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SECTION 22 67 00_PROCESS WATER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

B. The intent of these standards is to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 RELATED SECTIONS:

A. Section 22 05 00 – Common Work for Plumbing Systems

B. Section 22 05 01 – Common Requirements for Plumbing Systems

C. Section 22 11 00 – Domestic Water Piping Systems

D. Section 26 29 23 – Variable Speed Drives

1.3 DESIGN REQUIREMENTS

A. Distilled water systems shall not be used for process water systems.

B. Use this standard to specify Deionized (DI) and Reverse Osmosis (RO) systems, Large Scale Polishing Systems and Ultra-Pure Water Systems. This standard does not apply to bench top polishing systems.

C. Use this standard to specify DI water piping systems, and RO water piping systems for laboratories, process areas (pilot plants) and clean rooms.

D. Design process water systems so that impurities cannot be trapped in the piping systems and that biological growth is inhibited. Dead legs in process water systems are not permitted.

E. Risers shall have isolation valves between each floor and at each floor branch. All take offs from mains shall have isolation valves.

F. All branch take offs from piping mains are required to have shut off valves at the take offs so that repairs can be performed on the branch piping without shutting down the system.

G. Provide shut off valves at each equipment connection.

H. Provide isolation valves for each gage connection and level indicating instrument.

I. Route all process water piping in inside walls only. Consult the University Sustainability Energy and Engineering Group if it is necessary to route process water piping in an exterior wall.

J. If possible, process water piping systems shall be routed as to not be exposed to direct light or Ultraviolet radiation. All process water piping shall be pigmented (natural) to limit degradation due to ultraviolet light exposure.

K. If process water piping must be routed through spaces with fluorescent lighting, UV filtering sleeves must be installed over the fluorescent light bulbs.

L. When designing laboratory process water systems, all branch take offs into each individual laboratory suite shall have an isolation valve. Each connection to a laboratory bench or equipment must have an isolation valve. Maximum isolation within the laboratory is critical so that experiments can continue within the laboratory when repairs or tie-ins are required.

M. For projects in laboratory settings, consult with researchers and technicians to determine their process water quality requirements are included in the design.

N. Specify flushing procedures for piping. Flushing must be performed after all piping components are permanently installed and at each point of use within each laboratory.

O. Engineer shall include static pressure in the hydraulic calculations for the entire process water piping systems and must consider the effect of the holding tank on the system static pressure.

P. Process water systems shall have a base system water resistance of 1 megohms-cm. Lab water users that require a greater purity will be required to polish at the point of use.

Q. Consult the University Sustainability, Energy and Engineering group when connecting new materials to existing materials at each location. Confirm all new materials are compatible with the existing materials.

R. Absolutely no metallic pipe or pipe fittings shall be used in any process water piping in either distribution system or equipment skids.

S. Coordinate with University Vendor and confirm with Project Manager/ SEE Engineer on project for contact information.

1.4 SUBMITTALS

A. Product Data:

1. Piping: Submit data on pipe materials, fittings, and accessories. Submit manufacturers catalog information.
2. Valves: Submit manufacturers catalog information with valve data and ratings for each service.
3. Piping Specialties: Submit manufacturers catalog information, component sizes, rough-in requirements, service sizes, and finishes.

B. Manufacturer's Installation Instructions: Submit installation instructions for material and equipment.

C. Sanitation Procedures: Submit manufacturer's approved procedure.

1.5 CLOSEOUT SUBMITTALS

A. Not Applicable

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

B. Do not store process water pipe and fittings in direct sunlight.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 WARRANTY

A. Furnish two-year parts and labor manufacturer warranty for process water piping system.

1.9 EXTRA MATERIALS

A. Furnish five (5) extra kits for manufacturing of pipe joints.

B. If a kit for manufacturing pipe joints has a shelf life, provide five (5) fresh kits at the end of the warranty period.

PART 2 PRODUCTS

2.1 PROCESS WATER SYSTEM

A. Acceptable Manufacturers:

1. Culligan

2. Evoqua
3. Neu-Ion

B. System Performance Criteria

1. The design engineer shall determine system performance based on a careful evaluation of specific program requirements. Process water systems typically have high first and ongoing operational costs, therefore the design engineer shall take particular care not to “over-specify” the system. The proposed system performance will be presented no later than SD phase, for approval by the assigned Sustainability, Energy and Engineering (SEE) engineer. It shall be updated through CD phase, as the requirements for the exact equipment served becomes more precisely determined. The A/E shall provide the following design criteria for approval:
   a. Make-up rate in gpm
   b. Daily production in gallons per 24-hour day
   c. Storage tank size (gallons)
   d. Distribution loop flow rate (gpm) and head (ft.)
   e. Distribution loop temperature
   f. Primary DI loop (to storage) product quality: Resistivity (megohm-cm), silica, total organic carbon (TOC), sodium, chloride, sulfate.

C. Distribution loop water criteria:

1. Resistivity (megohm-cm), silica, TOC, sodium, chloride, sulfate, oxygen, boron, particulate (maximum particle size and quantity per unit volume), bacteria (viable per ml), Ph.
   a. Point where distribution loop water criteria are to be achieved (e.g., at point of use, leaving post filter, etc.).
   b. Outline calculations identifying how make-up rate and distribution flow rate and head were determined
2. Not all the criteria listed above will apply to a project, for instance TOC limits typically apply to semi-conductor projects, but not to generic research labs. The engineer shall explicitly indicate which criteria are not applicable when providing design criteria for approval. Water resistivity above 10 megohm-cm (CAP-1) is not typically required for general lab use, however the engineer shall determine exact resistivity requirements based on the program.

D. Plans and Specification Requirements

1. Include a clear statement of the system performance criteria within the specification.
   a. This statement shall include all the system performance criteria listed above.
   b. Obtain the most recent city water analysis and include in the specification.
   c. Include the minimum expected feed-water temperature.
   d. Indicate that system performance be guaranteed based on the stated feed-water analysis, including temperature.

2. Plans shall include a detailed system schematic, showing the arrangement of major system components, instruments, meters, isolation valves, gages, etc. The system schematic shall also indicate make-up flow rate, distribution flow rate, distribution pump GPM and head, and storage tank volume. The system schematic shall indicate piping materials for feed water, RO water, distribution supply, and distribution return.

E. Typical Component Arrangement and Requirements:

1. The following sections outline the typical RO/DI system arrangement at the University of Delaware and the requirements for individual components, starting at the feed-water input. It is not the intent of this section to dictate exact system arrangement; the engineer shall design a project specific system to meet program requirements. However, variances from this arrangement shall be called to the attention of the SEE engineer, for approval.

F. Feed Water:

1. Provide back-flow prevention (BFP) at the feed water input to the system. Provide a pressure gage up and downstream of the BFP.
2. Evaluate the benefit of preheating feed water to improve RO system performance (by improving RO membrane production rate, allowing reduction in RO size). Consider mixing valve or heat exchanger. Preheating shall be evaluated on large systems (make-up rates above 10 GPM); however, its use typically mandates a distribution loop cooling heat exchanger be employed as well.

G. Feed Water Pre-Filter:

1. Provide simplex 10-micron cartridge (disposable element) filter with bypass. Specify minimum 20” long cartridges. Provide pressure gages across filter.

H. Water Softener:

1. Duplex softener arrangement, demand (flow) initiated type, common brine tank, shall be provided. Very small systems not requiring 24/7 production may utilize a simplex arrangement. For simplex arrangements, specify demand initiated/timer-based regeneration type softeners interlocked to prevent RO operation during softener regeneration cycle. Provide a hard-piped bypass around the softener arrangement. Softeners for boiler water make-up systems shall be duplex demand-initiated type. Brine tanks shall be specified large enough to hold enough salt for 1 month’s soft water production. Maximum brine tank height shall be 4 feet. Indicate that the brine tank over-flow is piped to a floor drain. For systems with make-up rates above 15 GPM or with an estimated salt use more than 1000 lbs/month, bulk brine storage system shall be provided. Provide pressure gauges across softener bank. Salt maximum fill level shall be clearly marked on the brine tank.

I. Carbon Filter

1. Provide duplex carbon filter piping arrangement. UD utilizes a carbon bottle exchange program where a vendor replaces expired carbon bottles, therefore back-washing type carbon filters should normally not be specified and will only be considered on extremely large systems. The design should indicate all required piping for a duplex arrangement including flexible hoses for carbon filter bottle connection. Indicate carbon filters are supplied by UD. Provide pressure gauges across carbon filter bank.

J. Reverse Osmosis Prefilter

1. Provide simplex 1-micron cartridge (disposable element) filter without bypass. Specify minimum 10” long cartridges. Provide pressure gages across filter.

K. Reverse Osmosis System

1. Specify a skid mounted system furnished with controls providing automatic and manual operation. RO system shall include low pressure pump cut-out, relief valve, meters to monitor product and reject flow rates (typically rotameters) and isolation valves to allow pump and membrane change-out. Provide a resettable totalizing water meter that indicates total RO product produced.

L. Mixed Bed De-Ionization Bottles (If required)

1. A pair (or multiple pair on large systems) of mixed bed resin bottles, located upstream of the storage tanks, may be required for specific processes. The same piping arrangement and bottle exchange requirements described for the distribution loop mixed beds applies. See Q. below.

M. Resin Trap

1. If mixed bed DI bottles are provided in the make-up loop, provide a resin trap downstream consisting of a basket strainer with a 1/64” mesh opening strainer element. Provide pressure gages across the strainer.

N. Storage Tank(s)

1. The engineer shall carefully evaluate storage tank size based on program requirements. Minimum tank sizes adequate to hold a 1/2 days’ worth of production are typical. Tanks shall be translucent with a bottom sloped to the outlet connection. Tank vents and over-flows shall be protected by suitable filters. Provide a tank drain piped to a floor drain. Tanks shall be equipped with clear sight glasses. Provide isolation valves on sight glasses. Provide a drain valve for sight glasses piped to a floor drain. Specify external tank level sensors located in sight glass piping that allows disconnecting the sight glass tube to test the level controls without draining the storage tank.

O. Distribution Pumps

1. Normally provide 100% redundant distribution pumps. Indicate isolation valves and pressure gages on the inlet and outlet of each pump and provide a check valve on the outlet side of each pump. Provide a means to control pump flow. Variable frequency drives (VFDs) are preferred, except for very small systems. VFDs shall comply with UD standard Variable Speed Drives. Specify a low-pressure cutout switch for the distribution pumps. Due to the relatively fragile piping materials used on RO/DI systems, often at high pressures, a relief valve with discharge routed to the storage tank is recommended.

P. Ultraviolet Sterilizers (Upstream of Distribution Loop Mixed Bed De-Ionizers When Required)

1. UV filtration upstream of the mixed beds is not typically required except in special circumstances, such as systems serving nanotechnology laboratories or semi-conductor fabrication shops.
2. Skid design shall include adequate space for changing the UV light bulbs.

Q. Mixed Bed De-Ionization Bottles (Distribution Loop)

1. The standard bottle size utilized in this program is 3.6 cubic feet. Therefore, the Engineer shall design the mixed bed "farm" utilizing this bottle size. Since bottle capacity is typically 3-4 gpm/cubic foot of resin, multiple pairs of bottles are normally required. Each bottle pair shall be indicated as piped in series, with a "quality light" located between each bottle pair to indicate when the upstream bottle quality has degraded. On extremely large systems, larger bottle sizes may be considered, not to exceed 15 cubic foot size. Larger bottle sizes must be approved by the assigned SEE engineer. Mixed bed flexible connections shall be no longer than 6 feet. Normally Type 1 resins are utilized on UD laboratory systems. Ultra-pure systems (e.g., nanofabrication, semi-conductor applications) may require special mixed bed resins, such as virgin semi-conductor grade. Such resin requirements shall be reviewed and approved by the assigned SEE engineer.

R. Ultraviolet Sterilizers (Downstream of Distribution Loop Mixed Bed De-Ionizers)

1. Provide a simplex UV sterilizer downstream of the distribution loop mixed beds. Provide a hard-piped bypass around the UV sterilizer.

S. Post Filters, Distribution Loop

1. Provide simplex cartridge (disposable element) type filter with bypass, equipped with 0.2-micron absolute filter elements. Specify minimum 20" long cartridges. Provide pressure gages across filter. Evaluate higher levels of absolute filter performance ("ultra-filters") for ultra-pure or critical systems (e.g., semi-conductor applications).

T. Heat Exchanger, Distribution Loop

1. Provide when the program dictates that a maximum distribution loop temperature be maintained. Evaluate if a distribution loop heat exchanger is required due to feed-water pre-heating or other factors, to maintain loop temperatures within reasonable limits. Give consideration of final RO/DI water use, pipe expansion concerns, etc. Plate and frame type heat exchangers are preferred. Process water shall flow through the interior piping of the heat exchanger and shall not be exposed to metallic piping.

U. Sample Ports

1. Provide sample ports at each location shown on the sample system diagram. Sample ports shall be sized and designed to allow trickle draining prior to taking test sample.

V. Component Redundancy

1. For critical systems, in addition to the minimum redundancy requirements specified in the above sections, provide:
   a. Multiple storage tanks (50/50 or similar type arrangement in lieu of a single tank)
   b. Redundant final filters
2. Redundancy for other components, though not typically recommended, may be appropriate. The engineer shall evaluate with the UD customer and SEE engineer.

W. Controls

1. Specify a complete, central control panel with the following features:
   a. Distribution loop supply water resistivity and alarm
   b. Distribution loop supply water flow rate in gpm
   c. Distribution loop daily use in gallons
   d. Total RO water produced
   e. Tank level control
   f. Distribution pump low pressure alarm light
   g. Distribution pumps off alarm light (activated only if both distribution pumps are statused” off”)
   h. High storage tank level alarm light (latching, requiring manual reset).
   i. Low storage tank level alarm light (latching, requiring manual reset).
   j. BACnet card for integration with UD BAS system.
   k. Panel on/off switch
2. Though typically not required, the engineer shall consider if other monitoring and alarm features are appropriate, based on the planned use for the system. Small applications may not require all the control features outlined above. The RO skid shall utilize a PLC based controller. Specify that the vendor shall provide UD Maintenance and Operations all software, pass codes, etc. to allow UD Maintenance and Operations full access to the controller programming and settings, as well as a back-up copy of the project specific program.

3. The PLC controller shall have BACnet capability and shall integrate with UD's BAS system. The RO/DI system shall send to UD's BAS system all points monitored and all alarms.

X. Electrical

1. Do not specify a single point power connection for the system. Instead, indicate power connections to the individual components: Softener, RO Skid, control panel, distribution pumps, etc. The RO vendor shall be designated as providing combination starters for the RO skid pumps, and VFDs (or combination starters) for the distribution pumps.

2.2 PROCESS WATER PIPING

A. The University of Delaware will entertain either natural polypropylene (PP) or natural polyvinylidene fluoride (PVDF) process water piping systems.

B. All process water piping systems shall be a minimum equivalent to schedule 80 wall thickness.

C. All process water piping systems shall be made from electro-fusion type joint systems. Solvent weld process water piping is not permitted.

D. All elements of the process water piping systems (pipe, fittings, and valves) shall be of the same material and manufacturer. Do not mix different materials or manufacturers to make the process water piping system.

E. All process water piping shall be pigmented to resist degradation from ultraviolet light sources.

F. Acceptable Manufacturers:

1. Asahi Polypure
2. George Fisher Inc., PPRO-SEAL
3. Ipex Inc., Enpure
4. Nibco, Chempure

G. Couplings, Adapters and Transition Fittings: Assemblies with electro-fused or flanged parts; compatible with piping and fluids flowing through the system; and made by same piping manufacturer for joining piping systems.

H. BALL VALVES (Use for pipe size 2" and smaller)

1. Pressure Rating: 150psig
2. Body Material: Natural PP or Natural PVDF to match piping system
3. Body Design: Union type
4. End Connections: Detachable, butt or socket weld

5. Seats: PTFE
6. Stems: Stainless Steel or Match Body Type
7. Stem Seals: FKM- rubber O-rings
8. Handle: Tee shaped

I. BUTTERFLY VALVES (Use for pipe size 2-1/2” and larger)

1. Pressure Rating: 150psig
2. Body Material: Natural PP or Natural PVDF to match piping system
3. Body Design: Lug type only
4. Seats: FKM rubber
5. Stems: Stainless Steel
6. Stem Seals: FKM- rubber O-rings
7. Handle: Lever type with locking device

J. CHECK VALVES

1. Pressure Rating: 150psig
2. Body Material: Natural PP or Natural PVDF to match piping system
3. Body Design: Bolted-bonnet type
4. End Connections: Flanged
5. Shaft: Match Body Type
6. Disc and Arm: Match Body Type
7. Gasket and Seals: FKM- rubber O-rings

K. DIAPHRAGM VALVES (Use for throttling only)

1. Pressure Rating: 150psig
2. Body Material: Natural PP or Natural PVDF to match piping system
3. Body Design: Bolted-bonnet type
4. End Connections (2” and smaller): Detachable, socket
5. End Connections (2-1/2” and larger): Flanged
6. Diaphragm: FKM rubber
7. Seals: FKM- rubber O-rings
8. Handle: Wheel shaped

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION - PIPE

A. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

B. Install piping to maintain headroom without interfering with use of space or taking more space than necessary.

C. Group piping whenever practical at common elevations.

D. Slope piping and arrange systems to drain at low points.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings

G. Provide access doors where valves and fittings are not accessible.

H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

I. Sleeve pipes passing through partitions, walls, and floors.

J. Install firestopping at fire rated construction perimeters and openings containing penetrating sleeves and piping.

K. Install unions downstream of valves and at equipment or apparatus connections.

L. Install valves with stems upright or horizontal, not inverted.

M. Support piping as per pipe manufacturers recommendations so that there is no sag in the pipeline and no fluids will be trapped in the pipe.

N. Joints shall be constructed as per manufacturer's instructions. If joining dissimilar materials, adapter shall be compatible with both piping systems materials.

O. Route process water systems so that impurities cannot be trapped in the piping systems and that biological growth is inhibited. Avoid creating dead legs in process water systems.

3.3 FIELD QUALITY CONTROL

A. All personnel installing the process water piping system shall be factory trained in the performance of each step of the installation of the system. Contractor will provide certification of factory training for all employees used to install the process water piping system.

B. The mechanical contractor shall supply factory inspection of all process water pipe systems. The manufacturer must certify the process water pipe system installation conforms to its quality requirements. The manufacturer must submit written certification with the close out documents.

C. Test process water piping system in accordance with City of Newark Water Department requirements.

3.4 START UP & COMMISSIONING

A. The entire distribution loop piping system (supply and return) shall be sanitized (with Minncare or equivalent) prior to putting the system into operation. Mixed beds shall not be connected to the distribution piping during sanitization.

B. The RO/DI system supplier shall provide technicians specifically trained on RO/DI system start-up, for system start-up. During start-up, the vendor shall, in the presence of UD Maintenance, delete the PLC program and demonstrate reloading the back-up copy of the software program.

C. All systems shall have performance certified by an independent commissioning agent, including the taking of samples. On large systems, multiple samples shall be taken, e.g., one per floor. The first sample shall be taken by dumping the system make-up rate for 24 hours, and then taking a sample at a point of use location designated by the owner. The system shall then be operated 1 week, and additional sample(s) shall be taken at point of use locations designated by the owner. Specify that a certified performance report shall be provided to the owner.

The water sampling shall be performed by an independent laboratory. A water sample report shall be provided to the University of Delaware by the independent laboratory and shall include data on all requested criteria.

D. A list of all critical parts shall be submitted to the University of Delaware upon completion of the project.

PART 4 END OF SECTION