduit runs of medium-voltage power cable.

B. Design raceway systems so that the calculated pulling tensions and sidewall pressures will not exceed the cable manufacturer’s recommendations

C. Lacking manufacturer’s recommendations use the following maximum values:
   1. Cable tension:
      a. 0.008 lb./cmil for up to 3 conductors, not to exceed 10,000 pounds.
      b. 0.0064 lb./cmil for more than 3 conductors, not to exceed 10,000 pounds. c. 1000 lbs. per basket grip
   2. Sidewall pressure: 500 lbs./ft

D. The maximum length of raceways between cable pulling points shall be the lesser of 400 feet or a maximum of 90° in total horizontal bends between cable pulling points.

2.2 Above ground Installations

A. Within the perimeter of buildings, install aboveground medium-voltage cables in rigid metal conduit.

B. In areas protected with fire sprinklers, terminate conduits entering equipment enclosures
from above with water sealing fittings.

C. Install voltage markers on all conduits containing medium-voltage cables.

PART 3 MEDIUM-VOLTAGE SWITCHGEAR

3.1 Design Criteria

A. For facility-level medium-voltage switchgear lineups and unit substation switchgear, provide metal-enclosed interrupter switchgear conforming to IEEE C37.20.3, Standard for Metal-Enclosed Switchgear, with current-limiting E-rated power fuses conforming to IEEE C37.46, Standard Specifications for Power Fuses and Fuse Disconnecting Switches.

B. For facility-level medium-voltage switchgear applications that either exceed the current capacity of fused equipment or require complex or high-speed switching operations, use metal-clad switchgear with vacuum circuit breakers conforming to:
   1. IEEE C37.20.2, Standard for Metal-Clad and Station-Type Cubicle Switchgear
   2. IEEE C37.04, Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
   3. ANSI C37.06, Standard for Switchgear – AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

C. Provide 5kV medium-voltage switchgear having the following minimum ratings:
   1. 60Hz one-minute withstand voltage at mean sea level: 22kV; this rating may be obtained through insulation coordination with surge arresters.
   2. BIL at mean sea level: 75kV; this rating may be obtained through insulation coordination with surge arresters.

D. Provide 15kV-class medium-voltage switchgear with the following minimum ratings:
   1. 60Hz one-minute withstand voltage: 42kV at mean sea level; this rating may be obtained through insulation coordination with surge arresters.
   2. BIL at mean sea level: 95kV; this rating may be obtained through insulation coordination with surge arresters.
   3. Short-circuit rating: Provide equipment with a short-circuit rating greater than the available short-circuit current and not less than 25kA RMS symmetrical.


F. Switchgear shall come complete from manufacture with controls. All breaker Remote controls shall be wired to relay to support remote breaker control. Relay shall be model currently in use on campus and be fully compatible with campus SCADA for seamless
integration. Controls shall include:
1. Statuses: Breaker Open, Breaker Closed, Breaker Racked in, in local, in remote, Bus 86 tripped, Trip coil monitor.
2. Remote Controls: Open Breaker, Close Breaker
3. Local Controls: Open Breaker, Close Breaker, Local/Remote switch (43)
4. Local/Remote Switch shall completely disable remote controls while in local and completely disable Local controls while in remote, Local/Remote Switch shall not block trips from breaker.
5. All relays shall be wired to common Communication and programmable control hub. Such as an SEL RTAC. Communication hub shall be model currently in use on campus and be fully compatible with campus SCADA.

PART 4 OUTDOOR MEDIUM-VOLTAGE PAD MOUNTED SWITCHGEAR

4.1 4All 15kV switches shall meet either “15kv Switches - Pad Mounted” or “15kv Switches – Underground” TAMU UES’ standards.

4.2 Pad Mount Switches

A. Description
1. For purposes of this Section, “padmount switches” are understood to consist of a single self-supporting enclosure containing interrupter switches.
2. Padmount switches are restricted to outdoor use. A padmount switch may include power fuses and accessory compartments.

B. Application
1. Padmount switches are typically used for sectionalizing applications in the medium-voltage distribution system.

   Note: Within the limitations of their current-carrying capability, interrupting duty and available configurations, padmount switches typically offer the lowest-cost switching solution.

2. Install padmount switches atop or immediately adjacent to manholes.
3. Route cables to padmount switches through manholes.
4. Pre-cast, concrete vaults with 18” minimum depth shall be used as vault foundations. Vault foundations shall include ground ring around interior wall of vault, as well as two 3/4” diameter 10’ long ground rods.

C. Clearances
1. Design installations of padmount switches to permit maintenance access.
2. Design the installation of padmount switches to ensure 10 feet of clear working space in front of the switch enclosure doors for the full width of the enclosure.

   Note: In areas where vehicle parking may be possible, bollards, curbs or other structures should be installed to keep vehicles out of the working space. The sides of switches without doors or auxiliary compartments containing electrical control or instrumentation devices do not need working space greater than 30 inches for
personnel access. For switches with side-mounted accessories such as fuse storage compartments or crank-type switch operators, this access space is to be measured from the outer face of the accessory or the end of the crank handle.

3. Auxiliary compartments with electrical control or instrumentation devices must be provided with working space in conformance with NESC Rule 125

PART 5 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

5.1 5.1 Description

A. For purposes of this Section, “metal-enclosed interrupter switchgear” is understood to be equipment consisting of interrupter switches housed in individual steel compartments. Switching devices are fixed (not draw out). Busses are typically exposed when the compartment door is open. The switchgear may include fuses, sensing and metering devices and control equipment, but not power circuit breakers.

B. Metal-enclosed interrupter switchgear is available with enclosures suitable for indoor or outdoor installation.

C. Metal-enclosed interrupter switchgear shall be manufactured in accordance with IEEE C37.20.3.

5.2 5.2 Application

A. Metal-enclosed interrupter switchgear differs from padmount switches in its higher continuous current and interrupting rating, and wider availability of custom features. Metal-enclosed interrupter switchgear is commonly used as the primary disconnecting means for unit substations.

B. For application of metal-enclosed interrupter switchgear, consultation with the equipment vendors is recommended.

C. Manufacturers’ ratings do not take into consideration the effect of solar radiation on metal-enclosed interrupter switchgear installed outdoors. Use IEEE Standard C37.24 to calculate the derating of the continuous current rating of switchgear exposed to the sun.

PART 6 METAL-CLAD SWITCHGEAR

6.1 Description

A. For purposes of this Section, “metal-clad switchgear” is understood to be equipment consisting of individual steel compartments with draw-out switching devices. Switching devices may be load-break interrupter switches or power circuit breakers. The switchgear may include fuses, sensing and metering devices and control equipment.

B. Metal-clad switchgear is available with enclosures suitable for indoor or outdoor
installation.

C. Metal-clad switchgear shall be manufactured in accordance with IEEE C37.20.2.

6.2 Equipment

A. Specify Powell Power/Vac vacuum metal-clad circuit breaker elements for use on
B. 15kV-class systems.

**Note:** The requirement for GE Power/VAC equipment is not intended to unreasonably limit the market for the supply of switchgear equipment. The limitation extends only to the interrupter devices (the vacuum bottles) and the removable circuit breaker mechanism (the breaker” truck”). The switchgear control systems, buswork, and enclosures may be assembled by a qualified fabricator other than General Electric.

6.3 Application

A. Metal-clad offers the most flexible means of control and protection for power systems. Sophisticated protective relay schemes are readily applied to metal-clad switchgear. Of the three available types of switchgear, metal-clad is the most expensive.
B. For application of metal-enclosed interrupter switchgear, consultation with the equipment vendors is recommended.
C. Specify outdoor installations of metal-clad switchgear with walk-in aisle-type enclosures.
D. Provide ventilation (and air conditioning if required) as necessary to ensure that interior temperatures do not exceed 95°F.
E. Manufacturers’ continuous current ratings do not take into consideration the effect of solar radiation on metal-clad switchgear installed outdoors. Use IEEE Standard C37.24 to calculate the derating of the continuous current rating of switchgear exposed to the sun.

**PART 7 MEDIUM-VOLTAGE TRANSFORMERS**

7.1 Specify dry-type units for locations inside the building and oil-filled pad mounted-type units for locations outdoors.

A. Only the use of new copper wound, loop fed transformers are permitted for use in the 12.5kV TAMU electrical distribution (aluminum wound transformers are not acceptable for use).
B. Transformer Capacity: Base transformer capacity on load calculations per the requirements in NEC® and this Chapter and loading guidance in the following IEEE standards as applicable:
Average Winding Rise.


**Note:** The IEEE C57-91-1995 Guide combines the data previously issued in the IEEE Guides C57.91-1981, C57.92-1981, and C57.115-1991 (re-designated as Std. 756). It also updates the data and presents equations that approximate the empirical data previously presented in tabular form. The designer may apply either method.

C. All transformer shall come with complete set of “Routine Test” from manufacture as listed in IEEE C57 and sub standards, Transformers shall also be tested on site to NETA standards with the exceptions and additions as follows:

1. Outdoor Padmount transformers shall be proof tested using high potential test to manufactures standards.
2. Outdoor Padmount transformers shall not need Oil sample test provided, transform comes sealed from manufacture with oil test report, and seal remains intact.
3. Outdoor Padmount transformers shall not need power factor test provided, test comes from manufacture and transformer has not sustained any damage between test and commissioning.
4. All testing shall be with equipment list for test and equipment with current certified calibrations.
   All testing shall be schedule minimum 14 days prior to, and all allowances made so as to be witness tested by TAMU or appointed agency.

7.2 Indoor Dry-Type Medium-Voltage Transformers

A. Use dry-type transformers conforming to IEEE Std C57.12.01, Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings, where liquid containment is not practical. Use dry-type transformers having an 80°C winding temperature rise over a 30°C average, 40°C maximum ambient. Use cast epoxy resin transformers to serve critical loads or where the transformer is in a dirty environment. Use vacuum pressure impregnated or cast epoxy resin transformers to serve non-critical loads and where the transformer is in a clean environment. Specify copper windings only.

B. Install medium-voltage dry-type transformers indoors only.

C. Install indoor transformers in vaults or rooms with a fire-resistance rating of not less than 2 hour.

D. Doors in transformer vaults or rooms shall be fire-rated and swing outward in the direction of egress.
   1. Equip doors with panic hardware.
   2. Fire rating of doors shall match fire rating of room or vault.
   3. Provide door opening adequate for moving largest equipment in the room or vault.

E. Locate transformers a minimum of 36 inches from building walls.

F. Provide ionization type smoke detectors and automatic sprinkler protection for indoor
medium-voltage transformer vaults or rooms. Connect ionization-type smoke detectors to the building fire alarm system.

G. Provide automatic sprinkler protection system with a discharge density of not less than 0.20 gpm/sq. ft. over floor area of the transformer vaults, rooms, or spaces.

H. Provide mechanical cooling or ventilation powered from a reliable source to maintain transformer vaults or rooms within temperature limits appropriate for transformer operation.

I. Provide power ventilation system from an emergency or standby power source if available.

J. Specify primary overcurrent protection devices to provide through-fault protection of transformer in accordance with IEEE Std 242™.

K. Select distribution-class, gapless-type metal-oxide surge arresters for connection to the primary side of the transformer to provide additional protection against abnormally high voltage transients. Specify the maximum continuous operating voltage (MCOV) of the arrester according to its voltage-class rating. Apply arresters in accordance with IEEE Std C62.22, IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems or as recommended by the arrester manufacturer.

7.3 Outdoor Oil-Filled Pad Mounted Medium-Voltage Transformers

A. Install oil-filled medium-voltage transformers outdoors only.

B. Provide outdoor, pad-mounted, mineral oil-insulated, self-cooled medium-voltage transformers with integral dead-front loop-feed primary and live-front radial secondary cable terminating compartments. Windings shall be copper; aluminum windings are not acceptable.

C. Transformers shall be designed, constructed, and tested in conformance with IEEE C57.12.22TM, Requirements for Pad-Mounted Compartmental-Type, Self- Cooled, Three-Phase Distribution Transformers (High Voltage, 16340 Volts and Below; 2500 KVA and Smaller).

D. Transformers shall be designed to operate at a 65 °C average winding temperature rise over a 30 °C average, 40 °C maximum ambient temperature.

E. Furnish each transformer with the following accessories:
   1. Oil-immersed, load-break, bayonet fuse-holders with expulsion style fuses.
   2. Oil-submersible protector with current-limiting fuses rated for 50kAIC. Current-limiting fuses shall be placed in series with expulsion style fuses.
   3. Distribution-class, metal-oxide varistor elbow (MOVE) type surge arresters
   4. Two 2-1/2% above and two 2-1/2% below rated-voltage, full-current-rated for
changing under no load. Include externally-mounted handle for tap-changer.

F. Acceptable Manufacturers
1. ABB
2. Cooper
3. Square D
4. GE

G. Installation
1. Design a concrete foundation for the transformer. If required, provide an oil-containment system integral to the foundation in accordance with EPA regulations.
2. Install in accordance with the NEC® and the Factory Mutual Insurance Company Loss Prevention Data Sheet 5-412.

H. Determining Transformer Capacity
1. Use the following loading factors to determine transformer capacity:
   a. Average 24-hour ambient temperature
      i. Use the highest historical average (mean) daily temperature recorded at the University campus or at a location nearest the campus for which accurate data are available, such as the nearest airport or city. This data may be obtained from the National Weather Service at http://www.nws.noaa.gov or other source with similar reliable and/or official data. Refer to the appropriate sections in the ANSI/IEEE standards referenced above for further guidance concerning the determination of ambient temperature for use in the selection of the “Peak Load Per Unit” or peak load factor presented in the series of tables in both publications.
      ii. According to Weather.com, the highest 24-hour average temperature for College Station, TX (zip code 77843) is 30°C and occurred on August 4 and 5.
   d. Transformers serving facilities having a significant daily load cycle may be operated with the peak load above the transformer nameplate rating as long as normal transformer life expectancy is maintained; refer to the IEEE transformer-loading guides listed above.
2. For single-ended services, the calculated load using the NEC® plus future load growth shall not exceed the calculated transformer self-cooled peak loading capability.

Example 1 – For building or facility located on a campus in College Station with a significant daily load cycle: 685kVA calculated load per the NEC® plus 137kVA
future load growth of 20% = 822kVA.

3. Select a pad-mounted transformer with a standard base rating equal to or greater than
   \[
   822kVA / 1.68^* = 489kVA, \quad \text{or} \quad 500kVA, \quad \text{and a 2-hour peak loading capability of}
   \]
   approximately 500kVA \times 1.68^* = 840kVA based on Table 6 in IEEE C57.91-1981
   
   a. The peak load factor (per unit) assuming an ambient temperature of 30°C.
   
   b. Base the secondary service conductors on the 822kVA calculated load.

4. For double-ended services, the calculated closed-tie load using the NEC® plus
   future load growth shall not exceed the calculated forced-air cooled peak loading
   capability of either transformer.

PART 8 TESTING

8.1 All equipment shall be undergo a full NETA acceptance test. Test values of gear shall come from
   manufacture of equipment. Exceptions and alterations to test noted in this Standard shall apply.

   A. Existing Cable – Where projects receive permission from UES to reuse existing primary
      cables, cable must be pass a retesting. See UES cable splicing SOP for further details.

   B. Existing transformers – Where projects receive permission from UES to reuse existing
      transformers. Transformer must undergo full NETA test with no exceptions. If transformer
      is moved, even temporarily. a power factor test shall be perform prior to move and again
      before being reenergized.

   C. Gear with buswork – All gear contain bus work, such as bus duct, switchgear,
      panelboards, resister and capacitor banks, etc. Shall at minimum have receive a 10% spot
      check of torque on all bolts of bus work. This is in addition to using the resistive test
      spelled out in NETA to verify buswork.
Design Standard

Piping, Equipment, and Structure Color and Identification

Detailed specifications follow.

PART 1 - GENERAL

1.01 SUMMARY

A. This guideline is to cover Texas A&M University Utility Plant color and identification requirements for piping, equipment, structural steel, and miscellaneous features located inside and outside of Utility Plant buildings.

B. All new piping shall be coated and banded as prescribed in these guidelines.

C. Each pipe system shall be labeled per these guidelines.

D. All new equipment shall be coated per these guidelines.

1.02 PIPING NOT INCLUDED IN THESE GUIDELINES

A. Coating or identification of electrical conduit is not included in these guidelines.

1.03 STANDARDIZED COLORS

A. Colors shall be used for painting and banding of all piping and equipment in accordance with the table below. Selection of coating system (enamel, epoxy, or urethane) to be determined based upon service requirements.

1.04 STANDARDIZED SIZES

A. Identification of the material contained in piping and conduits will be in accordance with the table below. The titles will be lettered on bands. Upper case letters and Arabic numerals will be used. Where pipes or conduits are too small or not readily accessible for such application, a brass identification tag will be securely fastened at appropriate locations. Tags will be at least 1½ inches in diameter, with depressed block characters ¼ inch high.
1.05 PIPE IDENTIFICATION

A. Each pipe circuit is to be labeled by stencil, banded and painted per the chart below. Stencil shall include flow arrow and identification as follows. Labeling and flow arrow to be provided at least every 20' and at all changes in elevation or direction. Vinyl is acceptable on interior piping only. Specifications for acceptable vinyl labeling products will be provided by Utilities upon request. Provide pipe band identification for each pipe at lease at or near equipment served and at or near where pipe exits area. Pipe band locations to be approved by TAMU Utilities prior to installation.

<table>
<thead>
<tr>
<th>Band and Letter Size</th>
<th>All Dimensions in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Diameter Of Pipe Covering</td>
<td>Width of Color Band</td>
</tr>
<tr>
<td>1/2 to 1-1/4</td>
<td>2</td>
</tr>
<tr>
<td>1-1/2 to 2</td>
<td>2</td>
</tr>
<tr>
<td>2-1/4 to 3-1/4</td>
<td>2</td>
</tr>
<tr>
<td>3-1/2 to 6</td>
<td>6</td>
</tr>
<tr>
<td>8 to 10</td>
<td>12</td>
</tr>
<tr>
<td>Over 10</td>
<td>12</td>
</tr>
</tbody>
</table>

* Provide color band width as shown or, in tight locations, as wide as possible up to color band width shown.
<table>
<thead>
<tr>
<th>Piping System/Equipment</th>
<th>Description</th>
<th>Label</th>
<th>Label Color/Schema Letter Color on Background Color</th>
<th>Pipe/Equipment Color</th>
<th>Band Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel Oil</td>
<td>Diesel Fuel Oil</td>
<td>Fuel Oil</td>
<td>BLACK on ORANGE</td>
<td>Black – Sherwin-Williams BLACK 4090</td>
<td>Orange – Sherwin-Williams SAFETY ORANGE SW 4083</td>
</tr>
<tr>
<td>Natural/Fuel Gas</td>
<td>Natural Gas</td>
<td>Nat Gas</td>
<td>BLACK on YELLOW</td>
<td>Black – Sherwin-Williams BLACK 4090</td>
<td>Yellow – Sherwin Williams SAFETY YELLOW SW 4084</td>
</tr>
<tr>
<td>Steam 20 PSIG</td>
<td>Steam</td>
<td>STM 20 PSIG</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>None</td>
</tr>
<tr>
<td>Steam 150 PSIG</td>
<td>Steam</td>
<td>STM 150 PSIG</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>None</td>
</tr>
<tr>
<td>Steam 600 PSIG</td>
<td>Steam</td>
<td>STM 600 PSIG</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>None</td>
</tr>
<tr>
<td>Heating Hot Water</td>
<td>Heating Hot Water Supply</td>
<td>HHWS</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>Red – Sherwin-Williams REAL RED SW 6668</td>
</tr>
<tr>
<td>Heating Hot Water</td>
<td>Heating Hot Water Return</td>
<td>HHWR</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>Red – Sherwin-Williams REAL RED SW 6668</td>
</tr>
<tr>
<td>Steam Condensate</td>
<td>Hot Steam Condensate</td>
<td>Hot STM Condensate</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket</td>
<td>None</td>
</tr>
<tr>
<td>Condensate</td>
<td>Condensate other than from steam</td>
<td>Condensate</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
</tr>
<tr>
<td>Refrigerants</td>
<td>Refrigerants</td>
<td>Common Designation (ex. R-134A, R-22)</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
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<tr>
<td>Sanitary Sewer Drain</td>
<td>Sanitary Sewer Drum</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Cooling Tower Condenser Water Supply</td>
<td>CWS</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>Green – Sherwin Williams ECO GREEN SW 6739</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Cooling Tower Condenser Water Return</td>
<td>CWR</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>Green – Sherwin Williams ECO GREEN SW 6739</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Chilled Water Supply</td>
<td>CHWS</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket or White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>Blue – Sherwin-Williams SAFETY BLUE SW 4086</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Chilled Water Return</td>
<td>CHWR</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket or White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>Blue – Sherwin-Williams SAFETY BLUE SW 4086</td>
</tr>
<tr>
<td>Roof Drain</td>
<td>Drain from Roof</td>
<td>Roof Drain</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket or White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
</tr>
<tr>
<td>Floor Drain</td>
<td>Drain in Floor</td>
<td>Floor Drain</td>
<td>BLACK on WHITE</td>
<td>Aluminum Metal Jacket or White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
</tr>
<tr>
<td>Domestic Hot Water (Pot. Water)</td>
<td>Domestic Hot Water</td>
<td>DHWS DHWR</td>
<td>BLACK on LIGHT BLUE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
</tr>
<tr>
<td>Domestic Cold Water (Pot. Water)</td>
<td>Domestic Cold Water</td>
<td>BLACK on LIGHT BLUE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Process/Make-up Water</td>
<td>Process Water or Make-up Water</td>
<td>Non-Potable Water</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Compressed Air</td>
<td>BLACK on WHITE</td>
<td>White – Sherwin-Williams PILLAR WHITE SW 4029</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Fire Protection System</td>
<td>Materials for Fire Suppression</td>
<td>Sprinkler Water, Carbon Dioxide or FM 200</td>
<td>WHITE on RED</td>
<td>Red – Sherwin Williams SAFETY RED SW 4081</td>
<td>None</td>
</tr>
<tr>
<td>Outside Piping</td>
<td>None</td>
<td>None</td>
<td>Tan – Sherwin-Williams Sherthane BAGEL LIGHT (Custom for TAMU) Or Aluminum if insulated</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Equipment Outside</td>
<td>Appropriate Equipment Numbering</td>
<td>BLACK on AGGIE TAN</td>
<td>Tan – Sherwin-Williams Sherthane BAGEL LIGHT (Custom for TAMU) Or Aluminum if insulated</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Equipment Inside</td>
<td>Appropriate Equipment Numbering</td>
<td>See Note 2</td>
<td>See Note 2</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Structural Steel Outside/Inside (includes stairs, handrails, toe boards, and grating)</td>
<td>None</td>
<td>Galvanized or Gray Sherwin-Williams Sherthane ANSI #70 GRAY</td>
<td>None</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART 2 - EXECUTION

2.01 PAINTING

A. Provide surface preparation and coating per paint manufacturer’s recommendations. Refer to TAMU Utilities & Energy Services paint specifications.

2.02 MARKER INSTALLATION

A. Installation on Plain, Painted or Insulated Pipe. Clean section of pipe or insulation that has been selected for marker. Install per manufacturer’s written instructions.

B. Stenciling shall be bold and clear on all stenciled pipe. Blurred or smeared identification is not acceptable.

C. TAMU approved vinyl labeling to be applied per manufacturer’s written instructions.
Design Standard

Procedures for Receiving & Disconnecting Temporary and Permanent Utility Services

This standard was revised on May 19, 2017, and the latest changes are underlined. Please refer to Part 6 of this standard for full revision history.

Scope in this Section:

- New temporary utility connections and metering for construction purposes.
- Existing utility service connections and metering in renovation and construction.
- Permanent new utility service upgrades, connections, and metering, for construction or renovation.
- Utility connections, investigations and Contractor charges for construction or renovation.

Detailed specifications follow.

PART 1 - GENERAL

1.01 Texas A&M University (the Owner) maintains and operates full service utility production and distribution assets which serve the College Station campus and the RELLIS campus. Temporary and/or permanent utility services and metering required for a project may include primary and secondary type Electrical Distribution Systems, Chilled Water, Heating Hot Water, Domestic Cold Water, Domestic Hot Water, Sanitary Sewer, and Refuse Collection.

1.02 Unless otherwise noted in the contract documents, the TAMU Utilities & Energy Services Department will investigate, approve and activate all temporary and permanent utility services and metering to construction sites, campus facilities, buildings and structures.

1.03 The general responsibilities for requesting and receiving required utility connections and metering are: the Contractor, the delegated University Project Management Authority, and TAMU Utilities & Energy Services. A delegated University Project Management Authority could be one of the following:

A. Department of Facilities Planning & Construction (FP&C)
B. SSC Facilities Services Engineering Design & Construction Services (EDCS)
C. Other authorized University Project Management Authority

1.04 RESTRICTIONS

A. No direct connection between the public drinking water supply and a potential source of contamination is permitted. Potential sources of contamination shall be
isolated from the public water system by air gap or an appropriate backflow device. 2

B. No cross-connection between public drinking water supply and private water system is permitted. These potential threats to the public drinking water supply shall be eliminated at the service connection by the installation of an air-gap or a reduced pressure-zone backflow prevention device. 2

C. No connection that allows water to be returned to the public drinking water supply is permitted. 2

1.05 TERMS OF SERVICE

A. Refer to Appendix A for installation of fire hydrant and backflow prevention assembly. 4

B. Utilities and Energy Services will provide and install the water meter. 3

C. The customer shall, at his/her expense, purchase, properly install, test, provide field supporting device, and maintain RPZ backflow prevention device required by the TAMU’s Utilities and Energy Services. Copies of all water testing and maintenance records shall be provided to UES. 3

D. Water from the hydrant can only be turned on by TAMU personnel. A meeting time shall be set up for the water to be turned on and the backflow device be tested by a licensed plumber hired by the customer. TAMU personnel are to be given the test results. 3

E. All RPZ type backflow preventers must be rechecked annually at the expense of the customer. 3

F. The customer is responsible for damages to his/her installed equipment and is responsible for damage to the meter and or fire hydrant that is a result of misuse. 3

PART 2 - TEMPORARY UTILITY CONNECTIONS AND METERING FOR CONSTRUCTION PURPOSES

2.01 To activate an account for utility services with TAMU Utilities & Energy Services, the Contractor shall submit the completed form, Application to Receive Utility Services form, through the Project Management Authority, within ten days of receiving notification of contract award. The Application to Receive Utility Services form can be found at https://utilities.tamu.edu/customer-service/. The completed Application to Receive Utility Services form is to be sent to TAMU Utilities & Energy Services, contact information is on the application.
2.02 Utility rates for all commodities can be found at https://utilities.tamu.edu/customer-service/

2.03 Billing inquiries may be made by telephone from 9:00am to 4:00pm, Monday through Friday directly to the TAMU Utilities & Energy Services Department, contact information is located on each Application Form.

2.04 Unauthorized utility connections constituting un-metered services installed by a Contractor or its sub-contractor is strictly prohibited and may be referred to the University Police Department for its investigation. Any tampering of, or modification to, TAMU metering devices is strictly prohibited. In addition to potential legal implications, the Contractor will be responsible for all costs associated with properly provided utility connections, as well as TAMU Utilities & Energy Services estimated costs of un-metered utility services received by the Contractor.

2.05 All utility extensions from the metering points are the responsibility of the Contractor. These installations must conform to applicable plumbing, electrical and health codes and all standards required by the contract documents. Service extensions beyond any metering point that are installed by the Contractor shall be approved by TAMU Utilities & Energy Services prior to activating any utility services.

2.06 The Contractor, through the Project Management Authority, shall notify TAMU Utilities & Energy Services no less than 30 days prior to requesting termination of temporary utility services by submitting the completed form, Application to Disconnect Utility Service. The completed Application to Disconnect Utility Service is to be sent to the TAMU Utilities & Energy Services, contact information is on the application. The Application to Disconnect Utility Service is located at https://utilities.tamu.edu/customer-service/

A. The Contractor, through the Project Management Authority, shall notify TAMU Utilities & Energy Services no less than 30 days prior to requesting a transfer of Utilities from them to the University. The Application to Transfer Utility Service is located at https://utilities.tamu.edu/customer-service/

2.07 The Contractor is responsible for payment of all utility costs associated with its temporary or permanent services.

PART 3 - TEMPORARY AND PERMANENT SERVICE FOR NATURAL GAS

3.01 Natural gas services and metering are provided by the Local Distributing Company (LDC). When service connection or disconnection is required, the contractor or University Project Management Authority must contact TAMU Utilities & Energy Services to request the change be made. The Energy Office
will contact the LDC, arrange for the service order and record any changes for billing and tracking purposes.

3.02 Liquefied propane gas (LPG) is prohibited unless approved in advance by Utilities & Energy Services and the Environmental Health & Safety Department and written authorization is obtained. LPG stored and used on a construction site must be coordinated with and approved by the University Project Management Authority, and conform to all applicable University safety guidelines.

3.03 Permanent gas services to a new or existing structure, as may be required under a construction contract, including the meter installation and service extensions shall be coordinated through Utilities & Energy Services and the University Project Management Authority and the LDC. Please provide this information in the Application to receive Utility Service located at https://utilities.tamu.edu/customer-service/

3.04 Contractor has responsibility for all costs associated with temporary or permanent gas service, up to the date University Project Management Authority has determined a date of beneficial occupancy of the building, which includes connection fees, fixed and/or variable monthly charges, late fees, transactions costs, disputed charges, and any other administrative costs.

3.05 Payment for natural gas will be transferred from the Contractor to the TAMU Utilities & Energy Services Department at beneficial occupancy.

PART 4 - PERMANENT UTILITY SERVICES IN CONSTRUCTION CONTRACTS, EXISTING OR NEW

4.01 Permanent utility services in new construction or renovation may be classified as existing services not requiring an upgrade, existing services that will require an upgrade, or a new permanent service installation.

4.02 A Contractor who assumes control of an existing facility in its entirety, for renovation purposes, shall be responsible for all billing costs associated for utility commodities consumed.

4.03 The Owner may waive any utility service costs associated with new construction and renovation, when it has been determined that utility consumption by a Contractor is either negligible, indeterminable from utility usage of ongoing Owner functions, or for other possible reasons not specified herein.

4.04 There are no utility costs or fees being waived by the Owner in this contract. The Contractor is not exempt from any costs of special services that it requests TAMU Utilities & Energy Services to investigate.
4.05 Any costs associated with extensions and upgrades for permanent utility services will be covered by project construction funds. Payment of monthly costs of utility services used or consumed by the Contractor is the Contractors’ responsibility and is subject to all payment provisions stated in this contract.

4.06 When terminating utility services, the Contractor is responsible for submitting the completed form, Application to Disconnect Utility Service. The final billing for utilities will be prorated to the day that beneficial occupancy is deemed to have occurred by University Project Management Authority.

PART 5 - METERING FOR PERMANENT UTILITY SERVICES

5.01 New campus buildings, and major renovations of existing buildings, will use electronic utility metering. Metering devices will be certified “revenue-quality”, be of the type TAMU Utilities & Energy Services has standardized on, and will be connected electronically, by the Contractor, to the campus building automation system, or power monitoring system via campus Ethernet.

5.02 Metering points in this project may include, but are not limited to, Electrical, Chilled Water flow and temperature difference, Heating Hot Water flow and temperature difference, Domestic Cold Water, Domestic Hot Water, and Steam.

5.03 Important information on metering, and other TAMU design standards, are located at https://utilities.tamu.edu/design-standards/

PART 6 - REVISIONS TO DESIGN STANDARD

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
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APPENDIX A
TYPICAL INSTALLATION DETAIL FOR FIRE HYDRANT AND BACKFLOW PREVENTION ASSEMBLY
TEMPORARY WATER SERVICE
1. CUSTOMER/ CONTRACTOR SHALL CONNECT BACKFLOW ASSEMBLY, PIPING AND SUPPORT STAND AS ILLUSTRATED BELOW TO OWNER PROVIDED AND CONNECTED METER.

2. ALL FITTINGS, PIPING, VALVES AND MATERIALS INCLUDING THE APPROVED REDUCED PRESSURE BACKFLOW STANDARD (ASSE 1013) PREVENTION ASSEMBLY SHALL BE FURNISHED BY CONTRACTOR.

3. BACKFLOW ASSEMBLY SHALL BE TESTED ON INITIAL USE AND ANNUALLY THEREAFTER.

4. CONTRACTOR/ CUSTOMER SHALL PROVIDE PROTECTION FOR ASSEMBLY FROM DAMAGE.

WARNING
CONTRACTOR/ CUSTOMER SHALL OPERATE BACKFLOW ASSEMBLY VALVE ONLY FOR REGULATING FLOW OF WATER

HYDRANT OPERATING NUT SHALL BE OPERATED WITH A HYDRANT WRENCH AND OPENED FULLY (DO NOT THROTTLE)

HYDRANT ADAPTER
WATER METER
BACKFLOW ASSEMBLY VALVE (*)
REDUCED PRESSURE BACKFLOW PREVENTER ASSEMBLY STANDARD ASSE 1013, BY CONTRACTOR
ASSE 1013
CONNECTION BY CONTRACTOR/ CUSTOMER
NOTE: ADJUSTABLE SUPPORT BY CONTRACTOR
BASE TO SUPPORT ASSEMBLY

EXISTING FIRE HYDRANT
GRADE
BY TAMU UES
BY CUSTOMER/ CONTRACTOR

Appendix A - Hydrant Water Meter
Design Standard

Solid Waste and Recycling Containers

A Solid Waste Minimization (SWM) Committee was established in 2015 and includes key stakeholders from various departments on campus, with an objective to develop an action plan to minimize the amount of solid waste from campus delivered to the landfill by increasing the opportunities for recycling collection. Consistent and recognizable recycling containers and uniform labelling standards were identified as physical needs to best support the SWM Program objective.

To support the solid waste minimization goals and to continue to improve the recycling opportunities on campus and provide greater uniformity in the appearance and use of recycling containers, a labelling standard was approved by Texas A&M University Marketing and Communications in 2016 and standardized interior and exterior recycling units were approved by Texas A&M’s Council for the Built Environment (CBE) in 2017. Appendix A and B of this standard show visuals of these two items.

For the purpose of this standard, “waste” is referred to as material that cannot be recycled and therefore will be sent to landfill.

Detailed specifications follow.

PART 1 - GENERAL

1.01 All campus buildings should provide adequate containers for waste and recycling collection in common use area based on building occupancy. Waste and recycling containers should be included in budget for new buildings or renovation projects. New building construction should include an area where recycling materials can be centrally collected.

1.02 Any construction that includes recycling containers will adhere to the labelling and containers standards provided. Any exceptions to the design standards shall be reviewed and/or approved by Campus Architect.

1.03 Utilities & Energy Services (UES) shall provide service to central collection areas within buildings and SSC Grounds Maintenance will be provide service to exterior containers.

PART 2 - RECYCLING CONTAINERS

2.01 Recycling bin examples can be found in Appendix A of this design standard.

2.02 ACCEPTABLE MANUFACTURERS

A. CleanRiver® Recycling Solutions

2.03 INTERIOR RECYCLING BINS
A. Approved Type: CleanRiver®, Model XFF25-3.

B. Interior bins have the following specifications:
   1. 3-Streams, each with 25 gallon capacity.
   2. Made from at least 95% recycled material.
   3. Slanted tops.
   4. Display the 3 front labels and side labels.

2.04 EXTERIOR RECYCLING BINS

A. All exterior bin locations shall approved by the University Architect before placement on campus. All locations shall be made known to FCOR to be displayed on TAMU campus maps.

B. Approved Type: CleanRiver®, Model XD35-3.

C. Exterior bins have the following specifications:
   1. 3-Streams, each with 35 gallon capacity.
   2. Made from at least 95% recycled material.
   3. Curved tops.
   4. Display the 3 front labels and side labels.

2.05 BAGS

A. Clear/transparent bags are to be used in interior and exterior recycling bins to distinguish the difference between waste-to-landfill and recycling.

PART 3 - LABELS

3.01 All labels must be consistent with the university standard, any exceptions must be approved by the University Architect.

3.02 Label examples can be found in Appendix B of this design standard. These labels are solely for demonstration, and can be customized to meet the size of the bin.

3.03 Each department shall be responsible for the costs associated with adding labels that are not already included with the bin. For example, if an office space already has recycling bins, the department can order labels to add to the bin rather than purchasing new bins.

3.04 CleanRiver® 3-stream containers are available with labels already placed. However, individual labels can be purchased through various suppliers, with some providing on-site installation. Acceptable suppliers:
A. Fast Signs.
B. Alpha Graphics.
C. TAMU Graphics Shop.

3.05 Each compartment door on three-stream bins include the approved labelling that identifies the specific commodity collected. Compartments are configured in the following order (left to right):

A. “PLASTIC & ALUMINUM”
B. “LANDFILL”
C. “ALL PAPER”

3.06 End panels include “MAKE A DIFFERENCE” label.
APPENDIX A
APPROVED RECYCLING BINS
Interior Recycling Bins
Exterior Recycling Bins

Approved Recycling Bins
APPENDIX B
APPROVED RECYCLING BIN LABELS
Front of container labels:
Side of container labels:
Design Standard

Storm Drainage Utilities

All new construction should be modeled to demonstrate the impact to the existing storm water flows. The project must be designed in a way that does not create an increase to the storm water runoff from the campus.

Detailed specifications follow.

PART 1 - GENERAL

1.01 This policy applies to stormwater infrastructure within Texas A&M property.

1.02 Design in accordance with Unified Stormwater Design Guidelines, City of Bryan, City of College Station, August 2012 (or latest edition).

1.03 The Design Storm to be used is as follows:

A. 10 year recurrence interval:
   1. Design of storm drain conduits and inlets
   2. Design of minor surface streams that are linked to a downstream subsurface conduit

B. 100 year recurrence interval:
   1. Grading and design of surface conveyance pathways
   2. Design of on-site detention facilities
   3. Check flood: all 100 year surface flow should be within an established drainage path.

1.04 For new projects, all pipes shall have a larger hydraulic capacity and at least equal in internal hydraulic area to the conduit immediately upstream.

1.05 All new development projects shall be approved against the campus wide hydrologic and hydraulic model before construction and all new storm drain infrastructure shall be included in the campus wide storm drain hydraulic model.

1.06 New development shall have adequate on-site detention and shall not discharge more than pre-development flows to downstream infrastructure.

1.07 Building designs with below-grade spaces such as basements, service tunnels, etc. are discouraged in areas subject to flooding. Should below-grade service areas or basements be required, they should not have openings located below the 500yr+2ft in areas subject to flooding, or below grade of the surrounding terrain in areas not subject to flooding.

1.08 Storm sewer shall be RCP Class III (ASTM C76) for 12” and above, SDR 26 PVC (ASTM D3034) or heavier for less than 12”, or Corrugated HDPE (ASTM 2306). RCP joints shall meet ASTM C443. PVC pipe shall have water
tight push-on joints meeting the requirements of ASTM F477. Corrugated HDPE fitting shall meet ASTM F2648.

1.09 Storm roof drains shall be run separately from all other storm water sources to the outside of the building. Both sanitary and storm sewers sizes shall be determined by a Texas Professional Engineer (PE) and should be based on existing/future sewer capacities and a drainage study for storm sewers. If the existing infrastructure cannot accommodate the increased loads, then an estimate shall be presented to the Owner to determine if additional funds need to be appropriated for any up-sizing.

1.10 Manholes and/or junction boxes with access openings shall be installed on the storm sewer system at all piping intersections, changes in slope and angle points with the exception of small drain leads which may use appropriate wye fittings. Manholes shall be either pre-cast (ASTM C 478) or cast-in-place with a reinforced concrete foundation. Junction boxes shall be of reinforced pre-cast or cast-in-place construction. Minimum 28 day concrete strength shall be 3,000 psi. Foundation for manholes and/or junction boxes shall be on 1-1/2 sack cement stabilized sand.

1.11 Provide 30 inch diameter minimum size access openings for all manholes. Iron castings for manhole rings shall conform to ASTM A 48, Class 30 and be traffic rated. Area inlets for the storm sewer system shall be either pre-cast or cast-in-place reinforced concrete with frame and grate iron castings conforming to ASTM A48 Class 30 and shall be traffic rated. Curb inlets shall also be either pre-cast or cast-in-place with a manhole frame and cover installed in the top to allow access. In high visibility areas near buildings or at pedestrian drop off points, inlet tops shall be cast-in-place. Minimum concrete 28 day compressive strength for inlets shall be 3,000 psi. Typically storm sewer discharge points shall be stabilized with either a pre-cast or cast-in-place headwall structure with adequate surrounding rip-rap to control erosion. Minimum concrete 28 day compressive strength for headwalls shall be 3,000 psi. Iron castings for manhole rings and covers shall conform to ASTM A48, Class 30 and be traffic rated.

PART 2 - DESIGN STORM REOCCURRENCE INTERVAL

2.01 STORM DRAIN DESIGN EVENT

A. Drainage is to be designed such that 100-year rainfall event will be conveyed to the receiving stream within a designated public easement, such as within the street right-of-way or within a swale or a channel. The storm sewer system is to be designed to convey at least the 10-year storm. The rainfall intensity for both the 100-Year storm and the 10-Year storm is to be determined using a storm duration equal to the time of concentration at the outfall of the drainage basin.
2.02 FUTURE PROJECTS

A. Drainage design for any new development within campus must not result in an increase in peak discharge at the relevant drainage basin outlet over existing conditions for the 2-Year, 5-Year, 10-Year and 100-Year rainfall events. Local or regional detention may be used to attenuate peak flows. If regional detention is used, calculations by a Texas Professional Engineer must demonstrate that the conveyance path between the new development and the detention basin has the capacity for the increased discharge.

PART 3 - OTHER REGULATORY POLICIES

3.01 Local design projects on campus shall achieve full stormwater capture efficiency and meet the spread requirements of the Unified Stormwater Design Guidelines of the City of Bryan and the City of College Station.

3.02 New development projects shall include obtaining additional survey of storm drain facilities (inverts, conduit sizes, and connectivity) of the building as well as downstream. Extent of additional survey is to be determined with UES for each individual project.

3.03 Stormwater Best Management Practices (BMPs) recommended by the EPA, TAMU, and by the Unified Stormwater Design Guidelines include Low impact development (LID) green roofs, bio-swales, planted buffers, grassed swales, sand filters, local and regional detention, infiltration, irrigation cisterns, porous paving, natural prairie vegetation, protected wetlands, and constructed wetlands. These BMPs provide two significant benefits:

A. Reduce peak flows in receiving streams and thereby reduce erosion, improve bank stability, and help to sustain the natural flora and fauna.

B. Reduce pollution by filtering contaminants and providing time and space for bioremediation.


3.04 The EPA website – Water: Low Impact Development contains information and links to design and guidance manuals for the features listed above.

A. [http://water.epa.gov/polwaste/green/index.cfm](http://water.epa.gov/polwaste/green/index.cfm)
3.05 The use of the above mentioned BMPs/LID is highly recommended for new developments within campus.

3.06 Any new development on campus should be reviewed by UES staff to ensure that enough storm drain capacity is available downstream. Storm Drain design for new projects must take into consideration the entire trunk line, upstream and downstream for the new development. The storm sewer database provides the means to assess the changes.

3.07 Temporary stormwater BMPs need to be strictly enforced during construction to minimize erosion and sedimentation.

3.08 Evaluate the hydraulic capacity of the impacted storm sewer line all the way to the outfall before making new connections. Determine how the additional flow will impact water levels upstream and downstream.
Design Standard

Thermal Systems (Chilled Water and Hot Water Systems)

This standard was revised on September 6, 2017, and the latest changes are underlined. Please refer to Part 4 of this standard for full revision history.

For campus buildings served by TAMU central thermal distribution systems, supply and return lines typically have piping with identical size and material for each system - chilled water (CHW), heating hot water (HHW), and domestic hot water (DHW). Because these thermal distribution lines are identical in size and appearance for each thermal system, there is the potential for cross-connection between supply and return. To avoid possible cross-connection of supply and return lines, design engineers shall require field verification in construction documents and contractors shall field verify the configuration of supply and return lines, using an appropriate temperature sensing device and adequate system flow, before making building connections. Any discrepancy between construction documents and field verification should be promptly reported to the project A/E and the Owner’s representative before completing piping installation, so proper piping configuration can be verified.

Detailed specifications follow.

PART 1 CHW AND HHW SUPPLY TEMPERATURE RESET

1.1 The Utilities & Energy Services Department (UES) at Texas A&M University is actively identifying and implementing strategies to reduce the energy consumption and cost associated with campus heating and cooling requirements while ensuring customer needs are consistently met. Chilled water (CHW) and heating hot water (HHW) supply temperature reset schedules have been in effect on the campus for many years, with supply temperature adjusted based on outside air temperature. The supply temperature for chilled water ranges from 43 to 47 Degrees F and the supply temperature for heating hot water ranges from 130 to 170 Degrees F. The supply temperature reset schedule charts for both CHW and HHW are attached as Appendix A.

PART 2 HVAC COIL DESIGN DELTA T

2.1 All CHW cooling coils in facility air handling units (AHUs) and fan coil units (FCUs) shall have a minimum of 14 Degrees F design delta T based on a CHW supply temperature of 43 Degrees F, during peak cooling periods, except for spaces with high internal heat loads, such as server rooms. In spaces with high internal heat load, the system should be designed to meet maximum cooling requirements with a CHW supply temperature of 47 Degrees F.

2.2 For HHW, the minimum AHU and FCU design delta T shall be 30 Degrees F based on a design HHW Supply Temperature, during peak heating periods, of 170 Degrees F. The minimum coil design delta T’s specified above are contingent upon maintaining proper coil flow tolerance per 2008 ASHRAE Handbook, pg 12.18, Fig. 34.
(for both CHW and HHW) can be higher than indicated above, but this design requirement must be achieved, unless a modification to this design guideline is approved in advance as indicated at the end of this guideline. Coils shall be designed in accordance with the latest version of ARI Standard 410.

2.3 AHUs having greater than 50 percent outside air supply shall have an energy recovery system incorporated into the design, unless it is proven to not be justifiable based on a life cycle cost analysis. Energy recovery systems shall be designed to operate at a minimum of 70% efficiency and be connected to the Siemens BAS to allow for effective monitoring of the system operation. Pre-filters shall be provided on all energy recovery systems to prevent fouling of the heat transfer element.

2.4 A requirement for testing, balancing and commissioning of both water and air flow shall be included in the specifications for all HVAC systems installed in new buildings and with any significant HVAC system replacement or retrofit.

PART 3 CHW AND HHW DISTRIBUTION SYSTEMS

3.1 CHW and HHW distribution pumps in the buildings shall be equipped with variable speed drives, with pump speed modulated to maintain sufficient differential pressure at desired flow through all HVAC coils in the building. Variable speed drives shall be connected to the Siemens BAS for effective monitoring and control under all flow conditions. The Siemens BAS shall also monitor the status of CHW and HHW control valves and any valve which hasn’t opened a minimum of 20% at least once during any 168 hour (one week) period shall be programmed by the BAS to automatically open fully (during unoccupied periods) for a period of 15 minutes, in order to flush the thermal piping and minimize the potential for microbial growth.

3.2 All AHU and FCU fan motors and CHW and HHW pump motors installed in new buildings and with major system replacement or retrofit shall be specified to meet minimum efficiency requirements of National Electrical Manufacturers Association (NEMA) Standards Publication MG1-2006 (or any later edition) Premium Energy Efficiency Motor Standard, if a Premium Energy Efficiency Motor is available in the required size and rating. All new motors shall be sized to operate with a load factor of between 65 and 100 percent.

3.3 Three-way bypass control valves shall not be installed in any new CHW or HHW system. When HVAC systems in existing buildings are upgraded to include direct digital control (DDC), all existing three-way bypass control valves shall be removed and the DDC control system shall be programmed to provide flushing as previously described. Two-way characterized ball-style control valves shall be used for CHW and HHW flow control, rated to handle pressure drop that exceeds the highest differential pressure that the distribution pump(s) can generate, in order to avoid valve seat deterioration and leak-by. Control valve actuators shall have shut-off ratings that exceed the highest potential branch circuit differential pressure to ensure positive valve closure. Electric valve and damper actuators shall be specified for all HVAC systems that have DDC capability.
Notes:

1. See the UES Design Standard titled “Building Automation Systems” for additional requirements.

2. Any deviation from this design standard needs to be reviewed and approved by Utilities & Energy Services (UES).

PART 4 REVISIONS TO DESIGN STANDARD

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APPENDIX A

CHW & HHW SUPPLY TEMPERATURE RESET SCHEDULES
Note: CHW supply temperature range is 43 to 47 °F with reset based on outside air temperature. Actual loop temperature may vary +/- 1 °F from target.
Note: HHW supply temperature range is 130 to 170 °F with reset based on outside air temperature. Actual loop temperature may vary +/- 5 °F from target.
Design Standard

Underground Piping Systems

Uninsulated underground thermal piping systems experience significant energy losses to the soil over the course of their operating life. To minimize the heat gain/loss of these piping systems, Texas A&M University has chosen a mineral powder insulation system, similar to Gilsulate 500, as the Campus standard for insulating underground thermal lines. In addition to its insulating properties, this type of insulation system: 1) Is hydrophobic, 2) Has a high electrical resistivity preventing galvanic action between metal pipe and the soil, 3) Has good load bearing properties and 4) Is “green” since it’s made from minerals. All HHW thermal lines and CHW lines 12 inch and below are required to be insulated.

Work Includes:

An underground piping insulation system must be provided to enclose and provide thermal and waterproofing protection for piping specified and shown on Plans, including but not limited to the following:

- Piping insulation including expansion units.
- Miscellaneous materials incidental to complete installation of insulated underground sections.
- Supervision of installation as specified.

Detailed specifications follow.

PART 1 GENERAL

1.1 Insulating material which adheres to or becomes joined in any manner to piping during cycle of operation shall not be used.

1.2 Contractors are solely responsible to complete work for entire run of piping between points specified and shown on plans.

1.3 Adequate space and clearance with insulated underground piping system shall be provided to allow free movement of piping and avoid stress or abrasions to piping. No wood, masonry, metal, or any other abrasive pipe supports or guides, shall be left in contact with piping.

1.4 Provide fittings and accessories necessary and incidental to type of system selected.

1.5 Store materials and equipment on work site on wood platforms or members; stack and pile in substantial and safe manner so products will not easily dislodge while in storage.

1.6 Replace or repair wet or damaged insulation as directed by Engineer or product installation requirements.
1.7 Complete hydrostatic tests for all new lines. Perform hydrostatic leak test at 1.5 times maximum operating pressure to ensure piping system is free from leaks before application of field applied insulation and closures. See HDPE Piping Installation Design Standard for testing pressures and acceptance requirements. UES technical staff must be notified in advance of planned hydrostatic test and be present to witness the test. See pipe manufacturer’s recommendations for testing procedures.

1.8 All parts of system to be intact, undamaged, and free from leaks before backfilling with insulation material. Upon completion of backfilling of insulation material, work must be approved by construction inspector and UES representative before final backfilling is performed. Piping or insulation installation that is deemed to be inadequate or incorrect by Engineer, construction inspector, or UES representative must be corrected to meet specifications prior to backfilling.

PART 2 EXCAVATION, FILLING & BACKFILLING

2.1 Final grading for setting pipe units to be performed immediately prior to setting units or concrete supporting pad in trenches; backfilling around completed insulated system to be under direction of supervisor for installation of insulated underground system.

2.2 Restore all finished grades and improvements as detailed.

PART 3 TYPE OF CONSTRUCTION

3.1 The system for insulating pipes shall keep water and moisture from pipes.

3.2 Type of material and construction: The insulation shall be a dry, free flowing granular product formulated from selected inert, inorganic materials. It shall be non-toxic, non-flammable, and completely free of asbestos. It shall require no mixing prior to installation, and no curing. It shall be completely compatible with all materials typically used for piping in the service temperature range of +35°F to +230°F. It shall be of sufficient density so any stones or rocks inadvertently falling on insulation will not penetrate or migrate into or through insulation during placement and back-filling operations.

3.3 The insulation shall be composed of granular particles that cohesively bond with each other to form a closed cell compacted mass that effectively isolates pipe surfaces from air, water, moisture and chemicals. The granules shall be surface treated to render it hydrophobic. The compacted insulation shall be capable of withstanding up to 12,000 psf (58,000 kg/M²) at the manufacturer’s recommended density.

3.4 The insulation shall have a thermal coefficient of heat conductivity (K factor) of no more than 0.60 BTU/hr. /ft²/°F/in. at manufacturer’s recommended use density and a mean temperature of 175°F and 0.65 at a mean temperature of 300°F by the guarded hot plate method of ASTM C-277. If an insulation with higher thermal conductivity is proposed, bidding shall be based on the equivalent amount of insulation required to minimize heat loss/gain to that which would result with the thermal conductivities specified in the proceeding sentence. See Figure No. 1 for required insulation envelope dimensions.

3.5 Electrical resistivity of the insulation shall be greater than 10^{12} Ohm-cm.
3.6 The insulation shall be mineral powder with characteristics as described above similar to GILSULATE 500 as manufactured by American Thermal Products Inc.

3.7 The system shall be installed according to the published recommendations of the insulation manufacturer. The installer shall consult with and arrange for field assistance from the manufacturer’s representative prior to placement of the insulation system. Pipes, anchors-guides and expansion shall be in compliance with the recommendations of the insulation manufacturer or as shown on plans and specifications. Backfilling operations shall be performed according to HDPE Piping Installation Design Standard.

PART 4 PLACING MATERIALS

4.1 Insulation materials used must be capable of being placed and consolidated to prescribed density prior to any backfilling operation. Use of backfill to provide compaction of the material is not acceptable.

4.2 Installation Sequence: (Refer to Insulation Manufacturer’s Installation Sequence and notes.)

4.3 Excavate trench as near as possible to the required width of piping and insulation and pile backfill all on one side. Install pipes with required guides, supports, and anchors as shown on drawings and specifications. Perform pressure testing.

4.4 Grade and compact trench under pipes leaving required space for specified thickness of insulation. Clean any dirt or debris off pipes.

4.5 Precut gypsum board with attached spacers on the exterior may be driven into place. Horizontal spacers are used to determine envelope width. Leave forming in place. Forms are held away from pipes by temporary spacers which must be removed as insulation is installed and consolidated. Side forms must not extend above the finished consolidated insulation level of the envelope.

4.6 Provide compact sand or clean backfill behind the forms to pipe height.

4.7 All standing water shall be removed prior to placing insulation.

4.8 To minimize dust, empty the bags near pipes with as little “free fall” as possible. Fill trench to mid pipe height and consolidate. Remove spacers and temporary supports as work progresses.

4.9 Add additional layers of insulation and consolidate to specified thickness and density. A rod type concrete vibrator with a 1½ - 2” diameter head is the best and quickest means of consolidating insulation. Insert the head of the vibrator and pull along slowly.

4.10 Walk on the consolidated insulation envelope to insure proper density, footprints of approximately 1” deep or less are expected. Insulation coverage shall be according to insulation manufacturer recommendations or as shown on Plans.

4.11 An additional 2” of insulation is required over pipes in areas passing under streets or parking.
4.12 Complete compaction of sand backfill behind forms. Place a layer of flattened empty bags on top of the insulation envelope. Walk on top of the bags and hand place 6” clean backfill on top of empty bags to protect against damage in case of storms. Complete backfilling to grade level as specified under HDPE Piping Installation as soon as possible. Provide a minimum of 12” earth backfill.

PART 5 GUARANTEE

5.1 Contractor shall guarantee installation of insulating system for a period of one (1) year from date of acceptance by Owner against deterioration of insulating value, compaction or water leakage under normal operation conditions. Contractor, however, shall not be responsible for damage or failure of system due to damage caused by other parties.
Insulation Thickness Table

Design of the Insulation Envelope

Pipe Coverage Selection

Figure No. 1

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TABLE 1

Gilsulate 500 or Approved Equal Envelope Dimensions

Based on thermal conductivities (K factors) of Gilsulate 500xr insulation. If a product with higher K factors is proposed, insulation thicknesses shall be increased to provide a resistance to heat flow equivalent to the Gilsulate insulation shown in Figure 1.

Add 2 inches to C Dimension under streets. Parking lots and railroads tracks.
Utility Metering

This standard was revised on March 26, 2019, and the latest changes are underlined. Please refer to Part 3 of this standard for full revision history.

This section specifies the requirements for metering devices and other metering components associated with the measuring and reporting of utilities consumption. All metering for the project, thermal or domestic water service, including, but not limited to: Meter type (Magnetic or Turbine), meter manufacturer, meter locations, meter installed above or below grade, water meter pit design, transmitter locations etc., must be approved by TAMU’s Utilities and Energy Services (UES). All thermal and electrical meter submittals are to be reviewed by TAMU’s UES.

Detailed specifications follow.

PART 1 - GENERAL

1.01 WAGES Panel:

A. A Schneider Electric TAMUWAGESA16HM17R1-T12\textsuperscript{6} metering panel, of the appropriate input capacity, will be provided by the Div. 26 Contractor, complete with all microprocessors, software, programming, point data base, trends, terminal strips, and regulated power supply with battery backup.

B. The WAGES panel will require temperature and flow sensor wiring from the panel to sensors located in the primary supply and return piping on the Chilled Water, Heating Hot Water, and Domestic Hot Water, to be included as part of the BAS Contractor’s responsibilities.

C. The WAGES panel will require flow meter wiring from Domestic Cold Water, Irrigation Water, and Steam. Provide all wiring from the flow tubes to the flow transmitter, and from the flow transmitters to the WAGES panel.

D. This WAGES panel will require a dedicated 110 volt, 20 amp, single phase standby electric circuit source.

E. The WAGES panel will require a category 6 Ethernet cable. The project shall provide a dedicated Ethernet network connection between the WAGES panel and the Campus Metering Software. The BAS Contractor is responsible for coordinating the network drop (s) required for integration to the Campus Metering Software and will not receive final payment for the project until the Metering system is fully integrated and accepted by TAMU Utilities & Energy Services (UES). Prior to any Commodity being energized or supplied to the project, the metering must be in place, set up, integrated into the UES metering software, and logging correct consumption data in
the UES metering software database. All meter connections, and set up configuration, must be approved and documented by a UES metering representative.

F. The WAGES system will require start-up & integration to the Campus Metering and Analytical Software, by the Schneider Electric Square D Vendor.

G. A meeting between the TAMU UES and the BAS contractor will be held as early as possible, prior to purchase of any material, to review the installation, integration, and finalize panel and wiring locations.

H. The WAGES panel is used only when campus chilled or heating water is servicing the facility. In the event that a building will receive Heating Hot Water (HHW) and Chilled Water (CHW) from the University thermal system, the building shall be required to have a common data collection point.

1.02 Chilled Water, Heating Hot Water, Domestic Hot Water Supply, Domestic Hot Water Return, Domestic Cold Water, and Irrigation Water Flow Tubes and Transmitters

A. Acceptable Water Flow Meters and Remote Transmitters:


2. Flexim 5 series ultrasonic flow meter with remote mount transmitter.


B. The above Water Flow Meters and Remote Transmitters shall be, or equal/better to the specifications below:

1. The Flow Tube and Transmitter shall be calibrated to each other and shall be flow-calibrated and assigned a calibration factor at the factory. The calibration factor is entered into the transmitter, enabling interchangeability of sensors without calculations or a compromise in standard accuracy.

2. Accuracy: Includes the combined effects of linearity, hysteresis, repeatability, and calibration uncertainty. ±0.15% of rate ±1.0 mm/sec from 0.04 to 13 ft/s (0.01 to 4 m/s); above 13 ft/s (4 m/s), the system has an accuracy of at least ±0.2% of rate.

3. Each Flow Tube shall be sized specifically for the pipe and flow in which it is to be installed and to ensure flow velocity is within 2 to 20 ft./s.

4. A calibration certificate shall be provided from the manufacture.

5. Class 150 carbon steel flanges, Teflon (PTFE) or EDPM lining, and Type 316L stainless steel or Hastelloy C electrodes.
6. Transmitter: 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface.

7. Ambient Temperature Limits: -20 to 140deg.f.

8. Humidity Limits: 0 to 95% RH to 120deg.f.

9. Safety Approvals: FM Class 1 Division 2 for non-flammable; CSA Class 1 Division 2.

C. Alternate Meters for Domestic Cold Water and Irrigation.

1. When it is not appropriate to install magnetic flow meters for Domestic Cold Water (DCW), or irrigation (IRR), the meters must be AWWA.

2. Each irrigation and domestic water system are to be metered with the magnetic type meters as described above. Only written permission from Utilities & Energy Services department will allow for turbine type meters that are not connected to the campus WAGES system.

1.03 STEAM

A. Acceptable Steam Flow Meters

1. Rosemount 3051 SFP Integral Orifice Plate / Flowmeter MultiVariable Transmitter and Flowmeter.

2. Siemens Sitrans FX300 Vortex Multivariable Flow Meter.

B. The above Steam Flow Meter shall be, or equal/better to the specifications below:

1. The Flow Meter and Transmitter shall be calibrated to each other and shall be flow-calibrated and assigned a calibration factor at the factory. The calibration factor is entered into the transmitter, enabling interchangeability of sensors without calculations or a compromise in standard accuracy.

2. Accuracy: ±1%.


7. Output: 4-20 mA.

8. A calibration certificate shall be provided from the manufacture.

9. Meter must be installed per the manufactures specifications and must be field verified by campus personnel. Approval from the campus must be
obtained before sizing the flow meter to ensure it is within allowable flow ranges.

1.04 IMMERSION TEMPERATURE SENSORS AND THERMOWELLS

A. Acceptable Immersion Temperature Sensors and Thermowells
   2. Rosemount.
   3. Honeywell.

B. The above Immersion Temperature Sensors shall be equal/better to the specifications below:
   1. Temperature Sensor: RTD using a Pt1000, or Pt 100.
   2. Output Temperature Ranges: User selectable any range between -30 to 250 deg.f. with minimum span of 40 deg.f.
   4. Accuracy: Transmitter: +/- 0.1% F.S. Probe: +/- 0.3% F.S.
   5. Thermal Drift Effects: +/-0.02% deg.C max.
   8. Process Connection: ½” male NPT.
   9. Conduit Connection: ½” female NPT.
   10. Probe Length: 2” to 18” depending on model.
   11. Pressure Limits: 2000 PSI.
   12. Power Requirements: 10 to 35 VDC.
   13. Output Signal 4-20mA.
   14. Display: 2 lines X 8 character LCD.
   15. Enclosure Rating: NEMA 4X (IP66) and explosion proof for Class I, Groups B, C, D; Class II, Groups E, F, G; Class III.
   16. Agency Approvals: FM, CE.

C. Thermowells shall be equal/better to the specifications below:
   1. Hardware: 316SS Sheath.
   2. Taper/Bore: Straight/0.260.
   3. Inside Threads: ½ NPSF.
   4. Process Connections: ½” NPT.
   5. Mounting: Threaded.
   6. Lag: None.
   8. Length: From 4” to 24” as needed to fit Temperature sensor length required for tip of probe to be in center of piping.
PART 2 - ELECTRICAL METERING SPECIFICATIONS

2.01 SUMMARY

A. This section provides information on acceptable electric meters and associated devices for metering electrical systems and components, including Current Transformers (CT’s) Potential Transformers (PT’s), Fuse Blocks, Fuses, Shorting Blocks, enclosures, Ethernet Communications, meter capabilities, and integration into the Campus Metering Software.

B. Refer to the Construction Documents for meter locations.

2.02 WORK INCLUDED

A. The Electrical Contractor will provide Electric Meters of the type and capabilities required to meter all electrical power serving the project.

2.03 ELECTRICAL METERING

A. All metering requirements vary with the size, design, scope, and complexity of the project. The correct meter will require review of the project scope by a UES meter representative.

B. Acceptable Manufactures:
   1. Schneider Electric Series.
   2. Siemens (Model #s only):  
      a. Access 9300
      b. Access 9510
      c. Access 9510 RTU
      d. Access 9610
      e. 9410

C. The Electric Meter shall be equal/better to the specifications below:
   1. Digital electric meters connected to the UES metering software via Ethernet shall be capable integration into the Schneider Power Monitoring Expert (PME) Server Software.
   2. All Electric Meters shall certified revenue accuracy as per ANSI C12.20 0.2% Accuracy Class. ANSI C12.1 and other C12 Standards apply.
   3. Current Transformers (CT’s) shall be 0.3% Accuracy Class.
   4. Voltage Transformers shall be 0.3% Accuracy Class and the Secondary Voltage shall be 115V.
   5. The Electric Meter shall directly accept any voltage input from 120-480 VAC.
   6. When connected via the network to the Campus PME Server Software, the Meter shall provide logging, trending, and alarming information.
7. The Electric Meter shall provide, at a minimum, the following metered values:
   a. Real Power (kW), three-phase total.
   b. Real Energy (kWh), three phase total.
   c. Current, per phase & three-phase total.
   d. Voltage, per phase & three-phase total, phase-to-phase & phase-neutral.
   e. Real Power (kW), per phase & three-phase total.
   f. Reactive Power (kVAR), three phase total.
   g. Apparent Power (kVA), three phase total.
   h. Power Factor, per-phase & three-phase total.
   i. Real Energy (kWh), three phase total.
   j. Real Power Demand (kWd) readings, three phase total, present & peak.

8. All setup parameters required by the Electric Meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.

9. The Electric Meter may be applied in three-phase, three- or four-wire systems as well as single phase.

D. The Electrical Contractor will furnish and install all components but not limited to all Conduit, wire, CT's, PT's, fuse blocks and fuses, shorting blocks, Ethernet gateways, communication wiring between meters, remote displays, and all enclosure panels.

E. Submit for approval, appropriate product data cut-sheets for all material/components intended for use prior to beginning work.

F. All Electric Meters to be installed, calibrated and adjusted by trained instrument technicians. The Electrical Contractor will be responsible for all work performed by their subcontractors.

G. Submit engineering/wiring drawings and receive approval prior to beginning work. These drawings shall be submitted in a timely manner to provide sufficient time to review drawings so as not to hold up the project.

H. The project shall provide a dedicated Ethernet network connection between the Electrical Meters and the Campus Metering Software. The Electrical Contractor is responsible for coordinating the network drop(s) required for integration to the Campus Metering Software and will not receive final payment for the project until the Metering system is fully integrated and accepted by TAMU Utilities & Energy Services (UES). Prior to any Commodity being energized or supplied to the project, the metering must be in place, set up, integrated into the UES metering software, and logging correct consumption data in the UES metering software database. All
meter connections, and set up configuration, must be approved and documented by a UES metering representative.

I. Provide one-line drawings showing the location of all meters. Drawings must be in the format acceptable to TAMU Utilities & Energy Services (UES).

J. All wiring shall be in conduit (1/2” minimum). All active Ethernet switches, hubs, and routers required for the communication between BAS panels shall be Electrical Contractor-provided and installed. The conduit/wiring system required for electric metering shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted. All conduit shall enter electrical enclosures from the bottom of the panel or enclosure.

K. The electrical metering will require start-up & integration to the Campus Metering Software, by the Schneider Electric Square D Vendor. A meeting between the TAMU UES and the Electrical Contractor will be held as early as possible, prior to purchase of any material, to review the installation and finalize panel and wiring locations.

2.04 RELATED WORK

A. If the Electrical Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

2.05 SYSTEM VERIFICATION – PROCEDURE TO BE FOLLOWED

A. Provide minimum 2 week written notice for all inspections.

B. Prior to energizing any electrical switchgear or Main Distribution Panel, and upon completion of all mounting and terminations, and wiring into and out of the electric meter and enclosures the TAMU Project Inspector & UES representative shall inspect and approve this work. The Electrical Contractor shall make his representative(s) available and coordinate with the TAMU Project Inspector & UES representative during this inspection process. At the successful conclusion of this inspection, the Electrical Contractor shall provide a written report stating all work is complete. Electrical Contractor, General Contractor and TAMU Project Inspector & UES representative shall sign. This should be filed with Project Commissioning/ Startup documents.

C. Upon such approval, the Electrical Contractor shall be allowed to energize the electrical systems approved.
# PART 3 - REVISIONS TO DESIGN STANDARD

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Location</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6/12/2017</td>
<td>Intro</td>
<td>All metering for project must be approved by UES</td>
</tr>
<tr>
<td>2</td>
<td>6/12/2017</td>
<td>1.02A</td>
<td>Yokogawa meter removed from standard. Siemens Mag 5100 changed to 6100W. Spirax Sarco added to standard.</td>
</tr>
<tr>
<td>3</td>
<td>6/12/2017</td>
<td>1.03A</td>
<td>Yokogawa Digital YEWFLO Multivariable DY MV removed from standard.</td>
</tr>
<tr>
<td>4</td>
<td>6/12/2017</td>
<td>2.03B2</td>
<td>Siemens Model #’s updated.</td>
</tr>
<tr>
<td>5</td>
<td>10/17/2017</td>
<td>1.02C</td>
<td>Meters are to be used for each irrigation and domestic water system.</td>
</tr>
<tr>
<td>6</td>
<td>3/26/2019</td>
<td>1.01A</td>
<td>Meter panel type changed to TAMUWAGESA16HM17R1-T12</td>
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<tr>
<td>7</td>
<td>3/26/2019</td>
<td>1.02A</td>
<td>Previous Revision #2 (Acceptable Water Flow Meters) updated.</td>
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</table>
Design Standard

Wire Labeling

PART 1 - GENERAL

1.01 WIRES SHOULD BE LABELED WITH SLIDE-ON LABELS

1.02 EACH TERMINATION POINT SHOULD HAVE A LABEL WITH THREE LINES:
   
   A. The top line indicates the point name.
   
   B. The second line indicates the current location where the line is landed.
   
   C. The third line indicates where the other end of the wire is landed.