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| <b>33 00 00</b>   | <b>UTILITIES</b> |

Part 1 - General

Owner (NAU Utility Services & Trade Personnel), in conjunction with the DP firm, shall establish the connection point for each required service during schematic design and before design development.

The DP shall submit hydraulic calculations for each utility system in the BOD along with each design phase submittal.

Utility shutdowns must be done in accordance with procedures in Division 1.

## Inspection Process:

1. The individual Owner Trades will inspect the components that they are responsible for on the FS#15.
2. The components listed on the FS#15 for the Locating Services need to be inspected by the Owner's Locating Supervisor on every utility. Locating Services will check as-builts as part of the shading/backfill inspections.
3. Meters need to be inspected by the Owner's Trade department responsible for the utility and the Owner's EMS Coordinator prior to any insulation and energization of the system.
4. The Owner's Director of Utilities must sign the FS#15 prior to utilities being energized. At no time is a Contractor to energize a distribution line or building feed without approval from the Owner (Director of Utilities).
  - a. For distribution lines, the Contractor will need to provide the individual inspection reports (FS#15A) of numbers 1-3 in the process and as-builts for the utility. Refer to Division 1 for surveyed as-built requirements.
  - b. For building feeds, the Contractor will need to show signoff of the appropriate line in Sitework and Utilities on the FS#15, the individual inspection reports for Locating Services, Metering and interior inspections; and updated as-builts for the utility. The Contractor also must have requested an in service meter inspection.
5. An additional meter inspection is required to review the meters for accuracy after the individual utility system is energized. The Contractor will have 1 week to respond to any accuracy issued found and an additional week to make any corrections. If corrections are not made at the end of the 2-week period Owner may de-energize the utility in question until satisfactory progress is made.
  - a. If the Contractor is unable to correct the issue in the specified time, Owner may hire another contractor to fix the issue and back charge the failed Contractor.

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**Shading around all utility pipe shall be constructed as follows:**

|                | Bottom | Sides | Top |
|----------------|--------|-------|-----|
| Chilled Water  | 6"     | 6"    | 12" |
| Sewer          | 6"     | 6"    | 12" |
| Gas            | 8"     | 8"    | 8"  |
| Domestic Water | 6"     | 6"    | 12" |
| Electrical     | 6"     | 6"    | 6"  |
| Storm Drain    | 6"     | 6"    | 12" |

Locator Wire

Locator wire is required on all utility installations. It shall be 12 AWG solid copper wire, PVC insulated, type UF, UL listed for direct burial in ground. Wire shall be installed continuously (without interruption/splicing) on the surface of the pipe, except for locator wire for natural gas shall be in the first lift of shading. When connecting to existing tracer wire, splicing system shall consist of a copper wire crimp, PVC split case gland, and epoxy waterproof sealing compound.

Trace wire shall be required on all newly installed utilities that extend outside of the building to the point where contract boundaries end. If tying into an existing utility and that utility will not come above ground, (tying into an existing sewer line, for example), then the trace wire shall be brought to the surface and terminated in a box directly above the newly installed utility. Sanitary sewer and storm sewer manholes shall have a tracer wire j-box within the manhole ring. Box lids shall be marked "trace wire", and what utility the trace is for. If a utility comes above ground then the trace wire shall come above ground with the same utility in valve cans, manholes, junction boxes, box pads. For components that come above ground without a junction box or box pad (fire hydrants, etc.) shall have the tracer wire terminated in a box next to those components. In concrete and asphalt, the boxes shall be valve cans. In landscape areas, the boxes shall be 6" diameter or less green irrigation boxes. Installation is required to be inspected and signed off on the FS#15.

Tracer wire damaged during excavation will be repaired to the satisfaction of the Locator Supervisor and be included in the inspection signoffs.

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### Utility Markers

#### Survey Markers

Utility survey markers will be required on all new construction projects and renovation/replacement projects that do not have existing markers placed directly above the utility line. On exterior walls where the utility enters the building the marker shall be installed 1' above finished grade with the wording parallel to the ground and not upside-down. Cast/wet set in the top of curbs on both sides of a street/pedway when within a project boundary with the wording parallel to the utility flow direction. Owner may request markers be placed in other locations on new construction, renovation or on concrete replacement projects. Owner will provide the survey markers on new marker locations.

Building, utility and concrete renovation projects may run into existing survey markers. The Contractor is required to preserve the markers, reset the existing markers or replace the marker if damaged during removal. Owner will not provide replacement survey markers.

#### Other Utility Markers

Valve can, manhole, and pullbox lids for utilities shall be installed with the appropriate utility name (Water, Gas, Electric, Telecom, ETC.)

Verification of marker location requires signoff on the FS#15 prior to substantial completion.

### General Utility Meters

Utility meters shall be designed and specified by the Design Professional. Contractor shall furnish and install all utility meters. Utility meter commissioning shall be a joint effort between the Contractor, Design Professional, Commissioning Agent (where applicable), and the Owner. Owner will not energize any utility until the meter has been shown to be fully functioning and operational.

Design and construction documents to specify, schedule and require furnishing, installing, and commissioning of all utility meters. Documents shall include a flow meter schedule that explicitly defines:

- Utility service
- Meter type
- Meter size
- Maximum, minimum and normal Flow range
- BTU range
- Temperature and pressure

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Design documents shall include meter installation details that are complete and include all necessary information, including, but not limited to, length of straight pipe required upstream and downstream, distance required from valves or fittings, any required concentric reducers and location of temperature and pressure sensors.

Utility meters shall be specified to provide a local readout- either in transmitter head or in a suitably rated box on an adjacent wall. In either case, meter readout shall be designed to be readily accessible- between 4’ and 5’6” AFF.

Utility meters shall communicate with Owner’s campus Energy Management System (EMS), which is Alerton. Specify all necessary components and communication protocols to assure meter information can be mapped to Owner’s building EMS web page.

All gas and steam flow meters shall be temperature and pressure compensating.

Part 2 – Products  
N/A

Part 3 – Execution

The supply of any utility to a building shall not be activated until the specified metering is in place, functional, and has been commissioned.

During the final phase of the project and before Final Completion, Contractor shall be required to prove that all utility meters are installed properly and function as designed and specified. The utility meter commissioning shall be accomplished by the Contractor in conjunction with the Design Professional, Commissioning Agent (where applicable) and the Owner.

Calibration data, O & M manuals, details, etc., to be submitted after meters accepted.

Existing Plant Material/Temporary Protection  
See Division 32 93 00, Section 3 - Execution

**33 11 00 Water Utility Distribution Piping**

33 11 16 Site Water Utility Distribution Piping

Part 1 - General

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This section defines the general design parameters for the water distribution system, including domestic and fire protection water distribution, service lines, fire hydrants and system appurtenances.

The Design Professional (DP) shall conduct a Fire Flow test at the project site. Tests shall be performed by the Owner and witnessed by the Owner's Fire Marshal.

Refer to Division 21 for fire requirements.

Design and construction of all water systems shall comply with the rules and regulations of the Arizona Department of Environmental Quality (ADEQ), the Arizona Administrative Code (ACC), and MAG Standards.

The Design Professional (DP) shall size the piping system based on the design flows. Coordinate with the Project Manager and Director of Utilities regarding existing flows and pressures within the system and provisions for future campus expansion and additional demands in the system.

#### Part 2 – Products

All materials that will come in contact with potable water shall conform to ANSI/NSF Standard 61 and the rules and regulations of the Arizona Department of Environmental Quality.

Chlorination shall be separate for all site piping and building infrastructure.

All material used in the construction of Fire Service lines shall conform to NFPA 13 and NFPA 24. All material shall conform to the requirements of Underwriter's Laboratory (UL) or Factory Mutual (FM), and listed.

Polyvinyl Chloride (PVC) Pipe 4-inch diameter to 12" diameter shall conform to AWWA C900, Class 200 (SDR 14) and cast iron outside diameter. Elastomeric gaskets shall conform to ASTM F477 providing a watertight seal when tested in accordance with ASTM D3139. Fittings used on PVC pipe shall be mechanical joint ductile iron (DI) fittings as specified below.

#### Ductile Iron Pipe

Ductile Iron Pipe (DIP): All pipes shall be push-on Tyton joint, mechanical joint (MJ) joint or integral restrained joint ductile iron pipe. The pipe shall be manufactured and tested in accordance with the American Water Works Association (AWWA) Standard C151, and have working pressure (pressure class) of not less than:

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4"-12" dia (Class 350)                      350 PSI

Rubber gasket joints shall satisfy requirements of AWWA C111. Flanged ductile iron pipe shall be manufactured in accordance with AWWA C115, Flange Class 250. The minimum thickness class for ductile iron pipe to be threaded shall be thickness Class 53. Threads for threaded flanged pipe shall be taper pipe threads in accordance with ANSI B2.1, with thread diameters adjusted to conform to ductile iron pipe standard outside diameters.

All ductile iron pipe shall have a standard thickness cement-mortar lining followed by a seal coat of asphaltic material in accordance with AWWA C104. The exterior surfaces of all ductile iron pipe and fittings shall be coated with a bituminous material in accordance with AWWA C151 before shipment.

Ductile Iron Fittings and specials shall conform to AWWA C110, AWWA C153, and AWWA C111. Fittings and specials shall be cement-mortar lined in accordance with AWWA C104. Linings shall be standard thickness and seal coated with a bituminous material. The exterior surfaces of all ductile iron fittings shall be coated with a bituminous material in accordance with AWWA C110.

Control Valves

Gate valves (4" to 12") shall be resilient seated gate valves meeting the requirements of AWWA C509, and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 630. The valves shall be rated bubble tight at 200 PSI. The exterior and interior shall be coated with a thermo-setting or fusion bonded epoxy coating meeting the requirements of AWWA C550. The dry coating thickness shall not be less than 12 mils. Valves shall have mechanical style connections, except flanged joints may be used on the side of the valve that connects directly to a tee or tapping sleeve. Direct buried valves shall have a 2-inch operating nut. Direct buried valves shall be supported by a concrete base according to MAG standards.

The direction to open the valve shall be to the left (counter clockwise). Valves shall have a minimum of two (2) turns per inch of diameter.

Valves shall be rate for a minimum working pressure 250 PSI and be tested and certified by the manufacturer as being bubble tight at 200 PSI.

Fire Hydrants shall comply with the City of Flagstaff (COF) Engineering Design Standard 9-06-060. Fire Hydrants shall be manufactured and tested in

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accordance with AWWA C502, dry barrel fire hydrants. Hydrants shall be traffic type with break-a-way flange unit installed just above grade.

Tapping Sleeves shall conform to MAG Specification No. 630 with prior approval from the Owner (Plumbing department). Sleeves shall be ductile iron or fabricated from ¼-inch (minimum) ASTM 286 Grade C steel or ASTM A-36 steel. Sleeves shall be factory coated with corrosion resistant epoxy in accordance with AWWA C550. Flange shall be 150 LBS MSS-SP60. Bolts shall be corrosion resistant, high strength, low –alloy, per AWWA C-111. Gasket shall be Burna-N or neoprene. Sleeves shall be rated for 250 psi. Tapping sleeves shall be furnished with a 3/4 inch test plug. Plug shall be bronze NPT, coupling shall be epoxy coated.

Backflow Assemblies shall be reduced pressure backflow assemblies conforming to AWWA C511 and approved by the Foundation for Cross-Connection Control and Hydraulic Research at the University of Southern California. Assemblies shall have OS&Y resilient seated gate valves and shall be epoxy coated per AWWA C550. Assemblies shall be installed in buildings unless approved by Owner’s Plumbing Supervisor. If exposed to the elements then it must be protected from freezing. Owner has pre-approved the following backflow assemblies to be in compliance with these standards: reduced model Wilkons XL 975.

Couplings used on ductile iron and PVC C900 pipe shall be ductile iron, solid sleeves with mechanical joints, complying with AWWA C110 and C111 and as specified for ductile iron fittings. Couplings shall be fully restrained.

Air Relief Valves shall be vacuum and air relief valves shall be of the size shown on the plans. Corporations shall be full opening with O-ring seal and bronze ball and conform to AWWA C800. Taps into ductile iron pipe may be made by direct tapping of the pipe or with a service saddle. Taps into PVC pipe shall be made with a service saddle. Service saddles shall conform to AWWA C800, and be constructed of bronze or epoxy coated ductile iron. Saddles shall have a single or double strap. The outlet of the valve shall be equipped with a gooseneck and stainless steel screen as indicated on the drawings. Copper tubing shall be Type K, ASTM B88.

All valves underground or in vaults shall be gate valves.

#### Joint Restraint Devices

All joints, fittings, and valves within the system shall be fully restrained.

Ductile iron fittings mechanical style joints - EBAA Iron Sales, Inc. “Mega Lug” joint restraint or approved equal. The specific model utilized shall be compatible with the type of pipe (DIP or PVC) connected to the fitting.



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PVC pipe push-on style joints – EBAA Iron Sales Series 1600, or approved equal.

Ductile iron push-on style joints – EBAA Iron Sales Series 1700, or approved equal.

Ductile iron pipe and PVC integral joint restraint type - U.S. Pipe “TR Flex” restrained joint pipe and fittings. Pacific States Thrust-Lock.

Integral joint restraint type - U.S. Pipe “TR Flex” restrained joint pipe and fittings, Pacific States “Thrust Lock” joint system, Griffin Pipe “Snap Lok” joint system, or approved equal.

Thrust blocks shall be used in conjunction with joint restraint devices and constructed according to MAG standards.

The use of gaskets with integral restraint grippers shall not be permitted.

Valve Boxes and cover shall consist of a cast iron box and cover and PVC riser. The valve box and cover casting shall be manufactured in conformance with ASTM A48, Class 30B. Cover shall be labeled “Water”, and paint box blue. Valve can risers shall have a debris cap with a color handle applicable to the designated utility.

Valve stem risers shall comply with Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610 and as detailed on the plans.

Polyethylene Encasement (DI Pipe) shall conform to AWWA C105. The color of the polyethylene encasement shall be black or blue.

Part 3 – Execution

General

Fire service lines shall be installed in accordance with NFPA 13 and NFPA 24.

Minimum depth of cover, measured from top of pipe, shall be as follows:

- Water Mains: 42-inches
- Fire Service Mains: 42-inches (12-inches below frost depth).

In order to energize water to a building the Contractor must have U3, U5 and U6 on the FS#15 signed, and an approved FS#15A for B1-B3 and C6 for the water system.

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### Pipe and Fittings

Do not make the connections to the existing system until such time that the system has been cleaned; flushed, disinfected, and all hydrostatic testing has been completed and accepted.

All work associated with modifications to the water system, fire service lines, and building service lines shall be carried in an expeditious manner to minimize the time frame during which the water supply to the campus facilities and building automatic fire sprinkler system is impacted. No water main or service line shall be taken out of service until all piping, fittings, and appurtenances, required to complete the system modifications and return the system to operating condition, are available on the project site.

PVC pipe shall be installed in accordance with the requirements of AWWA C605, the manufacturer's recommendations and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

### Ductile-Iron Pipe

Install in accordance with the recommended procedures set forth in AWWA C600 and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

The maximum allowable joint deflection will be as given in AWWA C600, AWWA C605. If the alignment required deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be utilized to provide angular deflections within the limits set forth.

Install all joint restraint devices in accordance with the manufacturer's instructions and prior to pressure testing of the system. Do not bend or deflect the pipe.

All piping shall be fully restrained.

Install all valves in accordance with the manufacturer's instructions. When the top of the operating nut is 4 feet or greater below finish grade, install a valve nut extension.

Install air relief valves at high points.

Cleaning and Flushing

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It shall be the responsibility of the Contractor to keep the lines clean of all foreign materials during construction. Flush lines per ADEQ Rules and regulations.

The system shall be flushed at a minimum of 2.5 FPS for a minimum of 60 seconds per 100 feet of pipe. Water used for flushing shall be potable water.

Should dirt, debris, and/or foreign material be allowed to accumulate in the lines, the Contractor shall be responsible to remove all such material from the line by flushing the lines or other approved methods. In the event that such measures are required, the Contractor shall provide a written proposal to the Owner stating the methods to be utilized. In review of the proposal, the Owner will consider the potential for adverse impacts on the Campus.

#### Disinfection

Disinfect all lines per ADEQ rules and regulations. Disinfect all lines per ADEQ Engineering Bulletin No. 8.

The Contractor shall submit a disinfecting plan to the Owner's review. The plan shall detail the method for disinfecting the system and identify the certified laboratory that will sample and perform the microbiological testing. The Contractor shall be responsible for the cost of all laboratory testing.

#### Separation between Potable Water Mains and Sewers/Reclaimed Water Mains

Per ADEQ rules and regulations.

Hydrostatic testing shall conform to AWWA C600 / C605 at a test pressure of 200 PSI, modified as follows.

Allowable Leakage Determination: During the 2 hour, 200 PSI pressure test, the makeup water to maintain the test pressure within 5 psi of the test pressure and re-pressurize the system to the starting pressure shall be measured. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or approved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled. No piping installation will be accepted until the leakage is less than the number of gallons per hour as determined by the formula:

$$L = 0.00013 * N * D * (P \text{ raised to } 1/2 \text{ power})$$

In which L equals the allowable leakage in gallons per hour; N is the number of joints in the length of pipeline tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test, in psi gauge. Should any test of pipe disclose leakage greater than that specified in the

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foregoing table, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Owner.

The Contractor shall provide certified test pressure gauges, calibrated within 8 months of the test. The gauges shall be a minimum of 4-inches in diameter, with a 1-psi scale.

After installation of the tapping sleeve and valve and prior to making the tap, the sleeve shall be tested at 200 psi for 2 hours. There shall be no pressure drop during the test period.

System Connections

Unless specifically approved by the Owner in writing, connections to the existing system shall be made only after all pipes have been disinfected and all hydrostatic testing have been approved by the Owner.

Where utility access hatches/vaults/manholes are installed within 2 feet of sidewalks, they shall be 1 inch below top of finished sidewalk to accommodate snow removal without damage to boxes or lids.

Where utility access hatches/vaults/manholes are installed in sidewalks, patios, roadways, or any other structure where snow removal shall occur, the top of the access hatches shall be a minimum of ¼” and a maximum of ½” below finished surface of concrete to accommodate for snow removal without damage to boxes or lids.

33 11 50 Reclaimed Water Distribution System

Part 1 – General

This Section includes the following for direct buried reclaimed water distribution systems, including mains, service lines, pipe, fittings, valves, and joint Restraint.

The Design Professional (DP) shall size the piping system based on the design flows. The maximum velocity in the system shall be 5 feet per second. Coordinate with the Project Manager the existing flows and pressures within the system and provisions for future campus expansions. Submit calculations to the Project Manager.

Valves, install valves on three sides of all tees and four sides of all crosses. Maximum spacing between valves shall not exceed 300 feet.

Part 2 – Products

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Refer to Domestic Water standards for products but use Reclaimed designations for installation.

Part 3 – Execution

Minimum depth of cover, measured from top of pipe, shall be as follows:

|                                |           |
|--------------------------------|-----------|
| Reclaimed water mains:         | 42-inches |
| Reclaimed water service lines: | 36-inches |

In order to energize water to a building the Contractor must have U3, U7 and U8 on the FS#15 signed and an approved FS#15A for B1-B3 and C6 for the reclaimed water system.

Pipe and Fittings

PVC pipe shall be installed in accordance with the requirements of AWWA C605, the manufacturer’s recommendations and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

Ductile-Iron Pipe: Install in accordance with the recommended procedures set forth in AWWA C600 and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

The maximum allowable joint deflection will be as given in AWWA C600, AWWA C605. If the alignment required deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be utilized to provide angular deflections within the limits set forth. Do not bend or deflect the pipe.

Install all joint restraint devices in accordance with the manufacturer's instructions and prior to pressure testing of the system.

All piping shall be fully restrained.

Install all valves in accordance with the manufacturer's instructions. When the top of the operating nut is 4 feet or greater below finish grade, install a valve nut extension as detailed on the drawings.

Install air relief valves at high points.

Install locator wire to the top of the all water line. The Contractor shall minimize the number of splices in the wire. All splices shall be made with a watertight gland.

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Concrete Encasement

The Contractor shall coordinate with the Owner if the existing main can be depressurized during concrete encasement work. The Contractor shall adjust their schedule to correspond with the approved shut down period. In the event that the existing system cannot be depressurized, the Contractor shall construct the encasement in segments that allows the system to remain in service. Prior to placing the concrete the existing joints in the existing system shall be exposed and inspected under system pressure. Any leaks or damage to the existing pipe shall be repaired prior to placing concrete.

The Contractor shall install all required temporary supports required to support the existing piping while excavating around the pipe. If the existing pipe is deflected or damaged during construction, the Contractor shall replace all deflected and damaged piping.

Filling System, the pipe shall be filled with potable water or from the existing reclaimed water system.

It shall be the responsibility of the Contractor to keep the lines clean of all foreign materials during construction. All lines shall free of debris and soil materials. Should soil, sand, debris, and/or foreign material be allowed to accumulate in the lines, the Contractor shall be responsible to remove all such material from the line by flushing the lines or other approved methods. In the event that such measures are required, the Contractor shall provide a written proposal to the Owner stating the methods to be utilized. In review of the proposal, the Owner will consider the potential for adverse impacts on the Campus.

Separation between Reclaimed Water Mains and Potable Water Mains

The minimum separation between potable water mains and reclaimed water mains shall be six (6) feet vertically, with the water main above the reclaimed water line, and six (6) feet horizontally, unless extra protection is provided. In no case shall the reclaimed water main be placed within one (1) foot vertical or horizontal of a water main.

Extra protection shall be mechanical joint ductile iron pipe, restrained joint push on ductile iron pipe, or concrete encasement of the pipe within a minimum of 6-inches of concrete on all sides of the pipe.

Where reclaimed water lines crosses above or less than six (6) feet below a water line, or within 6-feet horizontally of a water main, the reclaimed water line shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet on either side of the water main crossing, or both the water and the reclaimed water main shall be concrete encased.

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The horizontal and the vertical dimensions shall be measured from outside of pipe to outside of pipe.

Comply with ADEQ’s Rules and regulations.

Hydrostatic testing shall conform to AWWA C600 / C605 at a test pressure of 200 PSI, modified as follows:

Allowable Leakage Determination: During the 2 hour, 200 PSI pressure test, the makeup water to maintain the test pressure within 5 psi of the test pressure and re-pressurize the system to the starting pressure shall be measured. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or approved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled. No piping installation will be accepted until the leakage is less than the number of gallons per hour as determined by the formula:

$$L = 0.00013 * N * D * (P \text{ raised to } 1/2 \text{ power})$$

In which L equals the allowable leakage in gallons per hour; N is the number of joints in the length of pipeline tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test, in psi gauge. Should any test of pipe disclose leakage greater than that specified in the foregoing table, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Owner. The Contractor shall provide certified test pressure gauges, calibrated within 8 months of the test. The gauges shall be a minimum of 4-inches in diameter, with a 1-psi scale.

After installation of the tapping sleeve and valve and prior to making the tap, the sleeve shall be tested at 200 psi for 2 hours. There shall be no pressure drop during the test period.

System Connections

Unless specifically approved by the Owner in writing, connections to the existing system shall be made only after all pipes have been disinfected and all hydrostatic testing have been approved by the Owner.

**33 12 00 Water Utility Distribution Equipment**  
33 12 13 Water Service Connections  
Part 1 – General  
Domestic and Reclaim Water Meter

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Positive displacement meter with pulse counter and totalizing head.

Specify compound meter where necessary to manage high (maximum – minimum) turn down. Owner has pre-approved the following manufacturer to be in compliance with these standards: Onicon meter.

Part 2 – Products

N/A

Part 3 - Execution

Meter EMS Displays: Displays within the EMS for meters shall include the following when applicable:

- Domestic Water: Flow in GPM, totalized in gallons. Peak flow rate with the date and time that point was reached.
- Reclaimed Water: Flow in GPM, totalized in gallons. Peak flow rate with the date and time that point was reached.
- All maximum and minimum values shall have a button to reset when those values were tracked from. Multiple meters may be required to record maximum and minimum flows. Trends on flow rate and totalized energy must be setup within the EMS prior to substantial completion.

**\*\*END OF SECTION\*\***



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| Section<br>Number | Title                                   |
| <b>33 30 00</b>   | <b>SANITARY SEWERAGE UTILITIES</b>      |
| 33 31 13          | Public Sanitary Utility Sewerage Piping |

Part 1 – General

This section defines the general design parameters for the sanitary sewer collection system, including pipe and fittings, service lines, manholes and system appurtenances.

General Design Considerations:

Minimum velocity when flowing full, and a Manning n=0.013.

Normal reaches                      2.5 feet per second.

Terminal reaches                      3.0 feet per second.

Maximum wet weather flow shall not exceed 0.75 percent of the pipe diameter.

Minimum Pipe Diameter:

Mains    8-inch.

Terminal reaches less than 200 feet              6 inch.

Service lines    4 inch.

Manholes:

Install manholes at horizontal deflection points, grade changes, all sewer main line junctions, and at all building service lines 6-inch or larger.

Install water tight covers on manholes that may be subject to surface stormwater flows.

Install bull horn clean out no more than 5' from building.

The maximum spacing between manholes shall not exceed 350 feet.

Do not use curvilinear sewers.

The Design Professional (DP) shall size the piping system based on the wet weather peak design flows. Coordinate with the Project Manager regarding existing flows within the system and provisions for future upstream campus expansions. Submit flow and hydraulic calculations to the Project Manager.

The Design Professional (DP) shall design a Flow Management Plan (FMP) when the construction restricts the flow in the existing system. The FMP shall detail all

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temporary bypass pumping facilities required to maintain continued sewer service to the upstream users.

Pipe lining and other in-situ rehabilitation shall be coordinated with the Project Manager.

Design of all sanitary sewer system shall comply with the rules and regulations of the Arizona Department of Environmental Quality (ADEQ) and the Arizona Administrative Code (ACC).

#### Part 2 – Products

All sanitary sewer piping, manholes and fittings shall conform to the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction and the rules and regulations of the Arizona Department of Environmental Quality.

Polyvinyl Chloride (PVC) Pipe, ASTM D-3035, SDR-35 minimum, pipe and fittings shall have integral bell gasketed joint, gaskets shall conform to ASTM F-477.

#### Ductile Iron Pipe

Push-on Tyton joint, mechanical joint, epoxy lined. Rubber gasket joints shall be in accordance with AWWA C111. Epoxy lining shall be a Hybrid novolac epoxy lining system a minimum of 40 Mil thick.

Manholes shall be precast concrete riser sections conforming to ASTM 478, with cast in place concrete base. Minimum manhole diameter shall be 5-feet. Frames and covers shall be cast iron with a minimum diameter of 24-inches. Frame and covers shall be labeled “Sanitary Sewer”. All manholes shall have steel reinforced polypropylene steps.

Couplings shall be epoxy coated steel barreled, compression styled couplings, sized for the OD of the pipe.

Polyethylene encasement for ductile iron pipe shall conform to AWWA C105. Color shall be black or green.

#### Part 3 – Execution

General Installation, install system in accordance with the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction and the rules and regulations of the Arizona Department of Environmental Quality (ADEQ).

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When connecting directly into a City of Flagstaff sewer line, the Contractor is responsible for obtaining City of Flagstaff permit. Confirm with Owner on what is a City of Flagstaff or an Owner utility line (if not identified on the plans).

Minimum depth of cover, measured from top of pipe, shall be as follows;

Sewer Mains: 48-inches.

Service Lines: 36-inches

General Installation

Install manholes at horizontal deflection points, grade changes, all sewer main line junctions, and at all building service lines 6-inch or larger.

Where utility access hatches/vaults/manholes are installed within 2 feet of sidewalks, they shall be 1 inch below top of finished sidewalk to accommodate for snow removal without damage to boxes or lids.

Where utility access hatches/vaults/manholes are installed in sidewalks, patios, roadways, or any other structure where snow removal shall occur, the top of the access hatches shall be a minimum of ¼” and a maximum of ½” below finished surface of concrete to accommodate for snow removal without damage to boxes or lids.

Do not use curvilinear storm sewers.

During all periods when flow is restricted within the existing sanitary sewer system, the Contractor shall erect all provisions of the Flow Management Plan (FMP) and provide 24-hour per day maintenance for the pumping and force main equipment. All pumping equipment shall have redundant capacity. All pumping equipment used shall be set in a containment area acceptable to the Owner.

Report all Sanitary Sewer Overflows (SSO’s) immediately to the Owner. The Contractor shall be responsible for containing and cleaning up all SSO’s.

The Contractor shall not allow the release of silt, soil or other debris into the existing sewer system. If material is released into the existing system, the Contractor shall be solely responsible for cleaning the existing system.

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Test lines and manholes per the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction and per ADEQ Rules and regulations. Testing shall include, but not limited to the following:  
Vacuum testing of manholes, and structures per ASTM C1244.

Low pressure air testing of pipe lines per MAG Standard Specification 615.  
Deflection testing of all mains per ASTM D-3034.  
Lamp testing of mains.

The Owner requires closed circuit television (CCTV) inspections of the sewer by the Contractor upon substantial completion. The DVD shall be required as part of the closeout package.

#### Separation Between Sanitary Sewers and Water Mains

The minimum separation between potable water mains and sanitary sewers shall be two (2) feet vertically, with the water main above the sanitary sewer, and six (6) feet horizontally, unless extra protection is provided. In no case shall the sewer main be placed within one (1) foot vertical or horizontal of a water main.

Extra protection shall be mechanical joint ductile iron pipe, restrained joint push on ductile iron pipe, or concrete encasement of the pipe within a minimum of 6-inches of concrete on all sides of the pipe.

Where water lines crosses above or less than two (2) feet above a sewer main line, or within 6-feet horizontally of a water main, the sanitary sewer or the water mains shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet on either side of the water main crossing, or both the water and the sewer main shall be concrete encased.

The horizontal and the vertical dimensions shall be measured from outside of pipe to outside of pipe.

Per ADEQ Rules and regulations.

**\*\*END OF SECTION\*\***

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| <b>33 40 00</b> | <b>STORM DRAINAGE UTILITIES</b>      |
| 33 41 13        | Public Storm Utility Drainage Piping |

Part 1 – General

There are areas of Owner's campus that are in the FEMA flood plain and flood way zones. Refer to a current FEMA map for locations. Any work within these areas must be reviewed and approved by the FEMA flood plain manager.

General Design Considerations

Minimum velocity when flowing full, and a Manning  $n=0.013$ .

Mains 2.0 feet per second

Terminal reaches 2.5 feet per second

Minimum pipe diameter.

Mains 18-inch diameter.

Laterals less than 40 feet 12 inch diameter.

Storm Drains shall be designed to convey the 10 year storm event.

Hydrologic and hydraulic calculations shall be based on City of Flagstaff MHDUD (Manual for hydraulic Design for Urban Drainage)

The hydraulic grade line shall be computed at all junctions. At all inlet junctions the hydraulic grade line shall be within the limits set forth in the MHDUD (City of Flagstaff Manual for hydraulic Design for Urban Drainage).

The design flow and the hydraulic grade line shall be shown on the storm drain profile for each reach of the system.

Storm drainage piping, manholes catch basins, and junction structures shall be design for AASHTO HS20 wheel loads, and the design dead loads.

Part 2 – Products

General, all piping, manholes, catch basins and fittings shall conform to the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works .

Polyvinyl Chloride (PVC) Pipe and Fittings, ASTM D-3035, SDR-35 minimum, pipe and fittings shall have integral bell gasketed joint, gaskets shall conform to ASTM F-477.

High Density Polyethylene (HDPE) and Fittings, profile-reinforced and corrugated (Type S or Type D) pipe manufactured per ASTM F-894, AASHTO M-252 or AASHTO M-294 for gravity flow, low pressure storm drain systems. Pipe and fittings shall have gasketed joints.

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Reinforced Concrete Pipe (RCP) and Fittings, ASTM C76, Class III, or ASTM C655, D-load as indicated on the Drawings. Rubber gaskets shall conform to ASTM 765.

Corrugated Metal Pipe (CMP), AASHTO M-36, galvanized. Steel thickness shall be indicated on the drawings. Band clamps shall be dimpled. O-rings shall comply with ASTM C 361, Section 5.9 and shall be placed on the first corrugation of the pipe end and compressed by the band clamp.

Spiral Rib Corrugated Steel Pipe (CSP), Pipe shall be ALUMINIZED steel, Type 2, helically wound, with 3/4 by 3/4 by 7-1/2 inch rectangular ribs projecting outwards from the pipe wall and continuous lock seams. The ALUMINIZED steel shall conform to ASTM 929 or AASHTO M274. The pipe shall be manufactured in accordance with ASTM A760 or AASHTO M36. Pipe connected with band clamps shall be manufactured with a minimum of two annular re-rolled corrugations for the purpose of joining pipe together. Steel thickness shall be indicated on the drawings. Joints shall be bell and spigot with fluted gaskets, or band clamps with O-rings gaskets. The bell and spigot and band clamps shall be manufactured of ALUMINIZED Type 2 steel. Band clamps shall comply with AASHTO M-36, manufactured of material two gages thinner than the pipe. Band clamps shall be dimpled. O-rings shall comply with ASTM C 361, Section 5.9 and shall be placed on the first corrugation of the pipe end and compressed by the band clamp.

Ductile Iron Pipe (DIP) and Fittings, Ductile Iron Pipe (DIP): All pipes shall be push-on Tyton joint, mechanical joint, epoxy, lined. Rubber gasket joints shall comply with AWWA C111.

Manholes shall be cast in place concrete or precast concrete riser sections conforming to ASTM 478, with cast in place concrete base. Minimum manhole diameter shall be 4-feet for pipes 18-inches and smaller, 5 feet diameter for pipe between 18 and 36 inch diameter, and the pipe diameter plus 18-inches for pipe larger than 36 inches. Frames and covers shall be cast iron with a minimum.

Catch Basins and Inlets, cast in place concrete, conforming to the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction. Grates shall be welded steel, galvanized. Grates in pedestrian walkways shall conform to ADA requirements.

Precast junction structures shall be manufactured in accordance with ASTM C-478. Structures shall be sized as indicated on the Drawings. The design of the precast structure shall be include the design penetrations in the structure. Frames and covers shall be cast iron with a minimum diameter of 24-inches.

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Transition couplings shall be special manufacture of piping material or shall be a concrete collars conforming to MAG Standard Detail No. 505. Concrete shall be Class A, 3,000 PSI, reinforcement shall be Grade 40. Transition couplings on pipe 12-inches diameter or smaller may be mission style couplings.

### Part 3 – Execution

#### General

Install per the Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction and as specified below.

Install manholes at all changes of slope or pipe deflections.

Do not use curvilinear storm sewers.

During all periods when flow is restricted within the existing storm drainage system, the Contractor shall provide all required temporary conveyance measures to ensure that flooding or hazardous conditions do not occur upstream or downstream of the project.

The Contractor shall not allow the release of silt, soil or other debris into the existing storm drainage system. If material is released into the existing system, the Contractor shall be solely responsible for cleaning the existing drainage system.

Minimum depth of cover, measured from top of pipe, shall be as follows:

Storm sewer mains: 36-inches.

Storm sewer laterals: 24-inches.

#### Testing

Test all manholes, and structures per ASTM C1244.

Test all piping in accordance with MAG Standard Specification No. 615.

Separation between storm sewers and potable water mains shall be 12 inches minimum.

**\*\*END OF SECTION\*\***

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**33 50 00 FUEL DISTRIBUTION UTILITIES**

33 51 13

Natural Gas Piping

Specifications included below apply to internal and external gas piping.

Part 1 – General

NAU is considered an Owner Operator and all Arizona Corporation Commission (ACC) rules and regulations shall apply.

The gas distribution systems and gas service lines shall be constructed of welded steel pipe or High density polyethylene (HDPE). Plastic and copper pipe shall not be used in the gas piping system.

Design and construction shall be in accordance with the Code of Federal Regulations (CFR): Title 49, Chapter 1, Part 192, Transportation of Natural and Other Gas by Pipeline – Minimum Safety Standards, and codes referenced herein.

Cathodic protection shall be designed and constructed for all underground gas piping. The design shall be in accordance with National Association of Corrosion Engineers (NACE) International standards. All calculations, design and testing shall be performed by or supervised by the Corrosion Specialist or Engineer.

Part 2 – Products

Underground Piping

Black Steel, seamless or ERW, ASTM A53, Grade B, Schedule 40 (minimum), factory coated and protected with cathodic protection, U.S. domestic made pipe.

Shop-applied pipe coating shall be one of the following types:

Shop-applied pipe coating: Fusion Bonded Epoxy (FBE) meeting the requirements of AWWA C213. Coating thickness shall be a minimum of 14 mil base coat and 15 mil top coat. Repair of the coating shall be per the coating manufacturer's written instructions.

Adhesive-Thermoplastic Resin Coating: Fed. Spec. L-C-530, Type I.

Adhesive-thermosetting Resin Coating: Fed. Spec. L-C-530, Type II.

Field-applied plastic tape material for use on pipe joints and for repairing damaged areas of shop-applied coatings shall conform to Federal Spec. L-T-1512,



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Type I, 250  $\mu\text{m}$  (10 mils) nominal thickness for pipe joints, and Type II, 500  $\mu\text{m}$  (20 mils) nominal thickness for coating repairs.

All gas lines into building need to have insulating unions installed to isolate building pipe from underground piping.

#### Fittings

Steel Pipe Fitting:

Butt weld fittings shall be wrought steel, ANSI B16.9.

Socket weld fittings shall be forged steel, 2,000 PSI Class, ANSI B16.11.

Threaded fittings shall be malleable iron, ANSI 16.3 or forged steel, ANSI B16.11.

Flanges shall be steel, Class 150, ANSI B16.5.

#### Joints

Socket or butt welded for steel pipe, ANSI B31.8. Threaded joints not permitted except at above grade. Flanged joints at valve connections.

#### Control Valves

Valves 2-inches and larger shall be lubricated plug valves, semi steel, carbon steel, or cast iron, flanged connections conforming to API 6D.

Valves 1.5-inches and smaller shall be lubricated plug valves, semi steel or cast iron, screwed or but welded connections conforming to API 6D.

Direct buried valves shall have a 2-inch operating nut.

Tapping valves shall be cylindrical lubricated plug valves with 100 percent full pipe area, round port.

Valves shall be rate for a minimum working pressure 125 PSI and be tested and certified by the manufacturer.

#### Taps

Fully welded weld-o-let or welded fittings.

#### Valve Can

Valve can covers shall consist of cast iron box and riser. All valve can covers shall include a debris cap. The valve box and cover casting shall be manufactured in conformance with ASTM A48, Class 30B. Covers shall be labeled "GAS".

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### Meters

Owner has pre-approved the following product for gas meters to be in compliance with these standards: ONICON F-5000 Series Thermal Mass Flow Meters.

Meters shall comply with ANSI B109.2. Meters shall be pipe or pedestal mounted. Meters shall be provided with over-pressure protection as specified in ASME B31.8, tamper-proof protection, frost protection. Meters shall be suitable for accurately measuring and handling gas at pressures, temperatures, and design maximum and minimum flow rates.

Meters shall have direct reading indexes (cubic feet) and safe pulse output for remote reading. Output from meter shall be compatible with, and connected to, the Building Management System (BMS) system.

### Pressure Regulators

Pressure regulators for individual service lines shall be capable of reducing distribution line pressure to pressures required for users. Ferrous bodies. Pressure relief shall be set at a lower pressure than would cause unsafe operation of any connected user. Gas valve shall be installed immediately upstream of each pressure regulator and regulator shall have a single port with orifice diameter no greater than that recommended by manufacturer for the maximum gas pressure at the regulator inlet. Regulator vent valve shall be of resilient materials designed to withstand flow conditions when pressed against valve port. Regulator shall be capable of limiting build-up of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Contractor shall be responsible for the flow and lockup test.

### Anodes

Anodes shall be high potential magnesium alloy, factory packed in cloth bag or box containing prepared packing backfill mixture, and lead wires. Backfill materials shall be hydrated gypsum, bentonite, and sodium sulfate. Approximate magnesium alloy weight, 20 pounds, centered in packing, total weight approximately 45 pounds.

### Test Stations

Test stations shall be weatherproof, located at grade, or aboveground. Enclosed terminals for anode leads, test leads, and leads attached to protected system. Connection points for test instruments. The housing unit shall be of standard design, manufactured for use as a cathodic protection test station, complete

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with locking cover, terminal board, shunts, and brass hardware. The terminal board shall be removable for easy access to wires and constructed of high impact resistant plastic. Provide means to anchor housing below grade. Test station covers shall consist of manufactured integral yellow color.

#### Cable Connections

Cable Connectors between cables and pipes, casings or structures shall be exothermic fusion welding process using copper oxide, aluminum and vanadium welding material in graphite molds. Connections between cables and between cables and leads shall be corrosion-resistant split bolts. Insulation of cable to cable connections shall be epoxy resin splice kits with two part resin, mold, sealing mastic.

Where underground valve boxes or utility access boxes are installed with 2 feet of sidewalks, they shall be 1 inch below top of finished sidewalk to accommodate snow removal with damage to boxes or lids.

Where underground valve boxes or utility access boxes are installed in sidewalks, patios, concrete steps, or any other structure where snow removal shall occur, the top of the boxes shall be a minimum of ¼" and a maximum of ½" below finished surface of concrete to accommodate for snow removal without damage to boxes or lids.

#### Part 3 – Execution

Prior to the start of construction, the Contractor shall hold a pre-construction meeting with the Owner (Project Manager, Plumbing and Natural Gas Department) and the Design Professional. The meeting shall be attended by the gas system installers and shall review the installation and testing requirements for the installation of the gas system.

In order to energize Natural Gas to a building the Contractor must have G8 on the FS#15 signed, and an approved FS#15A for B1-B3 and C6 for the water system.

#### Special Submittal and Approvals

The Contractor shall submit all data on all materials, welding procedures, welding certifications, shutdown procedures and construction procedures as a package. This submittal will be reviewed by Owner and the DP. Upon approval by Owner and the DP, the submittal shall be sent by the Owner (Master Meter Operator) to the Arizona Corporation Commission (ACC). The review by the ACC

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shall take a minimum of 30 days. No work shall be started until approval is obtained from the ACC.

The welder's certification, shall be API-1104, and shall be current under the procedure proposed within the six months of the gas system construction.

The Contractor shall request through the Owner, all inspections required by the ACC. The schedule of the inspection is at the discretion of the ACC inspector. The ACC representative shall witness and/or performed visual inspection, including all pressure tests, pipe installation, bedding and shading operations, coating of pipes, installation and testing of cathodic protection systems, tracer wires and meter sets. No work shall be covered until the ACC has been notified, performed their inspection, and the Owner approves covering the work.

Trenching

All underground pipes shall be bedded and shaded with clean cinder sand and install at a depth to provide the minimum cover above the pipe. Shading shall be paced around the pipe, avoiding damage to the pipe coating. Install tracer wire along the top of the pipe and install marking tape at a minimum of 12-inches and a maximum of 18-inch below grade. The minimum depth of cover, measured from top of pipe, shall be as follows;

|                |            |
|----------------|------------|
| Gas Mains:     | 30-inches. |
| Service Lines: | 24-inches. |

Piping

Gas distribution system and equipment shall be installed in accordance with the manufacturer's recommendations and applicable sections of ANSI B31.8 and CFR Title 49, Part 192 - Minimum Federal Safety Standards.

All welding shall be done by welders certified for the type and size of the required welds on natural gas systems. All welding shall conform to CFR Title 49, Part 192.225. Certification of welders shall comply with CFR Title 49, Part 192.227. Welding shall be per the approved welding procedures.

The Contractor shall hire an Independent Testing Agency to inspect and test welds in accordance with CFR Title 19, Part 192.241, and pay all costs of the inspection and testing.

Separation between gas lines and other utilities and structures shall be in accordance with the ACC Rules and regulations. In no case shall the separation be less than 12-inches minimum from utilities lines or structures.

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The gas lines shall be as short and as straight as practicable between the point of connections to the existing gas main and shall not be bent or curved laterally unless necessary to avoid obstructions and permitted by the Owner. Gas lines shall be laid with as few as joints as practicable using standard lengths of pipe.

Make service connections at the top of the main, whenever the depth of the main is sufficient to allow top connections. When service connections cannot be made at the top of the main, they shall be made on the side of the main as close to the top as possible. Service connections shall not be made lower than the horizontal midpoint of the gas main.

Taps on the Existing system shall be welded construction, with flanged, full port, round opening, tapping valves. Tap and valve shall be pressure tested prior to cutting the existing pipe.

Schedule and coordinate with the Owner's Gas Shop and the City of Flagstaff Fire Department when working on live gas lines.

#### Purging of Gas Lines

It shall be the responsibility of the Contractor to purge lines in accordance with the rules and regulations of the ACC. Lines shall be purged with nitrogen. Lines shall be purged in such a way as to prevent the flow of natural gas into building, structure or to other ignition sources. All purges shall be coordinated with and supervised by the Owner's Gas Department.

#### Cathodic Protection

Install system per the National Association of Corrosion Engineers (NACE) International standards.

Anodes shall be place anodes into augured holes by grasping the cloth gathered at top of packaged anode. Replace ruptured anode packages with undamaged ones. Under no circumstances lower anode into hole by lead wire alone. Presoak packaged anodes in water for at least 15 minutes prior to installation. Tamp screened soil around anode to insure contact between anode and native earth. Provide adequate slack in the lead wire to preclude tearing lead wire loose during backfilling and compacting procedures. Locate anodes so that minimum distance of 36 inches is maintained between anode and gas line to which it is to be attached.

Connect lead wire to piping by using the thermite welding process.

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Provide one test station for each eight (8) anodes or 500 feet of piping to permit testing for performance of the cathodic protection system. Use a minimum of No. 12 stranded copper wire and termite welding process.

Testing of the cathodic protection system shall be per the National Association of Corrosion Engineers (NACE) International standards. Tests shall include testing of anodes prior to connecting anode lead wire to the piping and final testing of the cathodic protection system, including measuring pipe-to-soil potentials over the entire system. Make potential measurements with potentiometer voltmeter (minimum internal resistance of 50,000 ohms per volt) and a copper/copper sulfate reference electrode placed at the finished grade level and directly over the pipe. Adequate number of measurements shall be taken over the extent of piping to insure that a minimum potential value of negative 0.85 (-0.85) volts exist over all new gas piping. Upon completion of testing, a report setting forth potential values acquired by location shall be submitted to the Owner.

#### Pipeline Testing

The Contractor shall test all gas lines in accordance with NFPA 54, ANSI B31.8, and CFR 192.509 and 192.511.

All gas lines shall be tested at 90-PSI, or one and one half (1.5) times the system's design operating pressure, for a minimum period of one (1) hour with no pressure drop.

Holiday testing shall be performed by the Owner's Gas Department until coating deficiencies are corrected.

#### Sleeves

Pipelines crossing under structures shall be sleeved. Pipe shall be continuous through sleeves. Vent all sleeves to atmosphere and seal between sleeve and the pipe with modular mechanical type seal.

Split sleeves may be installed where existing lines pass under new construction.

#### Painting

All exposed exterior gas piping shall be painted with acrylic enamel. Color is to be specified by DP and approved by the Owner's PM.

#### System Abandonment

All abandoned gas line shall be purged and removed by the Contractor. When approved by the Owner (Director of Utilities), abandoned lines may be

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abandoned in place. All lines abandoned in place shall be purged, filed with water or nitrogen and capped.

All abandonments and removals shall be noted and dated on the record (as-built) drawings. The Contractor shall submit a written statement to the Owner confirming the date the system was purged, and that purging operations were completed in accordance with all governing regulations.

**\*\*END OF SECTION\*\***

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**33 60 00      HYDRONIC AND STEAM ENERGY UTILITIES**

33 61 13      Chilled Water Distribution System

Part 1 – General

The Design Professional shall size the piping system based on the design flows and a maximum velocity of 4.5 feet per second. Coordinate with the Project Manager regarding existing flows and pressures within the distribution system and allowances for future expansions of the system.

Valves, install valves on three sides of all tees and four sides of all crosses. Maximum spacing between valves shall not exceed 300 feet.

Part 2 – Products

Polyvinyl Chloride (PVC) Pipe

Polyvinyl Chloride (PVC) Pipe: PVC pipe 4-inch diameter to 12” diameter shall conform to AWWA C900, Class 200 (SDR 14), PVC pipe 12-inch diameter and larger shall conform to AWWA C905, Class 210 (SDR 18), cast iron outside diameter. Elastomeric gaskets shall conform to ASTM F477 providing a water tight seal when tested in accordance with ASTM D3139.

Fittings used on PVC pipe shall be mechanical joint ductile iron (DI) fittings as specified below.

Ductile Iron Pipe (DIP)

Ductile Iron Pipe (DIP): All pipes shall be push-on Tyton joint, mechanical joint (MJ) joint or integral restrained joint ductile iron pipe. The pipe shall be manufactured and tested in accordance with the American Water Works Association (AWWA) Standard C151, and have working pressure (pressure class) of not less than:

|                 |                    |
|-----------------|--------------------|
| 4”-12” diameter | Pressure Class 350 |
| 16” diameter    | Pressure Class 250 |

Rubber gasket joints shall satisfy requirements of AWWA C111.

Flanged ductile iron pipe shall be manufactured in accordance with AWWA C115, with Class 150 flanges. The minimum thickness class for ductile iron pipe to be



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threaded shall be thickness Class 53. Threads for threaded flanged pipe shall be taper pipe threads in accordance with ANSI B2.1, with thread diameters adjusted to conform to ductile iron pipe standard outside diameters.

All ductile iron pipes shall have a standard thickness cement-mortar lining followed by a seal coat of asphaltic material in accordance with AWWA C104.

The exterior surfaces of all ductile iron pipe and fittings shall be coated with a bituminous material in accordance with AWWA C151 before shipment.

#### Ductile Iron Fittings

Fittings and specials shall conform to AWWA C110, AWWA C153, and AWWA C111. Fittings and specials shall be cement-mortar lined in accordance with AWWA C104. Linings shall be standard thickness and seal coated with a bituminous material.

The exterior surfaces of all ductile iron fittings shall be coated with a bituminous material in accordance with AWWA C110.

#### Control Valves

Gate valves (4" to 12") shall be resilient seated gate valves meeting the requirements of AWWA C509, and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 630. The valves shall be rated bubble tight at 200 PSI. The exterior and interior shall be coated with a thermo-setting or fusion bonded epoxy coating meeting the requirements of AWWA C550. The dry coating thickness shall not be less than 12 mils. Valves shall have mechanical style connections, except flanged joints may be used on the side of the valve that connects directly to a tee or tapping sleeve. Direct buried valves shall have a 2-inch operating nut.

The direction to open the valve shall be to the left (counter clockwise). Valves shall have a minimum of two (2) turns per inch of diameter.

Valves shall be rate for a minimum working pressure 250 PSI and be tested and certified by the manufacturer as being bubble tight at 200 PSI.

#### Joint Restraint Devices

All joints, fittings, and valves within the system shall be fully restrained.

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Joint restraint devices shall comply with Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 750. Acceptable joint restraint devices include the following, or approved equal:

- Ductile iron fittings mechanical style joints - EBAA Iron Sales, Inc. "Mega Lug" joint restraint. The specific model utilized shall be compatible with the type of pipe (DIP or PVC) connected to the fitting.
- PVC pipe push-on style joints – EBAA Iron Sales Series 1600 or approved equal.
- Ductile iron push-on style joints – EBAA Iron Sales Series 1700 or approved equal.
- Ductile iron pipe Integral joint restraint type - U.S. Pipe "TR Flex" restrained joint pipe and fittings, Pacific States "Thrust Lock" joint system, Griffin Pipe "Snap Lok" joint system, or approved equal.
- The use of gaskets with integral restraint grippers shall not be permitted.

#### Valve Boxes

Valve box and cover shall consist of a cast iron box and cover and PVC riser. The valve box and cover casting shall be manufactured in conformance with ASTM A48, Class 30B. Cover shall be labeled "CHW" or with no logo.

Where underground valve boxes or utility access boxes are installed within 2 feet of sidewalks, they shall be 1 inch below top of finished sidewalk to accommodate for snow removal without damage to boxes or lids.

Where underground valve boxes or utility access boxes are installed in sidewalks, patios, roadways or any other structure where snow removal shall occur, the top of the boxes shall be a minimum of ¼" and a maximum of ½" below finished surface of concrete to accommodate snow removal without damage to boxes or lids.

Valve stem risers shall comply with Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610 and as detailed on the plans.

#### Air Relief Valve Vaults

All cast-in-place concrete shall conform to Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification Section 725, Class "S" (3,000 PSI).

|                   |       |
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Reinforcement shall conform to MAG Standard Specification 727, Grade 40.

Pre-cast manhole section shall have an inside diameter indicated on the plans and conform to the requirements of ASTM C478.

The frame and cover shall be 30-inch diameter; traffic rated (HS20), and has a bolted watertight lid.

#### Air Relief Valves (Manual)

Vacuum and air relief valves shall be of the size shown on the plans. Corporations shall be full opening with O-ring seal and bronze ball and conform to AWWA C800. Taps into ductile iron pipe may be made by direct tapping of the pipe or with a service saddle. Taps into PVC pipe shall be made with a service saddle. Service saddles shall conform to AWWA C800, and be constructed of bronze or epoxy coated ductile iron. Saddles shall have a single or double strap. The outlet of the valve shall be equipped with a gooseneck and stainless steel screen as indicated on the drawings. Copper tubing shall be Type K, ASTM B88.

#### Polyethylene Encasement (Dip Pipe)

Polyethylene encasement shall conform to AWWA C105. The color of the polyethylene encasement shall be purple.

#### Mechanical Couplings

Couplings used on ductile iron and PVC C900 pipe shall be ductile iron, solid sleeves with mechanical joints, complying with AWWA C110 and C111 and as specified for ductile iron fittings. Couplings shall be fully restrained.

#### Tapping Sleeves

All tapping sleeves shall conform to MAG Specification No. 630. Sleeves shall be ductile iron or fabricated from ¼-inch (minimum) ASTM 286 Grade C steel or ASTM A-36 steel. Sleeves shall be factory coated with corrosion resistant epoxy in accordance with AWWA C550. Flange shall be 150 LBS MSS-SP60. Bolts shall be corrosion resistant, high strength, low alloy, per AWWA C-111. Gasket shall be Burna-N or neoprene. Sleeves shall be rated for 250 psi.

### Part 3 – Execution

#### General

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PVC pipe shall be installed in accordance with the requirements of AWWA C605, the manufacturer's recommendations and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

Minimum depth of cover, measured from top of pipe, 36-inches.

There shall be 12 inches of red cinders above any direct bury chilled water lines.

In order to energize chilled water to a building the Contractor must have U14 and U15 on the FS#15 signed, and an approved FS#15A for B1-B3 and C6 for the water system.

Ductile-Iron Pipe

Install in accordance with the recommended procedures set forth in AWWA C600 and Maricopa Association of Governments Uniform Standard Specifications and Details for Public Works Construction Standard Specification No. 610, and as specified herein.

The maximum allowable joint deflection will be as given in AWWA C600. If the alignment required deflection in excess of the above limitations, a sufficient number of fittings shall be utilized to provide angular deflections within the limits set forth. Do not bend or deflect the pipe.

Install all joint restraint devices in accordance with the manufacturer's instructions and prior to pressure testing of the system.

All joints, fittings, and valves within the system shall be fully restrained.

Install all valves in accordance with the manufacturer's instructions. When the top of the operating nut is 4 feet or greater below finish grade, install a valve nut extension as detailed on the drawings.

Install air relief valves at high points. Tap ductile iron or PVC pipe at the high point and install a corporation stop or service saddle and corporation stop. Install copper blow-off line at an upward slope to the air relief valve. Install isolation stop in a location that it is accessible from within the vault.

Attach locator wire to the top of the all chilled water line. The Contractor shall minimize the number of splices in the wire. All splices shall be made with a watertight gland.

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#### Separation Between Chilled Water Lines and Potable Water Lines

The minimum separation between chilled water mains and potable water mains shall be two (2) feet vertically, with the water main above the chilled water main, and six (6) feet horizontally, unless extra protection is provided. In no case shall the chilled water main be placed within one (1) foot vertical or horizontal of a potable water main.

Extra protection shall be mechanical joint ductile iron pipe, restrained joint push-on ductile iron pipe, or concrete encasement of the pipe within a minimum of 6-inches of concrete on all sides of the pipe of the pipe.

Where chilled water mains crosses above or less than two (2) feet below a water main, or within 6-feet horizontally of a water main, the chilled water main shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet on either side of the water main crossing, or when approved by the Owner, both the chilled water and the water main shall be concrete encased.

The horizontal and the vertical dimensions shall be measured from outside of pipe to outside of pipe.

#### Concrete Encasement

The Contractor shall coordinate with the Owner if the existing main can be depressurized during concrete encasement work. The Contractor shall adjust their schedule to correspond with the approved shut down period. In the event that the existing system cannot be depressurized, the Contractor shall construct the encasement in segments that allows the system to remain in service.

Prior to placing the concrete the existing joints in the existing system shall be exposed and inspected under system pressure. Any leaks or damage to the existing pipe shall be repaired prior to placing concrete.

The Contractor shall install all required temporary supports required to support the existing piping while excavating around the pipe. If the existing pipe is deflected or damaged during construction, all damage piping shall be replaced by the Contractor.

#### Interior Inspection

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Inspect the interior of pipe, fittings and valves prior to installation. Damage pipe, fittings and valves shall not be installed or repaired to the satisfaction of the Owner prior to installation.

Inspection, Examination and Testing

Inspection and examination will be in accordance with ASME B31.9 except as follows:

- This section is applicable for C900 or equivalent only. All other piping is to follow section 33 63 13 requirements.
- All welds and connections are subject to visual inspection for compliance with specifications. Contractors shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds deemed unacceptable. In addition, the Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.9 and B31.3 due to the discover of poor, unacceptable or rejected connections.

Leak Testing

- Contractor shall be responsible for all equipment and material necessary to perform leak testing.
- The test equipment shall be examined before pressure is applied to ensure that is tightly connected. All low-pressure filling lines and all other items not subject to the test pressure shall be disconnected or isolated by valves or other suitable means. All test gauges shall be examined to ensure calibrations are current.
- Pneumatic testing may only be used if approved in writing by Owner (Central Plant Supervisor) prior to inspection request.
- Pressures shall be continuously maintained for a minimum time of 2 ½ hours and held for such time as may be necessary to conduct the examinations for leakage. The 2 ½ hour test will not eliminate the requirement to conduct a visual examination of the entire piping system being tested.
- Any initial service leak tests may be allowed according to ASME 31.9 but must be approved in writing by the Owner (Central Plant Supervisor).
- When performing an initial service test, the piping system shall be gradually brought up to normal operating pressure and continuously held for a minimum time of 10 minutes. Examination for leakage shall be made of all joints and connections. The piping system exclusive of

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possible localized instances at pump or valve packing shall show no visual evidence of weeping or leaking.

Filling System

The pipe shall be filled with potable water, not from the chilled water system.

Hydrostatic Testing

Hydrostatic testing shall conform to AWWA C600 / C605 at a test pressure of 200 PSI, modified as follows:

Allowable Leakage Determination

During the 2 hour, 200 PSI pressure test, the makeup water to maintain the test pressure within 5 psi of the test pressure and re-pressurize the system to the starting pressure shall be measured. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or approved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled. No piping installation will be accepted until the leakage is less than the number of gallons per hour as determined by the formula:

$$L = 0.00013 * N * D * (P \text{ raised to } 1/2 \text{ power})$$

In which L equals the allowable leakage in gallons per hour; N is the number of joints in the length of pipeline tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test, in psi gauge. Should any test of pipe disclose leakage greater than that specified in the foregoing table, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Owner.

The Contractor shall provide certified test pressure gauges, calibrated within 8 months of the test. The gauges shall be a minimum of 4-inches in diameter, with a 1 psi scale.

After installation of the sleeve and valve and prior to making the tap, the sleeve shall be tested at 200 psi for 2 hours. There shall be no pressure drop during the test period.

Cleaning and Flushing

C900 or equivalent only, if black iron is to be used, follow the same procedures as Steam, Condensate, and HTHW Distribution Pipe in section 33 63 13.

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Contractor shall provide all equipment and material necessary to perform cleaning and passivation of the piping system, sampling of treatment water, and testing of water during treatment.

Test gauges shall be located in a manner that provides easy access and a clear view to the inspector.

Flushing Process:

Remove any filters in the system

Flush pipe for a minimum of 6 hours or until discharge shows no sign of contaminants using a clean bucket to examine discharge (bucket test).

Following the flush, the Contractor will depressurize line and if line is not to be used to convey water or it will be more than 2 weeks before system is brought online, drain as much water as possible. If line is to be brought online within 2 weeks and will convey water, then line may be left filled (Owner may specify a pressure to leave the line at).

System Connections

Unless specifically approved by the Owner in writing, connections to the existing system shall be made only after all pipes have been cleaned and all hydrostatic testing have been approved by the Owner.

33 61 33

Hydronic Energy Distribution Metering

Chilled and Heating Water Meters

All items necessary to allow the chilled water flow sensors to function as energy meters shall be specified and shown on the drawings and included in installation details.

Output of energy meter shall be in BTU's and totalized in MBTU's.

These necessary items shall include, but are not limited to, temperature sensors, BTU totalizing computer, connection requirements to the campus EMS system, programming requirements and software.

Delta temperature transmitters shall be platinum 1000 OHM RTD, where 1000 ohms equals 32<sup>o</sup> F.



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Delta temperature sensors shall be matched pairs of calibrated sensors with an accuracy of 0.12° F.

Flow transducers shall be selected for the expected flow range encountered at present design conditions, pipe size and material. Particular attention shall be made to design minimum flow conditions.

For all installations an energy totalizing computer will be required.

#### Products

Owner has pre-approved the following to be in compliance with these standards: Insertible Magnetic Flow Meter- Onicon F3500 with Onicon Series 10 Totalizer.

#### Steam Meters

All items necessary to allow the steam flow sensors to be fully functional shall be specified and shown on the drawings and included in installation details.

These necessary items shall include, but are not limited to, flow (in lb/hr) totalizing computer, connection requirements to the campus EMS, programming requirements and software.

Temperature transmitters shall be platinum 1000 OHM RTD, where 1000 ohms equals 320 °F.

Flow transducers shall be selected for the expected flow range encountered at present design conditions, pipe size and material. Particular attention shall be made to minimum flow conditions.

For all installations an energy totalizing computer will be required.

#### Products

Owner has pre-approved the following to be in compliance with these standards: Insertion type vortex meter Onicon F2500 with Onicon Series 2500 totalizer

#### Part 3 - Execution

Meter EMS Displays: Displays within the EMS for meters shall include the following when applicable:

- HTHW: flow in GPM, energy flow in BTU/hr, totalized energy in BTU's, maximum and minimum instantaneous GPM and BTU/hr with the date and

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time that point was reached.

- Steam: Flow BTU/hr, totalized energy in BTU’s, pressure in psi, maximum and minimum BTU/hr with the date and time that point was reached.
- Chilled Water: Flow in GPM, energy flow in BTU/hr, totalized energy in BTU’s, maximum and minimum GPM, BTU/hr and peak load in tons with the date and time that point was reached.
- All maximum and minimum values shall have a button to reset when those values were tracked from. Multiple meters may be required to record maximum and minimum flows. Trends on flow rate and totalized energy must be setup within the EMS prior to substantial completion.

33 63 13 Steam and HTHW Distribution System

Part 1 – General

This section includes the general requirements for Steam and High Temperature Hot Water Distribution Systems (HTHW) up to a buildings heat exchanger. High pressure steam and condensate pipe, fittings, valves, insulation and accessories shall be in accordance with Division 23. High temperature hot water pipe, fittings, valves insulation and accessories with Division 23.

In order to energize steam or HTHW to a building the Contractor must have U11, U12 and U13 on the FS#15 signed, and an approved FS#15A for B1-B3 and C6 for the water system.

Part 3 – Execution

Inspection Examination and Testing

Inspection and Examination will be in accordance with ASME B31.9 except as follows:

All welds are subject to visual inspection and a minimum 10% by x-ray, for compliance with specifications. The Owner will, at the Owner’s option, provide a 3<sup>rd</sup> party testing company for the purposes of performing said x-ray testing. Initial visual and x-ray inspections will be provided by the Owner. Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds deemed unacceptable. If more than 50% of x-ray inspected welds fail than all welds will be x-ray inspected at the Contractor’s cost. In addition, Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.9 and B31.3 due to the discovery of poor, unacceptable, or rejected welds.

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Boiler external piping (all pipe upstream of the second isolation valve prior to connecting to the steam main\_ shall be hydrostatically tested in accordance with the ASME Boiler and Pressure Vessel Code. The test shall be conducted in the presence of a National Board of Boiler Inspectors certified inspector.

#### Leak Testing

Contractor shall be responsible for all equipment and material necessary to perform leak testing.

The test equipment shall be examined before pressure is applied to ensure that it is tightly connected. All low-pressure filling lines and all other items not subject to the test pressure shall be disconnected or isolated by valves or other suitable means. All test gauges will be examined to ensure calibrations are current.

Pneumatic testing may only be used if approved in writing by Owner's Central Plant Supervisor prior to inspection request.

Pressures shall be continuously maintained for a minimum of 2 ½ hours and held for such time as may be necessary to conduct the examinations for leakage. The 2 ½ hour test will not eliminate the requirement to conduct a visual examination of the entire piping system being tested.

Any initial service leak tests may be allowed according to ASME 31.9 but must be approved in writing by the Owner's Central Plant Supervisor.

When performing an initial service test, the piping system shall be gradually brought up to normal operating pressure and continuously held for a minimum time of 10 minutes. Examination for leakage shall be made of all joints and connections. The piping system exclusive of possible localized instances at pump or valve packing shall show no visual evidence of weeping or leaking.

#### Cleaning and Flushing

Contractor shall provide all equipment and material to perform cleaning and passivation of the piping system, sampling of treatment water, and testing of water during treatment. Water samples will be taken to the Central Plants for testing. The chemicals listed are based on material provided by the Owner's Chemical Treatment Representative. Contractors may contact Owner's Chemical

Treatment Representative to purchase chemicals at the Owner rate.

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Test gauges shall be located in a manner that provides easy access and a clear view to the inspector.

Flushing Process

Remove any filters in the system.

Flush pipe for a minimum of 6 hours or until discharge shows no sign of contaminants using a clean bucket to examine discharge (bucket test).

Drain system.

Refill with fresh water adding 1% of Ferroquest FQ7101 based on the volume of water in the system. (ex. 100 gallons of FQ7101 would retreat 10,000 gallons of system water).

Note: The conductivity will be ~2000 micromhos higher than the starting conductivity.

Take an initial water sample and check conductivity and pH. Record and retain sample.

As the pH increases during the cleaning, maintain the pH at 6.2 – 6.8 with Ferroquest FQ7102. One gallon/1000 gallons of system volume will drop the pH approximately 0.2 pH units.

Check water sample 3 times per day for pH add Ferroquest FQ7102 as needed to maintain the pH in correct range. Record pH and retain samples.

Circulate the cleaning solutions for 3 days. Maintain water temperature between 100° F and 120° F. Do not exceed 140° F. Prior approval from Owner is required if the temperatures cannot be maintained.

Take water sample before draining and retain.

Samples will be provided to the Owner's Central Plant Supervisor and then sent for lab analysis. Results to be provided to Owner's Project Manager and Contractor shall be responsible for cleaning.

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Flush the pipe and perform a bucket test. Flushing will be required until the conductivity is near that of the city water sample. Sample throughout the flushing and record conductivity and retain samples. Owner's Central Plant staff will be responsible to determine when flushing is complete by review of flushing record and sample.

Following the flush, Contractor shall depressurize line and if line is not to be used to convey water or it will be more than 2 weeks before system is brought online, drain as much water as possible. If line is to be brought online within 2 weeks and will convey water, than line may be left filled (Owner may specify a pressure to leave the line at).

33 63 20

Steam and High Temperature Hot Water Tunnels

Part 1 – General

This Section includes the general requirements for utility tunnels and vaults utilized for the campus steam and high temperature hot water distribution systems.

Tunnel and vaults may be precast concrete, cast in place concrete, large diameter pipe conduits, or composite pipe and concrete encasement.

Structural loading, tunnels shall be designed to be capable for supporting the following loads:

Live Loads shall be in accordance with one of the following American Association of State Highway and Transportation Officials (AASHTO) standards:

AASHTO "Standard Specifications for Highway Bridges". Structures under pedestrian areas, landscape areas, drives and parking lots shall be designed for HS20 truck loading (32 KIP axle load). Tunnels under principal roadways shall designed for the critical controlling loading condition of HS20 or the alternative military/interstate loading (two 24 KIP axle loads, 4 feet apart), in either single or passing mode.

AASHTO "LRFD (Load and Resistance Factor Design) Bridge Design Specifications". Structures under pedestrian areas, landscape areas, drives and parking lots shall be designed for HL93 truck loading (32 KIP axle load). Tunnels under principal roadways shall be designed for the critical controlling loading

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condition of HL93 truck loading or the design tandem load (two 25 KIP axle loads, 4 feet apart). "Lane loads" may be omitted from the loading calculations.

Impact Factor, per AASHTO standards.

Dead loads shall use a minimum soil density of 120 pounds per cubic feet.

Hydrostatic pressure, the design shall consider that excavation in rock or other low permeable soils may result in the backfill around the tunnel being a flow path for infiltrated stormwater. The design shall consider both the existing soil condition as well as all modifications that may result from the construction.

Pipe and equipment load shall be based on design piping configuration. Walking tunnels shall also include a 50 percent allowance for future piping and equipment.

Anchor and thrust restraint loads shall be based on the piping design. In walking tunnels there shall be anchor provisions at each deflection point of the tunnel and at vaults.

#### Tunnel Configuration

Type A tunnels shall be designed to accommodate the piping systems and provide maintenance access through the tunnel system as indicated in Figure 1 and Figure 2.

Piping systems may be orientated along one or both sides of the tunnel.

Maintenance access area shall be a continuous clear area, a minimum of 2'-6" wide by 6'-0" tall. Circular configurations shall have a concrete infill to provide a level walking surface.

Type B tunnels may be designed to only accommodate the piping systems, refer to Figure 3.

The lid or roof of the tunnel shall be removable to accommodate maintenance access. Do not attach pipes, hangers, or supports to the lid or roof.

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Mechanical equipment such as expansion joints, ball joints, etc within Type B tunnels shall be located under a hatch that provides maintenance access without the removal of the tunnel lid or roof.

Steam tunnels longer than 150 feet in length, and all steam tunnels that will ultimately provide steam distribution to more than two (2) buildings shall be Type A.

Steam tunnels less than 150 feet in length and will ultimately provide steam distribution to two (2) or less buildings, may be Type A or Type B.

High temperature hot water tunnels may be Type A or Type B.

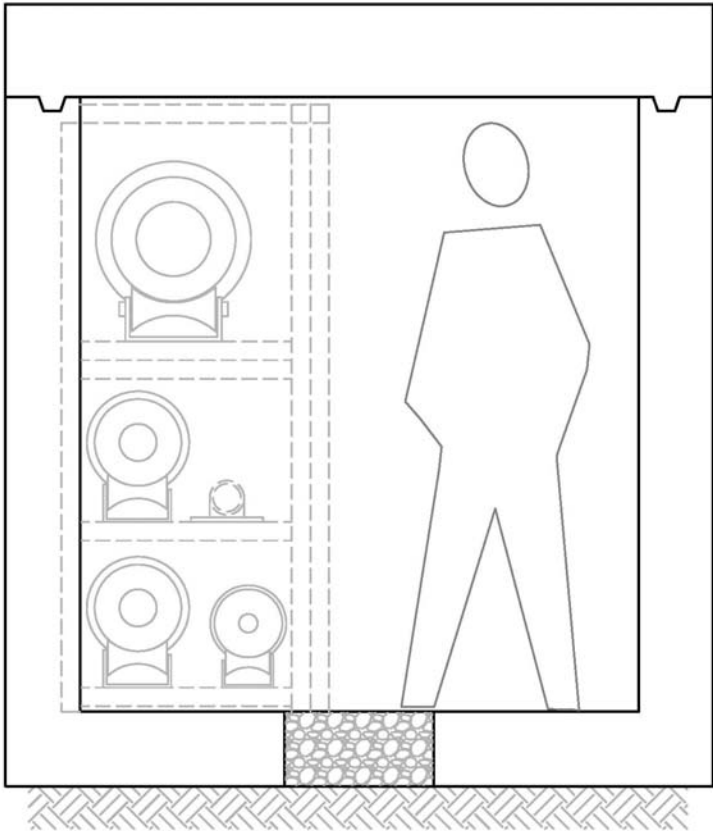


Figure 1 – Type A Tunnel – Rectangular Cross Section

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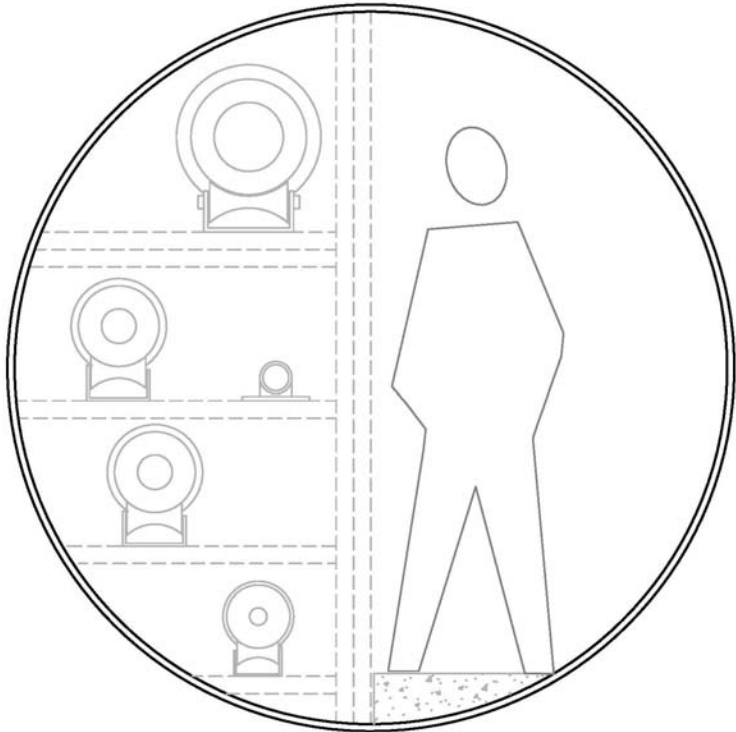
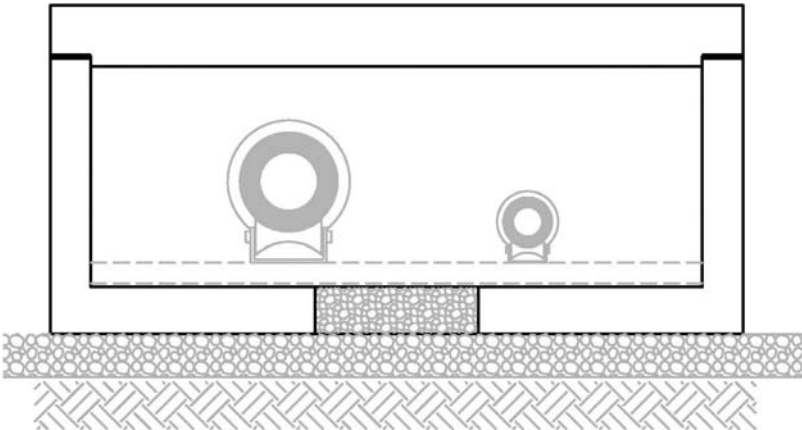


Figure 2 – Type A Tunnel – Circular Cross Section





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### Figure 3 – Type B Tunnel Cross Section

Vault shall be located at all junctions and service line connections.

Tunnels shall be water tight. Type A Tunnels may have a gravel floor, or drain sumps. Install sump pumps in low areas.

Ventilation of Type A tunnels and all vaults shall be in accordance with OSHA requirements.

Lighting shall be provided in all Type A tunnels in accordance with OSHA requirements. Avoid installing light above the access corridor that would impede access. Lighting circuits shall be switch at each access point in the tunnel system. Use toggle switches to control lighting circuits.

In Type A tunnels provide 20 amp, 120 volt electrical receptacles at 200 foot spacing for use by maintenance crews.

Grade of tunnel shall be in accordance with the requirements of the piping systems.

Provide all embeds, anchors, and accessories indicated on the drawings, and required to install the utility lines within the tunnel.

#### Part 2 – Products

##### Cast-in-place Concrete Tunnels

Cast in placed concrete tunnels shall be designed in accordance with the International Building Code (IBC) and ASCE 7 – Minimum Design Load for buildings and Other Structures.

Precast concrete tunnels

Design Criteria - Design units in accordance with:

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ACI 304 and 318.

CRSI Manual of Standard Practice.

Applicable ASTM Standard(s).

Concrete: Concrete shall be a uniform mix of quality materials shall be determined by following the standards in ACI 318 Chapter 5. Recommendations for selecting proportions for concrete are given in detail in Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete (ACI 211.1). Recommendations for lightweight concrete are given in Standard Practice for selecting proportions for Structural Lightweight Concrete (ACI 211.2).

Water-Cement Ratio: Concrete that will be exposed to freezing and thawing shall contain entrained air and shall have water-cement ratios of 0.45 or less.

Portland Cement: ASTM C150, V.

Aggregates: ASTM C33 or C330.

Water: Potable or free of deleterious substances in amounts harmful to concrete or embedded metals.

Admixtures:

Air-entraining: ASTM C260

Water reducing, retarding, accelerating, high range water reducing: ASTM C494

Pozzolans, fly ash and other mineral admixtures: ASTM C618

Ground granulated blast furnace slag: ASTM C989

Reinforcing Bars:

Deformed Billet-steel: ASTM A615.

Deformed Rail-steel: ASTM A616.

Reinforcing Wire: Plain Wire: ASTM A82.

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Welded Wire Fabric: Plain Wire: ASTM A185.

Precast Fabrication

Forms for manufacturing precast concrete products shall be of the type and design consistent with industry standards. They should be capable of consistently providing uniform products and dimensions. Forms shall be constructed so that the forces and vibrations to which the forms will be subjected can cause no product damage. Forms shall be cleaned of concrete build-up after each use. Form release agents shall not be allowed to build up on the form casting surfaces.

Reinforcement: Cages of reinforcement shall be fabricated either by tying the bars, wires or welded wire fabric into rigid assemblies or by welding where permissible in accordance with AWS D1.4. Reinforcing shall be positioned as specified by the design and so that the concrete cover conforms to requirements. The tolerance on concrete cover shall be one-third of that specified but not more than 1/2 in. Concrete cover shall not be less than 1/2 in. Positive means shall be taken to assure that the reinforcement does not move significantly during the casting operations.

Inserts and Embedded Metal - All items embedded in concrete shall be of the type required for the intended task, and meet the following standards:

Structural steel plates, angles, etc: ASTM A36

Welded studs: AWS D1.1

Finishes: Hot-dipped galvanized: ASTM A152 or Zinc-rich coating: MIL-P-2135 self-curing, one component.

Joint Sealant and Joint Gaskets:

External Sealing Bands for Noncircular Sewer, Storm Drain, and Culvert Pipe: ASTM C877.

Joints for Concrete Pipe, Manholes, and Manufactured Box Sections Using Preformed Flexible Joint Sealants: ASTM C990

Grout:

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Cement grout: Portland cement with enough water for the required strength and sand for proper consistency. May contain mineral or chemical admixtures, if approved by Owner's representative.

Non-shrink grout: Premixed, packaged expansive and non-expansive shrink-resistant grout.

#### Access Hatches

Access doors and hatches shall be aluminum construction, AASHTO HS-20 rated, gasketed, water tight. Door shall have compression spring assist opening mechanism, stainless steel hold open arms with positive locking, heavy duty hinges, lifting handles, and hasp. Doors shall be lockable.

Where utility access hatches are installed within 2 feet of sidewalks, they shall be 1 inch below top of finished sidewalk to accommodate snow removal without damage to boxes or lids.

Where utility access hatches are installed in sidewalks, patios, concrete steps, or any other structure where snow removal shall occur, the top of the access hatches shall be a minimum of ¼" and a maximum of ½" below finished surface of concrete to accommodate for snow removal without damage to boxes or lids.

#### Ladders

Ladders shall be all aluminum, fully welded construction. Rungs shall be ribbed, slip resistant 1-3/8 inch diameter, spaced on 12 inch centers. Rails shall be 3/8" x 2-1/2" flat bar, spaced 16 inches apart. Mounting brackets shall offset the ladder 7 inches from the wall. Provide telescoping extension rails that extend to 36 inches above the vault when extended.

### Part 3 – Execution

#### General

Cast in place tunnels shall be constructed in accordance with the recommendations of the geotechnical report and ACI standards.

Precast concrete tunnels shall be set on an aggregate base course, leveling pad. Install tunnels true to grade and equipped with all appurtenances required for the piping systems.

Minimum depth of cover, measured from top of tunnel, shall be as follows;

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Cast-in-place tunnels:      0-inches  
Precast tunnels:              12-inches

Embeds

Embedded Items: Embedded items shall be positioned at locations specified in the design documents. Inserts, plates, weldments, lifting devices and other items to be imbedded in precast concrete products shall be held rigidly in place so that they do not move significantly during casting operations.

Placing Concrete

Concrete shall be deposited into forms as near to its final location as practical. The free fall of the concrete shall be kept to a minimum. Concrete shall be consolidated in such a manner that segregation of the concrete is minimized and honeycombed areas are kept to a minimum. Vibrators used to consolidate concrete shall have frequencies and amplitudes sufficient to produce well consolidated concrete.

Cold Weather Requirements: Recommendations for cold weather concreting are given in detail in Cold Weather Concreting reported by ACI Committee 306.

Hot Weather Requirements - Recommendations for hot weather concreting are given in detail in Hot Weather Concreting reported by ACI Committee 305.

Curing

Curing by Moisture Retention - Moisture shall be prevented from evaporating from exposed surfaces until adequate strength for stripping is reached.

Joints

Install water-stops or joint sealants in all joints.

Moisture Protection

Install moisture protection on the top and sidewalls of all cast in place tunnels.  
Install sump pumps as required.

**\*\*END OF SECTION\*\***

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**33 70 00 ELECTRICAL UTILITIES**

In order to energize electricity to a building the Contractor must have U3, U5 and U6 on the FS#15 signed, an approved FS#15A for B1-B3 and C6 for the building and pad mounted switch metering and an approved work authorization.

Any changes to 12.47 kV distribution system, up to and including the transformers, shall require a modification to the campus one line diagram. Owner will provide a CAD file for the existing system. The DP is to include the revised campus one line in the construction drawings and must supply an as built CAD file as part of the closeout. The one line must include all pertinent data including but not limited to: conductor size, conduit size and quantity, switch cabinets with fuse and ct sizes, switch cabinet compartment numbers, transformer sizes and estimated loading, and building numbers that are connected to the transformer.

**33 71 00 Electrical Utility Transmission and Distribution**

33 71 19 Electrical Underground Ducts and Manholes  
Part 1 – General  
N/A

Part 2 – Products  
Owner has pre-approved the following pullboxes to be in compliance with these standards: Quazite PR style.

Part 3 - Execution

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Underground PVC conduits containing cables over 600 volts shall be a minimum of 4" and have a spare conduit for each feeder. The conduit system shall be encased with a 3000psi minimum of 3" of integral-color red concrete slurry (one 50lb bag of dye per cubic yard of concrete or 4% dye if liquid) on all sides of each conduit. Concrete shall be with aggregate small enough to work around conduits. Concrete around duct banks shall be carefully vibrated to prevent voids around and under conduits. Slurry shall not be used as backfill and shall only be used to encase conduits based on shading dimensions outlined in 33 00 00.

Pullboxes shall be round enclosures. Any pullbox located in a sidewalk or roadway shall be traffic rated.

33 71 39

High Voltage Wiring (Above 600-Volt)

Part 1 – General

Owner's primary electrical distribution system is a 12.47kV underground system, installed in ductbank. 12.47KV distribution will not be allowed in the tunnel network. The topology is looped on South Campus, and primary-selective on North Campus. Any modification to the primary distribution system shall maintain the existing topology.

High voltage switchgear shall be box pad mounted, low profile, dead front type, S&C Manufacturer. High voltage switchgear shall be set on box pads per APS standards.

A fault current indicator shall be provided on each cable at the source of each feeder to help operators locate system faults.

All modifications to or extensions of the existing Owner medium-voltage electrical system require the approval of the Owner's Electrical Shop and Director of Utilities at the Schematic Design level.

Part 2 – Products

Medium voltage cable shall be shielded ethylene-propylene-rubber (EPR) insulated, 133% insulation level, copper conductor, as manufactured by Okonite, Kerite, Prysmian, or approved equivalent, with a 40 year warranty.

All cable utilized in a pull shall have been manufactured during the same production run from the factory. All cable on the project shall be new, shall have

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been manufactured within 12 months of the date of receipt at the job site, and shall be shipped with original manufacturer's cable end seals. Cable reels shall be shipped and stored with end flanges vertical. Storage of cable prior to installation shall comply with the recommendations of the manufacturer.

### Part 3 – Execution

The installing contractor shall have an Arizona high-voltage license. Installing personnel shall be qualified and certified by the manufacturer in the installation and testing of cable, splices, and terminations.

New cables shall be tested after installation by insulation resistance testing and partial discharge testing, or hi-pot testing. Service-aged cables shall be tested after installation by insulation resistance testing and online partial discharge testing.

Testing shall be performed by an independent 3<sup>rd</sup>-party testing agency; the Design Professional shall coordinate with Owner to properly specify whether Owner or the installing contractor will be responsible for hiring the testing agency.

Insulation-resistance Test: Test all new and service-aged cables with respect to ground and adjacent conductors. Test data shall include megohm readings and leakage current readings. Cable shall not be energized until insulation-resistance test results have been approved by the Owner's Electrical Shop. Test voltage shall be 2,500VDC. Minimum acceptable resistance value shall be 5,000 megohms. Provide a comprehensive report that describes the identification, length, terminations and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who performed the tests; and identifies the insulation resistance for each cable section tested. The report shall provide conclusions and recommendations for corrective action.

Online Partial Discharge Test: Test all new and service-aged cables. Perform tests after cables have passed the insulation-resistance test, and after successful energization. Testing shall use a time or frequency domain detection process incorporating radio frequency current transformer sensors, with a partial discharge detection range of 10khz to 300Mhz. Provide a comprehensive report that describes the identification and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who



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performed the tests; and identifies numerically and graphically the magnitude of partial discharge detected for each cable section tested. The report shall provide conclusions and recommendations for corrective action.

Hi-pot test: Maximum test voltage shall be 55kV, or maximum as allowed by cable manufacturer. Apply voltage in approximately 8 to 10 equal steps. Raise the voltage slowly between steps. At the end of each step, allow 5 minutes for the charging currents to decay. Time and record the interval of decay. Make leakage current readings at 1 minute intervals for each voltage step. Read the leakage current and plot a curve of leakage current versus test voltage on graph paper as the test progresses. Stop the test and replace the cable if leakage currents increase excessively or a “knee” appears in the curve before maximum test voltage is reached. Upon reaching maximum test voltage, hold the voltage for five minutes for fifteen minutes. Read the leakage current at 30 second intervals and plot a curve of leakage current versus time on the same graph paper as the step voltage curve. Stop the test if leakage current starts to rise, or decreases and again starts to rise.

Leakage current should decrease and stabilize for good cable. Terminate test and allow sufficient discharge time before starting the next conductor.

33 71 73 Electrical Utility Services

Part 1 – General

Service Entrance Switchboards shall be provided with ammeter, voltmeter (both with phase switching positions and off positions). Provide kilowatt-hour meter with demand register. Multiplier shall be marked on meter. Label switchboards with CT ratios. KWH meters shall be adaptable to supply a pulse train output for future BMS system.

Part 2 – Products

N/A

Part 3 – Execution

N/A

33 71 73.33 Electric Meters

Part 1 – General

Section  
Number

N/A

Part 2 – Products

N/A

Part 3 – Execution

Meter EMS Displays: Displays within the EMS for meters shall include the following when applicable:

- Electric: demand in KW, Totalized in kWh, total voltage, voltage per phase, total amperage, amperage per phase, total power factor, and power factor per phase.

All maximum and minimum values shall have a button to reset when those values were tracked from. Multiple meters may be required to record maximum and minimum flows. Trends on flow rate and totalized energy must be setup within the EMS prior to substantial completion.

**33 73 00 Utility Transformers**

Part 1 – General

Building service transformers shall be outdoors, located so as to be accessible for maintenance. Transformers shall not be located in basements or other areas subject to contaminant by flood waters. Transformers will be minimum of 6’ from the edge of sidewalks, pedways or roadways.

Provide bollards to protect transformers. The number of bollards will be determined by transformer location.

Transformers shall comply with 2010 US Department of Energy requirements.

Part 2 – Products

Service transformers shall be liquid cooled non-PCB type. Locate at exterior service side of building for accessibility. Aluminum or copper windings are acceptable. Penta head bolts shall be used on transformer door. (Penta had socket to be turned over to Owner when job is complete.)

Box pads shall be pre-manufactured fiberglass type.

|                  |                                |
|------------------|--------------------------------|
| kVA              | as required for the project    |
| Temperature Rise | 65 degree average winding rise |

| Section Number | Title   |
|----------------|---|
|                | Cooling Class KNAN  |
|                | Frequency 60  |
|                | Insulating Fluid Envirotemp FR3   |
|                | Elevation Designed for operation at 2500 m (8250 ft) above sea level                    |
|                | Efficiency Standard DOR 2010, 10 CFR Part 431   |
|                | Sound Level NEMA TR1 Standard   |
|                | Primary Voltage 12470 Delta   |
|                | BIL kV as required  |
|                | kV Class kV as required   |
|                | Primary Configuration Dead Front  |
|                | Primary Configuration Loop Feed   |
|                | Taps 2 – 2.5% taps above and 2 – 2.5% taps below nominal                                |
|                | Tap Charger 100 amp 5 position tap changer  |
|                | Primary Bushings 200 amp copper bushing well(s) (Qty. 6)                                |
|                | Load-break Switching 630A four position T-blade switch                                  |
|                | Arresters None  |
|                | Overcurrent Protection Bayonet fuse in series with Partial-Range current-limiting fuses |
|                | Explosion Fuses Bayonet fuses   |
|                | Bayonet Holder Copper Bayonet Fuse Holder   |
|                | Spare Fuses Bayonet Fuses   |
|                | Pocket on Compartment Door for Spare Fuses  |
|                | Secondary Voltage 480Y/277 or 110/208 as required                                       |
|                | BIL kV as required  |
|                | Secondary kV Class kV as required   |
|                | Secondary Bushings 5/8" copper stud with 4-hole screw-on spade bushing(s)               |
|                | Cabinet 20in deep cabinet   |
|                | Cabinet Hardware Penta-head cabinet door bolts  |
|                | ANSI K-Dimension Loop feed per ANSI C57.12.34 Figure 2 minimum dimensions               |
|                | Notifications Danger High Voltage decals-one on each side of unit                       |
|                | Notifications DOE Efficiency Compliant Decal  |
|                | Gauges & Fittings Liquid Level Gauge  |
|                | Gauges & Fittings Thermometer, dial type  |
|                | Pressure/vacuum gauge   |
|                | Drain valve with sampler in LV Compartment (1")   |

| Section Number   | Title                                       |
|------------------|---|
|                  | Schrader valve                              |
|                  | Pressure relief device, 50 SCFM             |
| Tank Accessories | IEEE standard one-hole ground pads (Qty. 3) |
|                  | Nitrogen Blanket                            |
| Packaging        | Pallet                                      |
| Cover            | Bolted Cover                                |

Part 3 – Execution

The concrete pad shall extend 6” beyond transformer footprint on sides and rear, and 36” in front of the transformer. Top of pad shall be 3” above finished grade.

Installation shall be in accordance with the Arizona Public Service (APS) standard details.

Provide bollards to protect switchgear. The number of bollards will be determined by switchgear location.

10’ clearance must be maintained on the door side of the transformer.

**33 77 00 Medium – Voltage Switchgear and Protection Devices**

Part 1 – General

Each new building shall provide the necessary loop-feed box pad mounted switchgear (South Campus) or primary-selective box pad mounted switchgear (North Campus), and transformer(s) for its connected load. Switchgear will be minimum of 6’ from the edge of sidewalks, pedways or roadways.

Provide spare primary fuses for each conduit installed.

The Design Professional shall use the Arizona Public Service (APS) standard details for installing switchgear, and shall include the appropriate details on the drawings.

New or refurbished medium voltage box pad mounted switchgear shall be provided with integral bus voltage metering and switch position monitors which shall report to the central metering system.

Part 2 – Products

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Medium voltage switchgear shall be box pad mounted, low profile, deadfront type, as manufactured by S&C, or approved equal. All fuses shall be S&C SMU-20 with SME-20 fuse holders. Oil filled switches shall not be accepted.

Box pads shall be pre-manufactured fiberglass type.

Part 3 – Execution

Top of pad shall be 3” above finished grade.

Installation shall be in accordance with the Arizona Public Service (APS) standard details.

Provide bollards to protect switchgear. The number of bollards will be determined by switchgear location.

10’ clearance must be maintained on the door sides of the switch. 6’ of clearance for the other sides.

**\*\*END OF SECTION\*\***

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**33 80 00**      **COMMUNICATION UTILITIES**

**33 81 00**      **Communication Structures**

Any communication system installed in the tunnels shall be in inner-duct and secured to the tunnel wall so it is not in conflict with other utilities or means of egress from the tunnels. Inner-duct shall be supported no less than every six-feet on center. Sag of the inner-duct between supports shall be no more than 2 inches at mid-span.

33 81 26      Communications Underground Ducts, Manholes, and Handholes

Owner's communication pathway infrastructure consists of utility tunnel and conduit pathways connecting all campus buildings to three main switching nodes. All pathways and spaces to conform to TIA/EIA-758 standard. The Design Professional shall specify the following site development requirements:

- Minimum of two 4 inch conduits for building entrance cable. Larger complexes may need more. One complete spare must be available after cable is installed. Pull string in place in spare conduit.
- Minimum of one 4 inch conduit populated with two (2) packs of 4" 3 cell Maxcell Sleeves or three (3) packs of 3" 3 cell Maxcell sleeve minimum. One pack shall be detectable. Once the Maxcell is installed, verification by installation of replacement pull line (1200lb line minimum) in all sleeves shall be performed. Each Maxcell sleeve shall be color coded independently from each other. Consult with Owner (ITS) prior
- All conduits shall be buried at a minimum depth of 36".
- Minimum one (1) Maxcell sleeve shall be equipped with tracer wire.
- Conduit construction to be minimum schedule 40 rigid non-metallic.
- All conduit runs designed with drainage slope towards the manhole/vault and maximum of two 90° bends. All bends encased in concrete.
- The section length shall not exceed 600 ft between pulling points.
- When a joint trench method is used the following vertical and horizontal separations between telecommunications facilities and other facilities shall be maintained.
- All vaults/manholes shall be equipped with copper or copper clad grounding rod with .3 resistance to ground maximum.

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- All vaults/ manholes shall be placed on a minimum 12" bed of washed clean gravel and extending 12" minimum from the exterior walls of the vault/ manhole.
- All conduits entering the vault/ manhole shall be set minimum 8" above finished floor/ ground.
- All conduit duct banks shall be labeled inside the vault or manhole with the destination of the conduit bank
- All manholes shall have the ID of the manhole labeled on the inside of the vault or manhole and on the manhole lid/cover. Manhole lid/cover shall be labeled with a stamp or engraved, or a manufacturer label. No welding.

ADJACENT STRUCTURE

MINIMUM SEPARATION

Power or other foreign conduit

3 inches of concrete  
 OR  
 4 inches of Masonry  
 OR  
 12 inches of earth

Pipes (gas, oil, water, etc.)

6 inches crossing  
 OR  
 12 inches when parallel

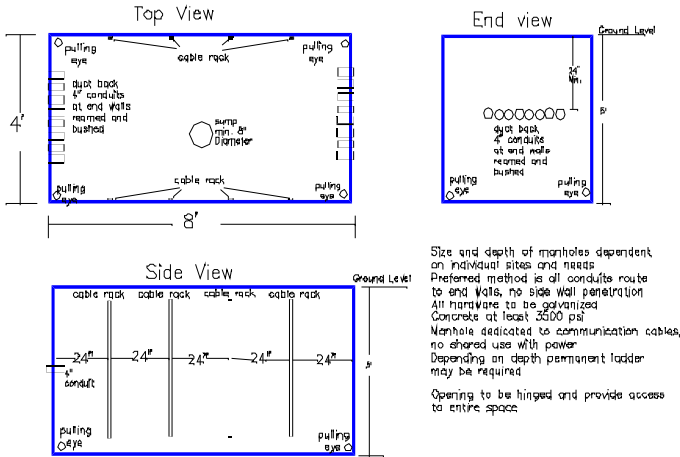
It is the Owner’s preference that there are no manholes or handholes in the pathway design. However if access points are necessary minimum requirements are as follows:

- 4'x 8'x4' with cover providing full access to entire space
- All access points will be equipped with cable racking. Pulling eyes and sump
- Conduits should enter and exit from end walls of access point
- All penetrations in maintenance holes shall be sealed in the maintenance holes and in the building with a reenter-able type solution approved by Owner (ITS). Rigid foams are not permitted.

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# Typical Manhole



## 33 82 00 Communications Distribution

The Owner’s communication system is based on a passive ring architecture with three switching centers located in building 24, building 54 and building 64. All copper and optical fiber backbone cabling shall be routed to the appropriate switching center. All distribution design is the responsibility of Owner (ITS) and the installation is the responsibility of the Contractor. All Owner buildings shall be fed with twisted pair copper (number of pairs determined by Owner on a per project), minimum of 24 strands of multi-mode optical fiber and minimum of 48 strands of single-mode optical fiber. Special applications may require more fiber strands.

## 33 82 01 Switching Center Terminations

Building 24 terminate twisted pair on Circa 1900-100K Series Stub in/out 100pr. BETs with cover units with gas modules. Building 54 terminate twisted pair on Circa 1900-100K Series Stub in/out 100pr. BETs with cover units with gas modules and 25 pair cables terminated on Rack Mount 110 blocks with cable management and C5’s. Building 64 terminate twisted pair on Circa 1900-100K



| Section Number | Title  |
|----------------|--|
|                | Series Stub in/out 100pr. BETs with cover units with gas modules and cables terminated on Rack Mount 110 blocks with cable management and C5's. All optical fiber shall be fusion spliced with keyed LC type connectors.   |
| 33 82 13       | <p>Copper Communications Distribution Cabling</p> <p>Copper cable shall be PE 39 type and meet the following requirements:</p> <ul style="list-style-type: none"> <li>• Solid annealed, bare copper conductors</li> <li>• Solid polyolefin insulation, color coded to telephone industry standards</li> <li>• Cable core filled with waterproofing compound</li> <li>• Aluminum shield with polyethylene jacket</li> <li>• 24 AWG, pair count determined by Owner per project</li> <li>• Cable shall meet the requirements of ANSI/CEA S-84-608</li> </ul>   |
| 33 82 23       | <p>Optical Fiber Communications Distribution Cabling</p> <p>Cable: Glass fiber, loose tube all dielectric gel filled osp cable rated for duct installation. Multi-mode OM3 50 micron core, 125 micron cladding diameter with MIFL of 3.5db/km &amp; 500 MHz-km @ 850nm, 1.5db/km &amp; 500 MHz-km @1300nm. Single-mode 125-micron cladding diameter with MIFL of 0.4 db/km at 1300nm and 0.3 db/km at 1550nm. Proof tested to 100kpsi.</p> <p>Fiber Distribution Shelf: Modular design with jumper routing guides for vertical and horizontal runs and all associated shelves, panels, interconnection couplers and hardware necessary to terminate all fibers with room for 25% growth.</p> <p>Wall Mount Distribution Units: Metal construction, lockable, capable of splicing and termination in same housing, all hardware necessary to terminate fiber (including cable attachment, connector panels, interconnect couplers, fan-out kits, etc.) All connectors and interconnect couplers must be from same manufacturer.</p> <p>Connectors: Keyed LC compatible with ceramic ferrule. Maximum attenuation of 0.4db and durability of 0.2db after 500 matings. All connectors and interconnect couplers from same manufacturer.</p> <p>Splice cases: Sealed, reenterable closure designed for fiber optic cable. All necessary trays, hardware, grommets, etc. to complete to manufacturer's instructions and specifications. All splices to be fusion, no mechanical splicing.</p> |

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All fibers (inter and intra building) tested for continuity and tagged at both ends with building number and ID number. All fibers tested for insertion loss, both directions, at 850nm and 1350nm on multi-mode, and at 1310nm and 1550nm on single-mode. All results documented. OTDR signature trace on all fibers with pertinent points documented (splice, endpoints, etc.) Only test results with University personnel present will be accepted.

**\*\*END OF SECTION\*\***