Section 33 00 00 – Utilities (Maintenance; Common Work Results; Schedules; Instrumentation & Control)

1. See also Division 02 for Site Improvement Standards.
2. See also Division 22 for Plumbing Standards.
3. See also Division 23 for HVAC (steam, chilled water, condensate, etc.) Standards.
4. See also Division 26 for Electrical.
5. See also Division 27 for Communications.
6. See also Division 31 for Earthwork Standards.
7. See also Division 32 for Exterior Improvements Standards.
8. See also appendices for various space type requirements.
9. FS Cartographer locates shall be initiated through 'one-call' to City of Eugene.
10. Exterior placement of any and all equipment requires CPRE and FS approval to ensure compliance with the UO Campus Plan. If approved, all University policies shall be followed.
11. Per the 'Design Review Requirements' at the beginning of this document, a drawing layer of 'Maintenance Access' is to be incorporated into ALL drawings and system designs. This layer MUST be maintained through all phases of design and construction.
12. ALL/ANY item that requires special tools and/or test equipment must be brought to the attention of the pertinent Owner's FS personnel prior to specification and/or installation.
13. Inaccessible Equipment:
    a. If after meetings, reviews, comments, etc., there are documented and/or discussed changes not incorporated into the construction documents and installed equipment is not accessible for operation and maintenance, equipment shall be removed and reinstalled at no additional cost to the UO or the project. Discussions of payment will occur with the design team.
    b. 'Accessible' is defined as being capable of being reached without climbing or crawling under or over obstacles such as motors, pumps, belt guards, transformers, piping and ductwork. Access must not exceed 14ft in height, a typical ladder working height.
14. FS maintains a survey database for storm sewer and sanitary sewer utilities on campus. These surveys shall be utilized in all design efforts. Coordination with FS for upgrades and/or replacements of nearby or impacted lines is also required.
15. Tunnel coordination with CPS is required for the following:
    a. Required tunnel ventilation locations and methods.
    b. Tunnel changes such as connection locations, connection methods, maintenance access locations, etc.
    c. Required tunnel access with each new building; locations and methods.
    d. New/replacement manhole locations for usability and maintenance; old manholes are then to be removed.
    e. Every straight tunnel length shall have at least one chase access.
    f. New building coordination with existing access locations.
    g. If tunnel ceiling damage occurs this must be adequately repaired at the contractor's expense.
16. For any and all penetrations through utility tunnel walls, ceilings, etc. use 'Link-Seal' to seal the penetration.
17. Manhole requirements:
    a. Manhole covers must be labeled storm, sanitary, etc.
    b. Manholes must be labeled with UO manhole number/ID on the lid and inside the rim / collar. ID number is to be determined during design by coordination with FS Cartographer and noted on final drawings.

Section 33 00 00 – Utilities continued

c. New/replacement manhole locations must be coordinated with CPS for locations that makes sense for usability and maintenance.
d. Old/Abandoned manholes are to be removed.

18. Central utilities (power, steam, chilled water, etc.):

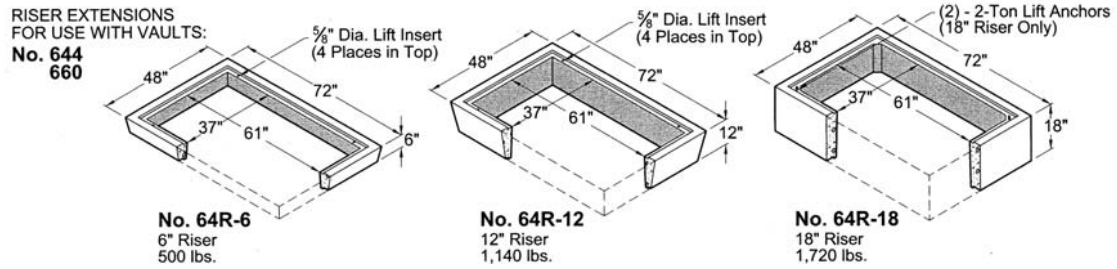
a. To be routed within tunnels and new tunnel connections shall be built where necessary.
b. All distribution lines are to be located underground (buried or encased in tunnels).
c. Direct burial of mainlines is not allowed unless CPS, FS, and FS Exterior approval is received via Construction Standards Substitution Request.

- IF utility piping is approved by CPS & FS to leave the tunnel and continue underground all piping must be sleeved / cased with a direct-buried piping system and must continue into the building a minimum of 12inches.

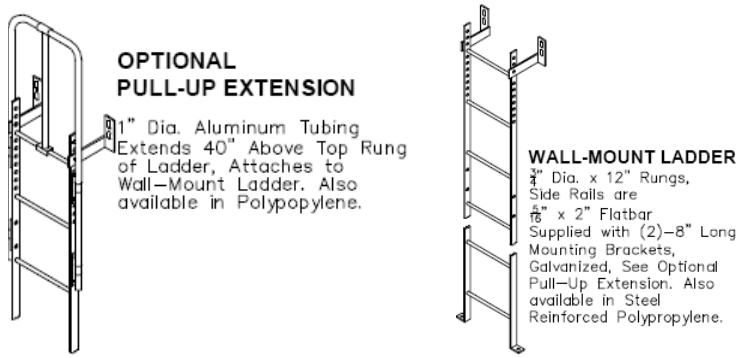
i. Do not locate condensate pipes in conduit casings with steam pipes.
ii. Provide a minimum of 1inch air space between pipe insulation and casing.

19. Utility Vaults and Transformer Padmounts:

a. Vault lids must be galvanized steel non-slip construction.
b. American Concrete Institute (ACI) Publication: ACI 318 – Building Code Requirements for Reinforced Concrete.
c. Vaults with built in ladders must have extensions above the opening that are OSHA compliant.
d. Vault doors must open completely so that in the open position there is no ceiling to the vault during maintenance.
e. Preferred vault manufacturer: Utility Vault, division of Oldcastle Precast Inc.
f. Preferred vault base: Utility Vault Model # 644-B.
g. Preferred vault top: Utility Vault Model # 44-332P.
h. Preferred padmount: Utility Vault PGE.
i. Preferred riser extensions for base No. 644: Utility Vault shown below.



j. Preferred vault ladders: Utility Vault Model pull-up or wall mount shown below.



Section 33 00 00 – Utilities continued

20. Utility Monitoring & Verification Instrumentation

    a. Reference SEED Program Guidelines, Appendix B, Metering Plan.
    b. Monitoring and verification follows IPMVP Option D for new buildings and Option B for ECM (Energy Conservation Measures) with Savings Method 2.
    c. Meter digital readouts are to be mounted and visible for manual read; not mounted within tunnels.
    d. All meters and related components are to be design, specified, and installed to manufacturer standards and recommendations.
    e. Metering and monitoring requirements must be clearly defined by 100% DD.
    f. Monitoring for all auxiliary buildings is required.
    g. Meter Communication Systems:

        - Connection to standby / emergency power.
        - Must be compatible with and connect to FS private Ethernet trunk.
        - Panels must be within 300ft of an Ethernet switch for remote monitoring.

End of Section

Section 33 10 00 – Water Utilities (Distribution Piping; Distribution Equipment)

1. In lieu of city water supply to a building a flow meter is required on water supplied reporting to the DDC system.
2. Gallon meter required for make-up water to heat exchangers with pulsed output ONLY to the DDC system.
3. Fire Hydrants:
    a. Reference the latest revision of the American Water Works Association (AWWA) standard C502.
    b. Manufacturers known to be acceptable; Mueller Centurion; Kennedy K-81D; M&H #129.
    c. Hydrants shall be painted safety yellow.
    d. Dry barrel compression type that opens against pressure is required. The valve shall be in the up position when closed.
    e. Provisions shall be provided for lubrication of the operating stem; either an oil reservoir or pressure lubrication fitting.
    f. The main valve's drain valve shall be of non-corrosive metal with rubber drain valve facings.
    g. All packaging glands and seals shall be O-ring type.
    h. Hydrants shall be the dry bonnet type with the internal operating nut enclosure located above the plane of the nozzles.
    i. The main valve shall be 5-1/4 inch.
    j. The inlet flanges shall be 6" with MJ style connection on the shoe; EWEB requirement.
    k. The nozzle section shall be a 3-way design with two 2-1/2 inch NST hose nozzles and one 5-1/2 inch NST pumper nozzle. There shall NOT be any type of cap retainer chains or devices.
    l. The operating nut shall be a one piece design with a weather cap or seals. It shall have a 1-1/2 inch pentagon, **opening left**.
    m. The hydrant shall be a high profile design with 30 inch minimum dimension from the top of the hydrant to the bury line at approximately 3 inches below the break flange.
4. Building Chilled water metering; Required:
    a. All measurements are to be remote monitored via the DDC system.
    b. Mag type flow meters:
        - Pulse output ONLY via the DDC system.
        - Manufacturers known to be acceptable: Foxboro; Bailey; Cadillac.
    c. Usage / flow to be measured in tons, calculated at the remote readout, and then pulsed to the DDC system.Section 33 10 00 – Water Utilities continued
    d. Usage / flow, supply temperatures, and return temperatures to be monitored via the readout at the sensor.
    e. Supply valve at the point of entry is to be remotely controlled via the DDC system.
    f. Supply valve is to be modulating and not 2-position.
    g. If chilled water is used for any application other than HVAC cooling, then a separate and additional mag type meter is required at the point of usage with remote monitoring to the DDC.
    h. Pete's plugs are required within 1ft of the temperature sensors on supply and return.
5. Building Domestic water metering, cold; Required:
    a. All measurements are to be remote monitored via the DDC system.
    b. Usage/flow is to be measured in K-gallons, calculated at the remote readout, and then pulsed to the DDC system.
    c. Flow meters:
        - Pulse output ONLY via the DDC system.
        - Manufacturers known to be acceptable: Foxboro; Bailey; Cadillac.

End of Section

Section 33 40 00 – Storm Drainage Utilities (Piping; Drains; Pumps; Subdrainage; Structures)

1. NO site drainage into sump pumps is allowed without FS approval due to a lack of gravity.
2. No downspouts or site drainage piping internal to a building.
3. Grates:
    a. 3/8" x 1" minimum grate openings.
    b. 60 square-inch minimum grate area serving a maximum of 300 square-feet of paved watershed.
    c. 144 square-inch grate to serve a maximum of 1000 square-feet of paved watershed.
    d. 4 square-feet grate to serve all areas larger than 1000 square feet.
    e. Decorative grates require prior FS Exterior Supervisor approval and will not be used in traffic areas.
    f. Grates require non slip surfaces.
4. Drains:
    a. Storm drains are to be labeled 'Storm Drain – Do NOT Dump' with a thermally applied decal.
    b. Corner drains are preferred vs. flat drains, and are to be installed against planters and/or retaining walls when possible.
    c. Positive drainage to storm sewer at building perimeters and entries is required.
    d. Positive drainage to building is prohibited.
5. Catch basins are not to be placed within parking spaces.
6. Rock drainage is required at all foundation walls and slabs.

End of Section

Section 33 50 00 – Fuel Distribution Utilities (Hydronic & Steam; Hydronic Energy; Steam Energy)

1. Building Steam metering; Required:
   a. All measurements are to be remote monitored via the DDC system.
   b. Vortex type flow meters:
      - Pulse output ONLY via the DDC system.
      - Manufacturers known to be acceptable: Foxboro; Bailey; Cadillac.
   c. Usage / flow are to be measured in K-pounds, calculated at the remote readout, and then pulsed to the DDC system.
   d. Usage / flow, steam temperature, and steam pressure are to be monitored via the readout at the sensor.
   e. Supply valve at the point of entry is to be remotely controlled via the DDC system. Valve is to be modulating and not 2-position.
   f. If there are multiple heat exchangers multiple / additional steam flow meters will be required to monitoreach exchanger.
2. Building Condensate metering; Required:
   a. All measurements are to be remote monitored via the DDC system.
   b. Mag type meter on the final condensate line to the tunnel located after the final steam trap.
      - Pulse output ONLY via the DDC system.
      - Manufacturers known to be acceptable: Foxboro; Bailey; Cadillac.
   c. Usage / flow are to be measured in K-pounds. Calculated at the remote readout, and then pulsed to theDDC system.
   d. If there are multiple heat exchangers multiple / additional condensate flow meters will be required tomonitor each exchanger.

End of Section

SECTION 33 61 33 Chilled Water Energy Metering

Document revision history: 11/2021 Original Publication

Date	Section	Description of Change

PART 1 – GENERAL

1.1 Summary

a. Section includes metering requirements and equipment including:
- Flow Meter
- Energy / BTU meter
- Chilled Water Supply and Return Temperature sensors / transmitters
- Utility plant monitoring software system

1.2 General Design Guidelines

a. Chilled water utility metering is required for all building connections to central chilled water distribution.
- Flow meters shall be installed to capture all use within the building. Multiple meters may be required based on design.
- Usage / flow to be measured in tons, gpm, temperature differential, displayed at the remote readout, and then sent to Utility Plant Monitoring system via Ethernet.

b. Campus chilled water system building connection detail is available as part of these design standards for reference, revision 4 dated 02/27/20.
- A utility flow meter shall be installed in the supply piping in the utility tunnel or within 10 feet of the utility tunnel doorway in the building.
- A utility Flow meter cannot be specified or installed as part of a pumping skid, cooling unit, or equivalent building equipment.
- The flow meter shall be installed on site.
- Provide high performance butterfly isolation valves on meter inlet and outlet.
- Provide bypass piping with 0% leak by isolation valve around meter, this can be sized for 50% of the design chilled water flow for the building.
- Provide differential pressure sensor across building connection and wire to the energy / btu meter additional I/O port.

c. Design documents are required to show all installation requirements from the meter manufacturer. This includes requirements for meter inlet and outlet straight lengths of pipe, location of pressure and temperature sensors, etc.

d. Electrical Power
- Flow meter and energy / btu meter shall be on a dedicated circuit from a building electrical power connected to standby power if available.
- Provide local lockable disconnect upstream of each flow meter and energy / btu meter.
    1. Label each disconnect with panel / circuit
- Flow meter power and communication wiring must route directly to energy / btu meter and shall not share conduit or enclosures with other equipment wiring.
- Conduit outside of tunnels can be Electrical Metallic Tubing (EMT).
- No ½’ EMT allowed
- Conduit inside tunnels and tunnel spurs shall be Rigid Metal Conduit (RMC).
- Conduit must maintain ¼” space from tunnel walls.
- Transitions from EMT to RMC shall be made within 4’ before entering tunnel.

- A Junction box (J-box) or conduit body shall be used when transitioning from conduit to flex.
- Flexible Metal Conduit (FMC) inside tunnel must be Liquidtight Flexible Metal Conduit (LFMC).
- LFMC and/or FMC not to exceed 4' in length.
- LFMC and/or FMC diameter to meter must be a minimum of ½".
- Conduit entering conduit bodies shall be supported within 3' of termination point.
- J-boxes must be a minimum of 4" square.
- All J-box knock-outs shall remain accessible for future use.
- There shall be a J-box located at least every 100'.
- Conduit bodies shall not be used as junction boxes.

e. Networking and Communication
- Gateways and panels must be within 300ft of an Ethernet switch for remote monitoring.
- Energy / BTU meter requires an ethernet data connection. Two ethernet cables should be pulled from the network switch to the energy / btu meter which provides for a spare.

1.3 Submittals

a. Flow Meter
- Product data

b. Energy / BTU Meter
- Product data
- Wiring diagrams

c. Utility Monitoring Software
- Template graphics
- Integration plan
    i. Include new building node layout
    ii. Proposed technician for startup and integration

d. Operation and Maintenance Manuals
- Product data
- Operation and maintenance data
- Meter Asset Management Data prior to substantial

1.4 Qualifications

a. Technician should have completed startup, meter integration, and graphic buildout in the Power Monitoring Expert software on a minimum of five projects.

PART 2 – PRODUCTS

2.1 Flow Meters

a. Chilled water flow meter
- Basis of design: Cadillac CMAG magnetic flow meter. No exceptions allowed.
- Communication protocol: Modbus, highway addressable remote transducer (HART).
- Integral LCD Display
    i. Usage / flow to be measured in tons, displayed at the remote readout

2.2 Energy / BTU Meter

a. Chilled Water Energy / BTU Meter
- Basis of design: Cadillac Heatx or Heatx2 based on project requirements, no exceptions
- Communication protocol: Modbus
- Integral LCD Display

i. Usage rate / flow to be measured in tons, displayed at the remote readout

- Ethernet gateway
  i. Provide Modbus-ethernet gateway(s) for integration with remote utility monitoring system located at the central power station.

2.3 Temperature Sensor / Transmitter

b. Chilled Water
- Basis of design: Cadillac precision matched RTD transmitter, no exceptions
- Temperature sensors required on supply and return water piping.
- Threaded outlets and thermowells installed in piping to allow removal of sensors for service and repairs.

2.4 Utility Plant Monitoring System

a. Basis of design: Power Monitoring Expert from Schneider Electric – existing system
- New meters are required to integrate into existing software monitoring system with custom graphics. Graphic requirements are as follows:
  i. Network diagram graphic updated with new or modified metering.
  ii. New custom graphics that display instantaneous and historical energy data, 15 minute / hourly./.daily / and monthly cumulative trend logs, and monthly peak demand.
  iii. Graphics should match existing layout and include the same data content, see graphics in part 3 execution section for more detail.

PART 3 – EXECUTION

3.1 Installation

a. Any deviations from Standards shall require written approval from the central power station Utilities and Energy Electrical Distribution Superintendent.
b. Utilities will not be turned on or energized until the following has been completed and verified by the central power station:
- Utility metering is permanently installed and powered.
- Utilities and Energy has inspected installation and accepted.
- Utility meters have been successfully commissioned and startup documentation provided to Utilities and Energy for acceptance.

c. Meters
- Location
  i. Meter displays must be mounted such that they are visible for manual reading from the ground.
  ii. Flow meters must be installed such that they can be accessed with 6 feet ladder and meter display can be read from the ground.
  iii. Energy / BTU meters must be installed such that they can be accessed from the ground
  iv. Energy / BTU meters in the same mechanical room should be installed in close proximity, ideally on same wall or column

d. Electrical Power
- All installations must meet or exceed NEC requirements.
- Cabling must be run in conduit, strapping to outside of conduit is prohibited.
- Tie wraps are not acceptable means of support for conduit.

3.2 Interface with other products

a. Utility monitoring software – Power Monitoring Expert (PME) from Schneider Electric

- Chilled Water Energy / BTU meter required to integrate with the campus utility monitoring software (PME). Energy / BTU meter required to have Modbus-ethernet gateway to provide communication between meter and monitoring software.
- Monitoring software (PME) includes custom graphics that display energy data from meters. All new meter installations will require new custom graphics to be created within monitoring software and meter data imported for display on graphics.

3.3 Testing

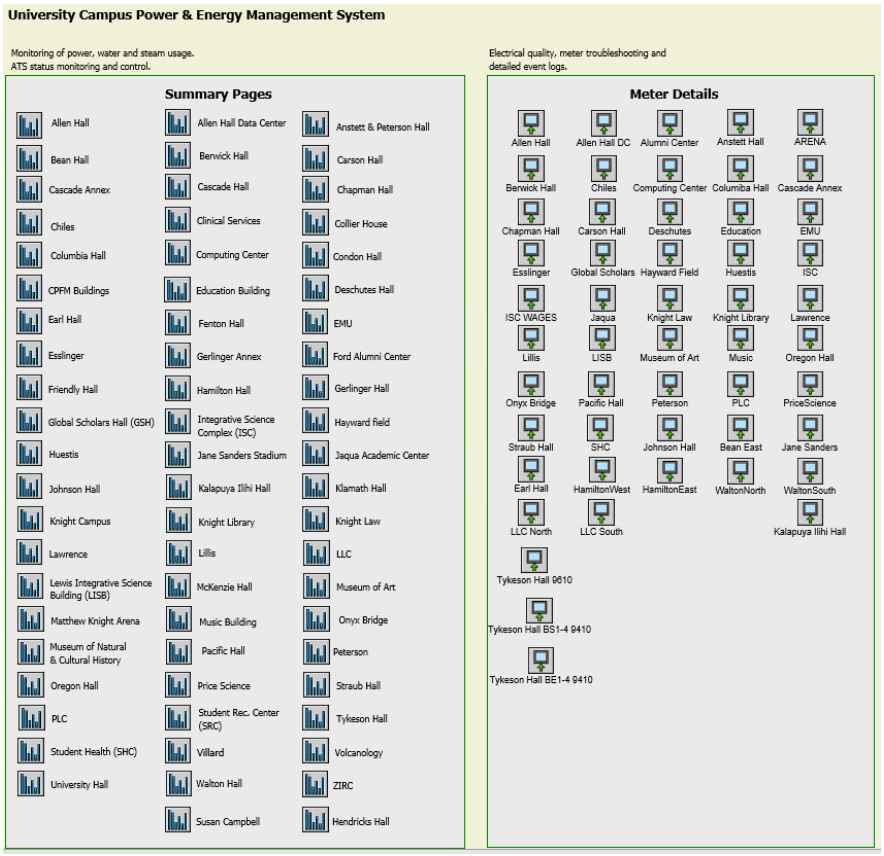
a. Startup and commissioning procedures from the meter manufacturer are required to be completed and all documentation provided to Utilities and Energy for review and acceptance prior to energizing utilities.
b. All startup, testing and commissioning must be witnessed by Owner.
c. Energy / BTU meters must be integrated into the existing utility monitoring software prior to substantial completion. This includes creation of custom graphics displaying energy use data points and trending.
    - Owner must be provided a minimum of 2 weeks-notice prior to scheduling meter integration.

3.4 Training

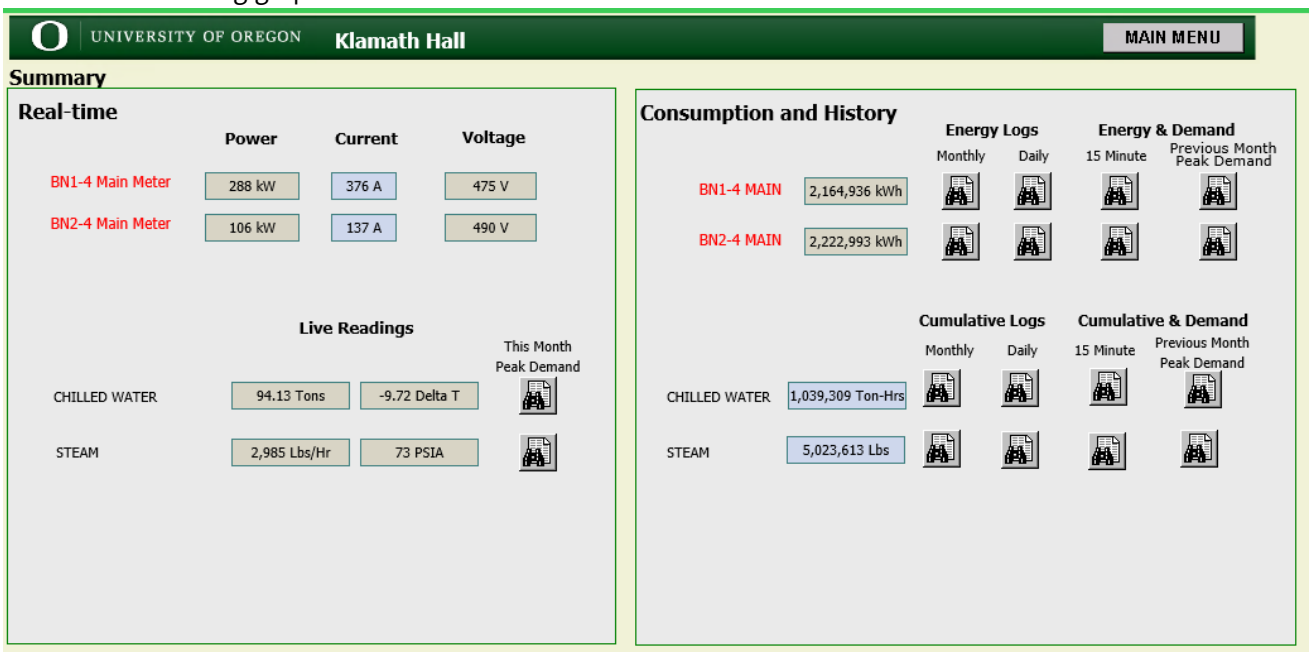
a. Furnish training plan for review by Owner at least two weeks prior to training.
b. Draft operation and maintenance manuals submitted prior to first training session.
c. Labeling of equipment, piping, and accessories is complete prior to first training session.
d. Training by qualified technicians knowledgeable in metering systems and components. Sales representatives are not acceptable to teach training courses unless approved by Owner prior to training.
e. Provide 4 hours of training in the following areas:
    - Review maintenance access and general installation
    - Review troubleshooting procedures
    - Review meter factory and field configuration settings

3.5 Graphics

a. Network diagram



b. Building graphic



END OF SECTION

SECTION 33 63 33 Steam Energy Metering

Document revision history: 11/2021 Original Publication

Date	Section	Description of Change

PART 1 – GENERAL

1.5 Summary

b. Section includes metering requirements and equipment including:
- Flow Meter
- Energy / BTU meter
- Temperature sensor / transmitter
- Pressure sensor / transmitter
- Utility plant monitoring software system

1.6 General Design Guidelines

f. Steam utility metering is required for all buildings connected to central steam distribution.
- Steam flow meter(s) shall be selected to capture at least 95% of design peak steam usage within the building. Multiple steam meters may be required based on design and building steam usage.
- Energy / BTU meter must include temperature compensation transmitter.

g. Usage / flow required to be measured in k-lbs / lbs per hour, displayed at the remote readout, and have data transmitted to existing Utility Plant Monitoring system via Ethernet communication. Hourly and monthly peak steam flow measurement required.

h. Provide gate type isolation valves on flow meter inlet and outlet.

i. Provide bypass piping with 0% leak by isolation valve around meter. Bypass piping to be sized to provide 50% capacity of design building load.

j. Design documents must show all installation requirements from the meter manufacturer. This includes requirements for meter inlet and outlet straight lengths of pipe, location of and temperature sensors, etc.

k. Electrical Power
- Flow meter and energy / btu meter are required be on a dedicated circuit connected to standby power.
- Provide local lockable disconnect upstream of each 120-volt flow meter and energy / btu meter
    1. Label each disconnect with panel / circuit
- Flow meter power and communication wiring must route directly to energy / btu meter and should not share conduit or enclosures with other equipment wiring.
- Conduit outside of tunnels can be Electrical Metallic Tubing (EMT).
- No ½' EMT allowed
- Conduit inside tunnels and tunnel spurs shall be Rigid Metal Conduit (RMC).
- Conduit must maintain ¼" space from tunnel walls.
- Transitions from EMT to RMC shall be made within 4' before entering tunnel.
- A Junction box (J-box) or conduit body shall be used when transitioning from conduit to flex.
- Flexible Metal Conduit (FMC) inside tunnel must be Liquid tight Flexible Metal Conduit (LFMC).
- LFMC and/or FMC not to exceed 4' in length.
- LFMC and/or FMC diameter to meter must be a minimum of ½".
- Conduit entering conduit bodies shall be supported within 3' of termination point.
- J-boxes must be a minimum of 4" square.
- All J-box knock-outs shall remain accessible for future use.

- There shall be a J-box located at least every 100'.
- Conduit bodies shall not be used as junction boxes.

l. Networking and Communication
- Gateways and panels must be within 300ft of a network switch for remote monitoring.
- Energy / BTU meter requires an ethernet data connection. Two ethernet cables should be pulled from the network switch to the meter which provides for a spare.

1.7 Submittals

e. Flow Meter
- Product data

f. Energy / BTU Meter
- Product data
- Wiring diagrams

g. Utility Monitoring Software
- Template graphics
- Integration plan
  i. Include new building node layout
  ii. Proposed technician for startup and integration

h. Operation and Maintenance Manuals
- Product data
- Operation and maintenance data
- Meter Asset Management Data prior to substantial

1.8 Qualifications

a. Technician should have completed startup, meter integration, and graphic buildout in the Power Monitoring Expert software on a minimum of five projects.

PART 2 – PRODUCTS

2.4 Flow Meters

b. Steam flow meter
- Basis of design: Cadillac Vortex CV-P, no exceptions
- Communication protocol: Highway addressable remote transducer (HART).
- Output: Simultaneous 4-20mA analog-pulse output
- Integral LCD Display
  i. Usage / flow in k-lbs / lbs per hr, steam temperature, and steam pressure are to be displayed and monitored via the readout at the meter.

2.5 Energy / BTU Meter

b. Steam Energy / BTU Meter
- Basis of design: Cadillac CMASS no exceptions
- Communication protocol: Modbus
- Integral LCD Display
- Ethernet gateway
  i. Provide Modbus-ethernet gateway(s) for integration with remote monitoring dashboard located at the central power station.

2.6 Temperature Sensor / Transmitter

6.1 Steam

- Temperature sensor / transmitter shall have an accuracy of +/- 0.1% of temperature span, be 24 VDC loop powered, provide a scalable 4-20 mADC output, and field adjustable through a local interface or via digital communications highway addressable remote transducer (HART).
- Threaded outlets and Thermowells shall be installed in steam piping without prohibiting full access to remove sensors for service and repair.

2.7 Utility Plant Monitoring System

7.1 Basis of design: Power Monitoring Expert from Schneider Electric – existing system

- New meters are required to integrate into existing software monitoring system with new custom graphics that displays instantaneous and historical energy data, 15 minute / daily / and monthly cumulative trend logs, and monthly peak demand. Graphics should match existing layout and include the same data content, see appended template for reference.

PART 3 – EXECUTION

3.6 Installation

e. Any deviations from Standards shall require written approval from the central power station Utilities and Energy Electrical Distribution Superintendent.

f. Utilities will not be turned on or energized until the following has been completed and verified by the central power station:
   - Utility metering is permanently installed and powered.
   - Utilities and Energy has inspected installation and accepted.
   - Utility meters have been successfully commissioned and startup documentation provided to Utilities and Energy for acceptance.

g. Meters
   - Location
     i. Meter displays must be mounted such that they are visible for manual reading from the ground.
     ii. Flow meters must be installed such that they can be accessed with 6 feet ladder and meter display can be read from the ground.
     iii. Energy / BTU meters must be installed such that they can be accessed from the ground.
     iv. Energy / BTU meters in the same mechanical room should be installed in close proximity to one another, ideally on same wall or column.

h. Electrical Power
   - All installations must meet or exceed NEC requirements.
   - Cabling must be run in conduit, strapping to outside of conduit is prohibited.
   - Tie wraps are not acceptable means of support for conduit or cabling.-

3.7 Interface with other products

a. Utility monitoring software – Power Monitoring Expert (PME) from Schneider Electric
   - Steam Energy / BTU meter required to integrate with the campus utility plant monitoring software (PME). Energy / BTU meter required to have Modbus-ethernet gateway to provide communication between meter and monitoring software.
   - Monitoring software (PME) includes custom graphics that display energy data from meters. All new meter installations will require new custom graphics to be created within monitoring software and meter data imported for display on graphics.

3.8 Testing

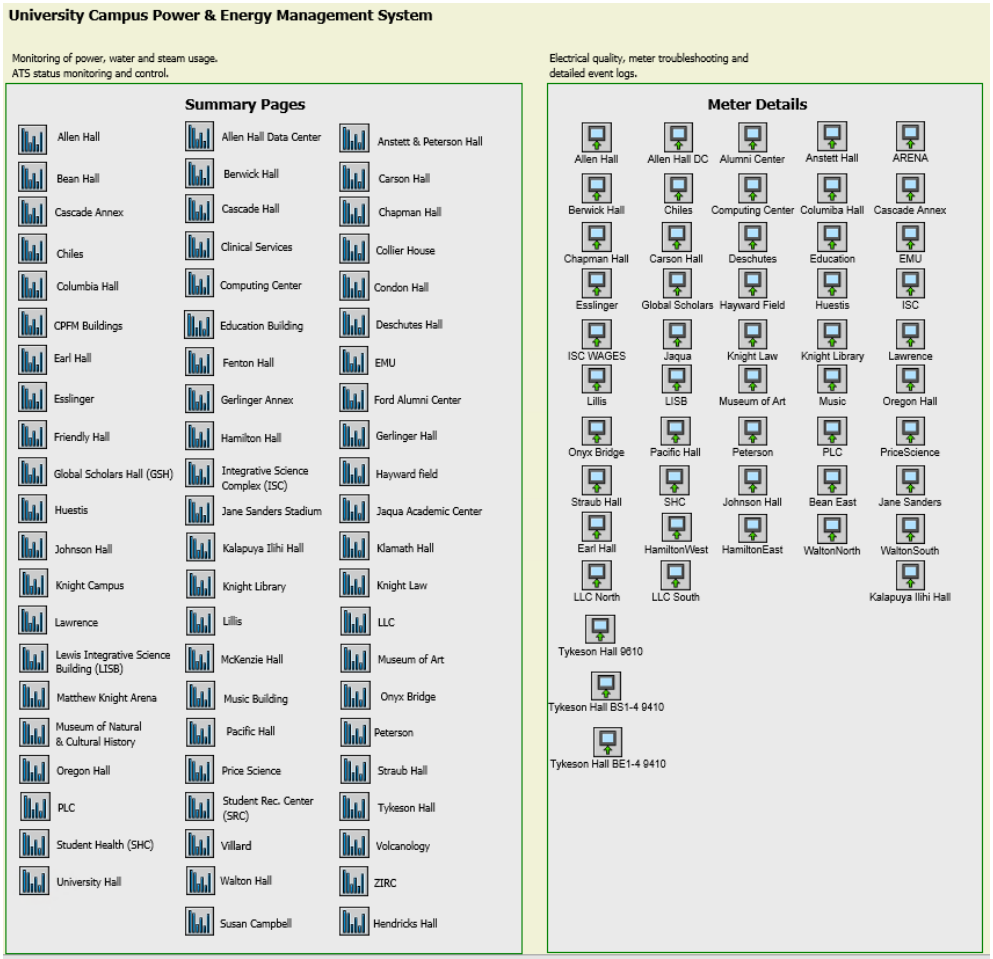
a. Startup and commissioning procedures from the meter manufacturer are required to be completed and all documentation provided to Utilities and Energy for review and acceptance prior to energizing utilities.
b. All startup, testing and commissioning must be witnessed by Owner.
c. Energy / BTU meters must be integrated into the existing utility monitoring software prior to substantial completion. This includes creation of custom graphics displaying energy use data points and trending.
    - Owner must be provided a minimum of 2 weeks notice prior to scheduling meter integration.

3.9 Training

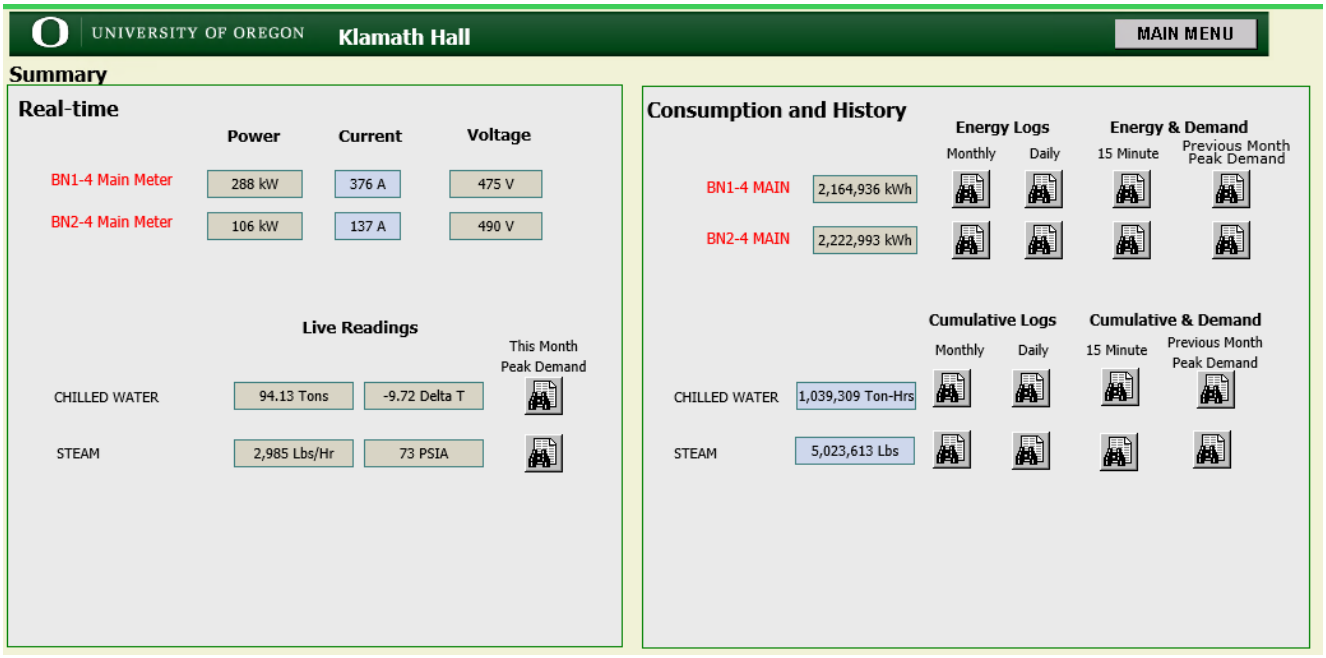
a. Furnish training plan for review by Owner at least two weeks prior to training.
b. Draft operation and maintenance manuals submitted prior to first training session.
c. Labeling of equipment, piping, and accessories is complete prior to first training session.
d. Training by qualified technicians knowledgeable in metering systems and components. Sales representatives are not acceptable to teach training courses unless approved by Owner prior to training.
e. Provide 4 hours of training in the following areas:
    - Review maintenance access and general installation
    - Review troubleshooting procedures
    - Review meter factory and field configuration settings

3.10 Graphics

a. Network diagram graphic



b. Building graphic



END OF SECTION

Section 33 70 00 – Electrical Utilities (Transmission & Distribution; Substations; Transformers; High-Voltage Switchgear & Protection Devices; Medium-Voltage Switchgear & Protection Devices; Site Grounding)

1. Primary power is to be encased in 2-inch cover minimum and in red-dyed cement.
2. Metering, reporting of meters, and commissioning of main meters must be complete and documented at the time the system is energized.
3. Campus Power Metering & Power Management; Required:

   a. General Requirements:

   - There shall be provided a UL listing for all equipment.
   - Manufacturer will provide services including all materials and labor to maintain operation of equipment for two years.

   b. Basic Power Meter:

   - Only manufacturer known to be acceptable: Square D
   - Features:

     i. Split Core CT's
     ii. Remote Display
     iii. Minimum Functions:

     ◊ Phase Current
     ◊ Volts, L-L
     ◊ Volts, L-N
     ◊ Real Power (KW)
     ◊ Reactive Power (kVAR)
     ◊ Apparent Power (kVA)
     ◊ Power Factor
     ◊ Real Energy (kWh)
     ◊ Power Demand with configurable demand interval
     ◊ Min-Max readings (kW)

     iv. Modbus communication capability to Ethernet Gateway.
     v. Capable of being configured to have specified data alarmed, displayed and logged using Square DSMS-3000 software via Ethernet Gateway or network interface card.

   c. Advanced Power Meter:

   - Only manufacturer known to be acceptable: Square D, PM 870
   - Features:

     i. Integral display with option for remote display.
     ii. Minimum Functions:

     ◊ Current, per phase RMS +/- 0.075%
     ◊ Current, 3-phase average RMS +/- 0.075%
     ◊ Current, apparent RMS +/- 0.075%
     ◊ Voltage, phase-to-phase & phase-to-neutral +/- 0.075%
     ◊ Power factor, per phase +/- 0.15%
     ◊ Power factor, 3-phase total +/- 0.15%
     ◊ Real power, 3-phase total +/- 0.15%
     ◊ Reactive power, 3-phase total +/- 0.15%
     ◊ Apparent power, 3-phase total +/- 0.15%
     ◊ Frequency +/- 0.01%
     ◊ Average demand current, per phase

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- ◊ Peak demand current, per phase, coincident with kW Peak, kVAR Peak, kVA Peak
- ◊ Average demand, real power
- ◊ Predicted demand, real power
- ◊ Peak demand, real power, coincident with kVA Peak, kVAR Peak
- ◊ Accumulated real energy In, accumulated real energy Out
- ◊ Accumulated reactive energy In, accumulated reactive energy Out
- ◊ Accumulated apparent energy
- ◊ Onboard Alarms (analog, digital, and Boolean)
  - ■ Undervoltage
  - ■ Overvoltage
  - ■ Unbalanced Current
  - ■ Unbalanced Voltage
  - ■ Phase Loss Current
  - ■ Phase Loss Voltage
  - ■ Reverse Power
  - ■ Phase Reversal
- ◊ Onboard logging of alarms, electrical data, trending, and forecasting, maintenance logs andwaveform capture using non-volatile memory of at least 800kb with zero blind sampling capability at 128 samples per cycle.
- ◊ Modbus communication capability to Ethernet Gateway.
- ◊ Capable of being configured to have specified data alarmed, displayed, and logged usingSquare D SMS-3000 software via Ethernet Gateway or network interface card.

d. Distribution Power Meter:

- Only manufacturer known to be acceptable: Square D, CM-4000T or CM3000
- Features

i. Remote Display
ii. Minimum Functions:

- ◊ Phase Current 0.04% of reading
- ◊ Volts, L-L 0.04% of reading
- ◊ Volts, L-N 0.04% of reading
- ◊ Real Power (KW) 0.075% of reading
- ◊ Reactive Power (kVAR) 0.075% of reading
- ◊ Apparent Power (kVA) 0.075% of reading
- ◊ Power Factor +/- 0.002 of reading
- ◊ Frequency +/- 0.01 of reading
- ◊ Real Energy (kWh) 0.075% of reading
- ◊ Reactive Energy (kVARh) 0.075% of reading
- ◊ Apparent Energy (kVAh) 0.075% of reading
- ◊ Energy Accumulation Modes
- ◊ KYZ Output
- ◊ Front Display
- ◊ THD, Voltage and Current with discrete harmonics to the 255th
- ◊ Current Demand
- ◊ Power Demand
- ◊ Date / Time Stamping

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- ◊ Predicted Power Demand
- ◊ Advanced Demand Options
- ◊ Onboard Alarms (standard, high speed, disturbance, digital, Boolean)
  - ■ Under voltage
  - ■ Over voltage
  - ■ Unbalance current
  - ■ Unbalance voltage
  - ■ Phase loss current
  - ■ Phase loss voltage
  - ■ Reverse power
  - ■ Phase reversal
- ◊ Min / Max Readings
- ◊ Data and Event Logging
- ◊ Downloadable Firmware
- ◊ Adaptive Waveform Capture configurable up to 64 seconds and up to 512 samples per cycle
- ◊ Sag / Swell Detection
- ◊ Programmable
- ◊ Oscillatory and Impulsive Transient Detection using 5mHz sampling on three channels simultaneously
- ◊ Sequence of Event Recording

iii. Modbus communication capability to Ethernet Gateway or integrally mounted Ethernet network interface card.

iv. Capable of being configured and having its data alarmed, displayed, and logged, including waveform capture and transient detection information using Square D SMS3000 software either directly or via an Ethernet Gateway.

e. Ethernet Gateway:

- Only manufacturer known to be acceptable: Square D EGX400
- Ethernet Gateway Requirements

i. Provide an Advanced Ethernet Gateway meeting the requirements.
ii. One 10/100 Mbps UTP port and one 100 Mbps fiber optic port.
iii. 16 MB of internal memory.
iv. Provide storage for standard and custom web pages to display real-time power equipment data and status, instruction manuals, and equipment drawings.
v. Capable of accepting HTML files, PDF files, Active X, CRG, GIF, JPG graphics, MS Office files (doc, xls, ppt, etc.).
vi. Configurable remotely using a standard internet browser.
vii. The Ethernet Gateway shall feature one RS-485 serial port and a second port configurable for RS-232 or RS-485 (support for 2-wire or 4-wire).
viii. A singe Ethernet Gateway, assigned a single IP address, shall provide high speed Ethernet support for up to 192 devices.
ix. Protocols supported: Ethernet – MODBUS / TCP HTTP, FTP. Serial – MODBUS, JBUS, and SY/MAX.
x. Input voltage: 24 Vdc; maximum burden 8 Watts.
xi. The Ethernet Gateway shall operate in ambient temperature of -30 to 80° C, an ambient storage temperature of -40 to 85° C and will operate in relative humidity of 5 to 95%.
xii. The Gateway shall be fitted with a web server to allow users to configure its Ethernet and Serial communication parameters, troubleshoot both Ethernet and serial communication, and add stand-

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xiii. alone product that offers various mounting configuration and includes at a minimum the following mounting options: DIN rail mounting; wall / panel mounting; flat surface or desk top.
xiv. UL, CUL, CE, NOM and FCC class A compliant.
xv. Compatible with Ethernet TCP / IP networks and allow users to access power monitoring information from any location on a local area network (LAN) or a wide area network (WAN).
xvi. Utilize Modbus / TCP protocol as its high-speed backbone network protocol.
xvii. Allow direct Ethernet connection to monitoring and protective RS-485 field devices. Powermonitoring software running on a PC with a Modbus / TCP driver shall be able to access monitoring, metering, and protective data via the LAN. The PC shall be connected to the Ethernet LAN via Network Interface Card (NIC).
xviii. The Gateway shall provide a twisted pair connection to connect to the Ethernet backbone. The Ethernet twisted pair port shall have the following:

- ◊ An RJ45 connector.
- ◊ Support for 10/100 BaseT connection (10 or 100 Mbit auto-negotiate)
- ◊ Support for both unshielded twisted pair (UTP) as well as shielded twisted pair (STP) wiring.
- ◊ LED's to indicate Ethernet activity. At a minimum, there shall be the following LED's; one for Physical Ethernet Link (LK), one for Transmit (TX), one for Receive (RX).

xix. Provide two serial RS-485 ports to connect serial field devices to the LAN. Each RS-485 serial port shall:

- ◊ Support up to 32 serial devices without a repeater.
- ◊ Support Modbus, Jbus, or mixed mode daisy chain devices.
- ◊ Support 2-wire or 4-wire daisy chain devices.
- ◊ Support baud rates of 1200 to 38400.
- ◊ Support parity values of even and none.
- ◊ Include screw type connectors with 5-positions.
- ◊ Include LED's to indicate serial communication activity. At a minimum, there shall be the following LED's; one for Transmit (Tx), and one for Receive (Rx) per port.

xx. A minimum of one port shall be configurable for either RS-485 or RS-232.
xxi. Each serial port shall have configurable biasing and termination to support 2-wire and 4-wire communicating devices.
xxii. The Ethernet Gateway shall allow a Modbus master on one of its serial ports to request data from devices on the second serial port.
xxiii. Compliant to industrial temperature. It shall withstand an operating temperature range of -30° to
xxiv. +80° C.
xxv. Configurable by either local RS-232 connection and a Hyper Terminal ® interface or local or remote Ethernet connection and a standard web browser.
xxvi. Setup of the Ethernet communication card shall be accomplished via the on-board Ethernet port and a web browser. It shall also be possible via the Ethernet port to upgrade the firmware of the Ethernet Gateway in the field to accommodate new system features.

f. Remote I / O Monitoring Module:

- Only manufacturer known to be acceptable: Square D EGX400
- Components

i. Programmable Logic Controller:

- ◊ Provide a fully functional Programmable Logic Controller (PLC), suitable for simultaneously monitoring up to 16 single ended analog points and 16 digital points (1 digital input module and 1 analog input module).
- ◊ PLC shall have an RJ-45 Ethernet output suitable for connection to the University of Oregon fiber backbone.

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- ◊ PLC shall be programmable to fully interface with the University of Oregon SMS-3000 power monitoring software via an Ethernet Gateway.
- ◊ PLC shall be capable of communicating over Ethernet using Modbus TCP.
- ◊ All components shall be housed in a steel enclosure.

ii. Uninterruptible Power Supply:
- ◊ Provide an Uninterruptible Power Supply (UPS), rack or wall mountable, suitable for operating the fully configured PLC for 30 minutes.
- ◊ The UPS shall be 120 volt AC input.

iii. Equipment Rack or Enclosure:
- ◊ Provide a standard equipment rack, designed for floor standing applications, suitable sized to support the PLC, the UPS, and any other accessories required in a fully configured system
- ◊ A wall-mounted NEMA 1 enclosure suitable to house all components is acceptable provided that this is the manufacturer's standard configuration.

iv. Digital Input Module: The digital input module shall accommodate up to 8 24-volt DC inputs.

v. Analog Input Module:
- ◊ The analog input module shall accommodate up to 16 single-ended analog inputs.
- ◊ Each of the analog inputs shall be user-configurable as either 4-20ma.

vi. Digital Output Module: The digital output module shall accommodate up to 8 24-volt DC contact outputs.

4. Medium Voltage Switching and Protection Cable: Includes: Medium Voltage Cable; Cable Terminations; Faulted Circuit Indicators

a. Manufacturer known to be acceptable: The Okonite Company.
b. Submittals:

- Product Data: Provide for cable, terminations and accessories.
- Test Reports; from the factory and prior to energizing: Indicate results of cable test in tabular form and in plots of current versus voltage for incremental voltage steps, and current versus time at 30 second intervals at maximum voltage.
- Manufacturer's Instructions:

i. Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements.
ii. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

c. Project Record Documents: Accurately record actual sizes and locations of cables.
d. Operation and Maintenance Data: Include instructions for testing and cleaning cable and accessories.
e. Qualifications:

- Manufacturer: Company specializing in manufacturing products specified in this section with minimum thirty (30) years documented experience.
- Installer: Company specializing in installing products specified in this section with minimum three (3) years documented experience.

f. Delivery, Storage and Handling:

- Accept cable and accessories on site in manufacturer's packaging. Inspect for damage.
- Store and protect in accordance with manufacturer's instructions.
- Protect from weather and provide adequate ventilation to prevent condensation.

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g. Project Conditions:

- Verify that field measurements are as shown on drawings.
- Verify routing and termination locations of cable prior to rough-in.
- Cable routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

h. Field Samples: After approval and prior to installation, furnish the Facilities CPS Electrician and Electrical Supervisor with a 2-foot length of each type and size of wire and cable along with the tag from the coils or reels from which the samples were taken. The sample shall contain the manufacturer's markings.

i. Industry Standards: Cable shall meet or exceed the latest editions of the following industry specifications.
- ICEA S-68-516.
- ASTM B-8, B-231.
- AEIC CS-6.
- REA Bulletin 50-70 (U-1).

j. Cable shall be manufactured on a continuous vulcanization machine with three tandem extruders.

k. Multi-Conductor Medium Voltage Cable, 15KV:
- All cable shall conform to the current standards, where applicable:
  iii. Insulated Cable Engineers Association (ICEA)
  iv. Institute of Electrical and Electronic Engineers (IEEE)
  v. National Electric Code (NEC)
  vi. Underwriters' Laboratories (UL)
  vii. Association of Edison Illuminating Companies (AEIC)
- Each reel of cable furnished shall be newly manufactured (no more than 12-months old), and shall bear a tag containing name of manufacturer, NEC designation, year of manufacture.
- Technical Requirements: Conductor shall be compact stranded, Class B annealed copper, covered with an extruded semi-conducting EPR strand screen, 220 mil ethylene-propylene insulation (133%), extruded EPT semi-conducting insulation screen, with a peel strength between 8 and 16 pounds per
- ½" width strip. 5 mil bare copper shielding tape with 12.5% minimum overlap. 80 mil PVC jacket. UL listed and labeled type MV 105, MC/HL. Suitable for operation continuous at 150°C conductor temperature, 140°C emergency conditions and 250°C for short circuit conditions.
- Insulation System: The ethylene content of the elastomer used in the insulation compound shall not exceed 72% by weight of ethylene, nor shall it contain any polyethylene; both features to limit the degree of susceptibility to treeing experienced by highly crystalline materials. The insulation shall be compounded by the cable manufacturer in its own facility using a closed system to insure maximum cleanliness. All ingredients will be mixed, screened through a 300 mesh screen pack and then treated with an accelerator agent to assure complete blending. The extrusion process will be true triple (utilize three distinct extruders and heads) in order to control the thickness and concentricity of each layer while providing the means to strip the EPR insulation screen from the EPR insulation. All variations in the extrusion process shall be recorded in the plant log.
- Cable Assembly: Three shielded conductors shall be cabled along with an un-insulated copper grounding conductor, and fillers, to form a round cable core covered with a binder tape overall. A tight fitting, continuously welded, impervious, corrugated aluminum sheath is applied over the cable core. The sheath shall have the ability to safely carry fault currents as indicated in the National Electrical Code. A red, PVC low temperature minimum 40°C jacket shall be extruded over the C-L- X core.
- Experience: The cable manufacturer shall have a minimum of 30 years proven and successful experience with the manufacturer of EPR insulated cables.
- Tests: Furnish certified test reports of all applicable tests per AEIC to the purchaser at the time of delivery.

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i. Apparent Discharge Test: The completed cable must be tested for corona discharge and shall comply with AEIC requirements. A copy of the original X-Y plot showing discharge levels for the cable shipped shall be submitted at time of delivery. The maximum discharge shall not exceed 5pico-coulombs for all voltage levels. No d-c test shall be performed.

- Shipping Reels: All reels shall be marked as to installation location as required by the purchaser. Cut lengths shall have a tolerance of -0/+3% or as agreed to by the purchaser.
- Warranty: The cable shall have a 40-year design life.
- Field Advisor: The cable manufacturer shall provide a field advisor for a full day of installation support that includes cable pulling calculation support, termination training, installation training, d-c testing recommendation.

l. Single Conductor Medium Voltage Cable, 15KV:

- All cable shall conform to the current standards, where applicable:

  i. Insulated Cable Engineers Association (ICEA)
  ii. Institute of Electrical and Electronic Engineers (IEEE)
  iii. National Electric Code (NEC)
  iv. Underwriters' Laboratories (UL)
  v. Association of Edison Illuminating Companies (AEIC)

- Each reel of cable furnished shall be newly manufactured (no more than 12-months old), and shall bear a tag containing name of manufacturer, NEC designation, year of manufacture.
- Technical Requirements: Conductor shall be compact stranded, Class B annealed copper, covered with an extruded semi-conducting EPR strand screen, 220 mil ethylene-propylene insulation (133%), extruded EPT semi-conducting insulation screen, with a peel strength between 8 and 16 pounds per ½" width strip. 5 mil bare copper shielding tape with 12.5% minimum overlap. 80 mil PVC jacket. UL listed and labeled type MV 105, MC/HL. Suitable for operation continuous at 150°C conductor temperature, 140°C emergency conditions and 250°C for short circuit conditions.
- Insulation System: The ethylene content of the elastomer used in the insulation compound shall not exceed 72% by weight of ethylene, nor shall it contain any polyethylene; both features to limit the degree of susceptibility to treeing experienced by highly crystalline materials. The insulation shall be compounded by the cable manufacturer in its own facility using a closed system to insure maximum cleanliness. All ingredients will be mixed, screened through a 300 mesh screen pack and then treated with an accelerator agent to assure complete blending. The extrusion process will be true triple (utilize three distinct extruders and heads) in order to control the thickness and concentricity of each layer while providing the means to strip the EPR insulation screen from the EPR insulation. All variations in the extrusion process shall be recorded in the plant log.
- The cable manufacturer shall have a minimum of 30-years proven and successful experience with the manufacturer of EPR insulated cables.
- Tests: Furnish certified tests reports of all applicable tests per AEIC to the purchaser at the time of delivery:

  i. Apparent Discharge Test: The completed cable must be tested for corona discharge and shall comply with AEIC requirements. A copy of the original X-Y plot showing discharge levels for the cable shipped shall be submitted at time of delivery. The maximum discharge shall not exceed 5pico-coulombs for all voltage levels. No d-c test shall be performed.

- Shipping Reels: All reels shall be marked as to installation location as required by the purchaser. Cut lengths shall have a tolerance of -0/+3% or as agreed to by the purchaser.
- Field Advisor: The cable manufacturer shall provide a field advisor for a full day of installation support that includes cable pulling calculation support, termination training, installation training, d-c testing recommendation.

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- Warranty: The cable shall have a 40-year design life.

m. Load break Elbow Termination Manufacturers: Elastimold #166LR, with test point; Cooper.
n. Load break Junctions:
- 4-way load break junction: Elastimold #163J4; Cooper.
- 3-way load break junction: Elastimold #163J3; Cooper.
- Provide (2) parking bushings for each junction.
- Provide ground wire lug at each junction.Provide an insulated cap with ground (Elastimold #160DRG) for each load break bushing insert that will not have a load break elbow connected to it.
- Load break elbow connectors must be compatible with those existing in the University's electrical distribution system.

o. Faulted Circuit Indicators:

- Acceptable Manufacturers: Edison Control EC-35, #3042540-D200-A1.0.
- Description: Three phase, standard indicator, hinged small core with 25-feet of cable, relay output and pull over bail, 200 amp timed inrush restraint trip, 1 amp standard reset and two point mounting (for three phase remote units).

p. Preassembles Cable Termination Kits or Splices:
- Acceptable Manufacturers: Elastimold Series K150; Cooper; Raychem; 3M.
- Description: IEEE 48; Class 1, molded rubber cable termination in kit form with stress cone, ground clamp, non-tracking rubber skirts, load break connector, rubber cap, for universal bushing.

q. Preparation: Use swab to clean conduits before pulling cables.
r. Installation:
- Install cable and accessories in accordance with manufacturer's instructions.
- At each point of termination, install plastic cable collars with printed feeder number. Write on this collar in indelible ink the location and distance in feet to the next termination point.
- Use suitable lubricating compounds on the cables and wires to prevent damage to them during pulling-in. Provide compounds that are not injurious to the cable and wire jackets and do not harden or become adhesive.
- Avoid abrasion and other damage to cables during installation.
- Do not exceed cable pulling tensions and bending radius as specified by the cable manufacturer.
- In cable trays, secure manholes to avoid interference with duct entrances.
- Provide a minimum of 3-feet extra armored cable per 100-feet of run when installed in cable trays to provide sufficient slack at terminal points and cable try expansion points so that movements of cable after installation will not cause damaging strain on cables or terminals.
- In manholes, underground raceways, vaults and other outdoor locations:
    i. Seal the cable ends prior to pulling them in to prevent the entry of moisture.
    ii. Allow sufficient slack in medium voltage cables, grounds and shield wires to allow elbow connectors to be moved to other existing and future load break junctions inside the vault.
    iii. Splice the cables and wires only in manholes and accessible junction boxes. Ground shields and neutral conductor.
    iv. In manholes, trenches and vaults install the cables on suitable porcelain insulators with steel cables racks. Ground cable racks.
    v. Install faulted circuit indicators so they are easily viewed from outside the vault
    vi. Arrange cable in manholes to avoid interference with duct entrances.
- Protect installed cables from entrance of moisture.
- Where CLX Armor is exposed for splices and terminations provide heat shrink (Ray-Chem) material over exposed shield.

s. Field Quality Control:

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- Inspect exposed cable sections for physical damage.
- Inspect cable for proper connections.
- Inspect shield grounding, cable supports and terminations for proper installation.Contractor shall contact cable manufacturer and arrange for one day of on-site cable installation advice prior to starting installation.
- Electrical Acceptance Tests:

i. The Electrical Contractor shall engage the services of a recognized independent testing laboratory for the purpose of performing inspections and tests.
ii. Tests are to assure that all electrical equipment is operational within industry and manufacturer's tolerances.
iii. Upon completion of the tests and inspections noted, a label shall be attached to all serviced devices. These labels will indicate date serviced and the service company responsible.
iv. The tests and inspections shall determine suitability for continued reliable operation.

t. Division of Responsibility:

- The Electrical Contractor shall perform routine insulation resistance, continuity and rotation tests for all distribution and utilization equipment prior and in addition to tests performed by the testing laboratory.
- The Electrical Contractor shall supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements.
- The Electrical Contractor shall notify the testing laboratory when equipment becomes available for acceptance tests.
- The Electrical Contractor shall supply a complete set of electrical plans, specifications and pertinent change orders to the testing laboratory prior to commencement of testing.
- The testing laboratory shall notify the Engineer prior to commencement of any testing.
- Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the Engineer and Facilities PM.
- The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report. The test report (6 copies) will be distributed to the Engineer, PM, and to the Electrical Contractor who shall include it into the project Operation and Maintenance Manuals.
- The test report shall include the following:

i. Summary of project.
ii. Description of equipment tested.
iii. Description of test.
iv. Test results.
v. Conclusions and recommendations.
vi. Appendix, including appropriate test forms.

u. The independent testing laboratory shall perform appropriate tests for the new primary cable installation. Responsibilities shall include the following:

- Medium Voltage Cable, Visual and Mechanical Inspections:

i. Inspect exposed sections from new metering cabinet to transformer vault for physical damage.
ii. Verify cable is supplied and connected in accordance with one line diagram.
iii. Inspect for shield grounding, cable support and termination.

- Visible cable bends shall be checked against ICEA or manufacturer's minimum allowable bending radius.Electrical Tests:

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iv. Perform a shield continuity test by ohm meter method. Record ohmic values.

v. Each conductor shall be individually tested with all other conductors grounded. All shields shall be grounded.

- ◊ Terminations shall be properly corona suppressed by guard ring, field reduction sphere or other suitable methods.
- ◊ A DC hypotential shall be applied in at least eight (8) equal increments until maximum test voltage is reached. D.C. leakage current shall be recorded at each step after a constant stabilization time consistent with system charging current decay.
- ◊ A graphic plot shall be made of leakage current (X axis) versus voltage (Y axis) at each increment.
- ◊ The test conductor shall be raised to a maximum test voltage and held for a total of ten (10) minutes. Readings of leakage current (Y axis) versus time (X axis) shall be recorded and plotted on thirty (30) second intervals for the first two (2) minutes and every minute thereafter.
- ◊ The applied conductor test potential shall be reduced to zero (0) and grounds applied for a period adequate to drain all insulation stored potential.

- Safety Precautions: Exercise suitable and adequate safety measures prior to, during and after the high potential tests, including placing warning signs and preventing people and equipment from being exposed to the test voltage.

vi. Feeder Identification:

- In each manhole and pull-box, install permanent tags on each circuit's cables and wires to clearly designate their circuit identification and voltage.
- In manholes, the tags shall be the embossed brass type and shall also show the cable type and voltage rating.
- Position the tags so they will be easy to read.

w. Quality Assurance: Cable shall be manufactured under a quality assurance program as defined by ISO 9000 and 10 CFR 50 of the Federal Register.

End of Section