

**SECTION 22 67 19.16
REVERSE-OSMOSIS WATER EQUIPMENT**

SPEC WRITER NOTES:

1. Delete between //--// if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraph.
2. RO systems require a duplex water softener on the inlet water side for optimum performance and reduced maintenance.
3. For boiler plants, the application of RO is indicated when make-up rates are high and the solids content of the make-up water is 450 ppm or higher. If the make-up water analysis indicates a dealkalyzer is needed, then an RO system should definitely be evaluated in lieu of the dealkalyzer. Use of RO will often decrease boiler water chemical costs by 80%, and will reduce blowdown energy losses. Normal make-up rates of 5% to 10% shall be confirmed with make-up water supply.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide complete industrial-type packaged reverse osmosis (RO) water treatment system producing high purity water by removal of dissolved minerals, bacteria, particles and organic impurities. Designed for continuous automatic operation. The system shall include pre-filter, product storage tank and all devices necessary for fully operational system. RO system operation shall be controlled by the water level in the product storage tank.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- //D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.//
- //E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Restraint.//
- F. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Systems for service other than boiler plant make-up water.

- G. Section 22 07 11, PLUMBING INSULATION.
- //H. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS. Requirements for commissioning, systems readiness checklist, and training.//
- I. Section 22 31 11, WATER SOFTENERS.
- J. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATION.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by their basic designation only.
- B. American Society of Mechanical Engineers (ASME):
B40.100-2013.....Pressure Gauges and Gauge Attachments
- C. ASTM International (ASTM):
A269/A269M-2014e1.....Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
D1785-2012.....Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- D. American Water Works Association (AWWA):
B300-2010.....Hypochlorites
B301-2010.....Liquid Chlorine
C651-2014.....Disinfecting Water Mains
- E. National Electrical Manufacturers Association (NEMA):
ICS 6-1993 (R2001, R2006) Industrial Control and Systems Enclosures
- F. National Fire Protection Association (NFPA):
70-2014.....National Electrical Code
- G. Department of Health and Human Services, Food and Drug Administration (FDA):
CFR 21, Chapter 1, Part 175.300, Resinous and Polymeric Coatings

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 67 19.16, REVERSE-OSMOSIS WATER EQUIPMENT", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights,

materials, applications, standard compliance, model numbers, size, and capacity.

1. Catalog cuts, complete description and specifications of all equipment and accessories.
 2. Accessories including filters, product storage tank, pressure gages and test kit.
 3. Performance data including normal and maximum flow and pressure drop. Certification that required performance shall be achieved.
 4. Piping.
- D. Complete detailed layout, setting, arrangement, and installation drawings including. Drawings shall also show all parts of the apparatus including relative positions, dimensions, and sizes and general arrangement of connecting piping.
- //E. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.//
- //F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.//

1.5 QUALITY ASSURANCE

- A. Manufacturer shall have been engaged in the manufacture of RO systems as a primary product for at least ten years. The ten year requirement supersedes any conflicting requirement in other parts of the project specification.
- B. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.

1.6 PROJECT CONDITIONS

- A. Influent Water Analysis:

Maximum Silt Density Index (SDI) Rating	
Turbidity, NTU	
Maximum Free Chlorine and/or Chloramine	ppm
Color:	
Maximum pH (continuous)	

Minimum pH (continuous) _____

Maximum pH (cleaning-30 minutes) _____

Minimum pH (cleaning-30 minutes) _____

Confirm the analysis with current samples and tests.

SPEC WRITER NOTE: Designer to confirm water quality with boiler manufacturer.

B. Design Parameters:

Normal System Flow: _____L/s (_____gpm)

Maximum System Flow: _____L/s (_____gpm)

Daily Water Usage: _____liters per day (_____gallons per day)

Daily Hours of Water Demand: _____

Operating Temperature Range: ___ to ___ degrees C (___ to ___ degrees F)

1.7 AS-BUILT DOCUMENTATION

SPEC WRITER NOTE: Coordinate O&M Manual requirements with Section 01 00 00, GENERAL REQUIREMENTS. O&M manuals shall be submitted for content review as part of the close-out documents.

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be // in electronic version on compact disc or DVD // inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version //____//

provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

SPEC WRITER NOTE: Make material requirements agree with applicable requirements specified in the referenced Applicable Publications. Update and specify only that which applies to the project.

2.1 RO SYSTEM

- A. Packaged automatic RO system mounted on steel frame, designed for project conditions. Equipment arranged on the frame to allow easy access for operating, maintenance and repair. Unit shall include RO membrane, pressure vessels, pre-filtration system, high pressure pump and all required piping, wiring and controls for a fully operational system.
- B. Performance Requirements:
1. Membrane reject ratio: 98 percent minimum. TDS of product is 2 percent maximum of input TDS.
 2. Capture rate: 75 percent minimum. Maximum amount of water to drain 25 percent of input.
- C. RO Membrane Elements: Thin-film composite with fiberglass reinforced polyester (FRP) over-wrap, anti-telescoping device, u-cup brine seal. The design salt rejection shall be 98 percent based on 2000 ppm water at 1550 kPa (225 psig) at 25 degrees C (77 degrees F).
- D. RO Element Housings: Type 304 stainless steel with PVC end caps held in place with stainless steel bands. Each housing assembly complete with one set of O-rings and O-ring lubricant. (Bio-based materials shall be utilized when possible.) Housings for systems over 34,070 L per day (9,000 gallons per day) shall be constructed of FRP. Provide cleaning connections.

- E. High Pressure Pumps and Motors: // Single // Duplex // vertical multistage high efficiency centrifugal type with Type 304 stainless steel casing, shaft, impellers. Tungsten carbide and ceramic shaft seals. Cast iron frame with flanged piping connections. Premium efficiency TEFC motor selected to be non-overloading on the entire performance curve.
- F. Manual Valves:
1. Pump Throttle Valve: Type 316 stainless steel ball valve, socket welded.
 2. Concentrate Throttle Valve, Recycle Throttle Valve: In-line needle style, stainless steel, rated for 2070 kPa (300 psig) minimum.
 3. Inlet Isolation Valve, Product and Concentrate Check Valves: PVC with EPDM seats and seals.
 4. Feedwater Sample Valve, Product Water Sample Valve: PVC plug valve with EPDM seats and seals.
 5. High Pressure Sample Valve: Type 316 stainless steel plug valve.
- G. Automatic Valves:
1. Automatic Inlet Shut Off Valve: Solenoid type, diaphragm actuated, normally closed, constructed of glass-filled Noryl thermoplastic.
 2. Automatic Membrane Flush Valve: Provide for purging the membranes with fresh water upon machine shut down.
- H. Piping:
1. Low Pressure Feed, Reject and Recycle Piping 520 kPa (75 psig and under): ASTM D1785, Schedule 80 PVC, socket welded and flanged.
 2. RO Product Tubing From Each Membrane Housing: ASTM D1785, Schedule 80 PVC, socket welded and flanged.
 3. Low Pressure Control and Pressure Gage Tubing: Polyethylene.
 4. High Pressure Reject and Recycle Piping 520 kPa (above 75 psig): ASTM A269/A269M, Type 304 Schedule 10 stainless steel with butt welded joints.
 5. High Pressure Control and Pressure Gage Tubing: 6895 kPa (1000 psig) burst nylon.
- I. Controls:
1. Electronic // PLC // DDC // controller providing automatic control for all operating functions. Motor starter panel. All in FRP enclosures rated NEMA 4. All wiring factory-installed and tested. Comply with Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES and NFPA 70.

2. Autoflush indicator and control to flush RO concentrate at shut down or at predetermined intervals.
3. Warning Alarms: Low quality product, low feed pressure, high feed temperature. Connect to BAS system.
4. Automatic Shutdowns and Alarms: Low feed pressure, low product quality, pretreatment out of service, storage tank full.
5. Status Indicators: Low feed pressure, low quality, flow alarm, high feed water temperature, product divert to drain valve open, pretreatment lockout, storage tank full.
6. Low and High pressure safety switches.
7. Tank water level control switches.
8. Pump Motor Starter: Comply with Section 26 29 11, MOTOR CONTROLLERS.

SPEC WRITER NOTE: Designer to note auxiliary contact requirements if other than noted below.

9. Miscellaneous Controls: Elapsed run time indicator, alarm horn, chemical pump receptacles, convenience receptacles, minimum 8 auxiliary contacts 2DI, 2DO, 2AI, 2AO.

J. Instrumentation and Displays:

1. All instrumentation readouts panel-mounted in FRP enclosures rated NEMA 4. All factory wiring. Comply with NFPA 70.
2. Digital flow indicators for, product, reject, recycle.
3. Pressure gages for inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product.
4. Conductivity indicator measuring product quality with digital displays, alarm relays and automatic temperature compensation.
5. Conductivity probe mounted in the RO product.

K. Skid and Frame Assembly: RO machine shall be built on a skid and frame constructed of welded structural carbon steel. The entire surface shall be sand-blasted and coated with high solids epoxy coating. Bio-based materials shall be utilized when possible.

L. Reassembly: Unit shall be shipped to the site completely assembled and tested. If units or sections are to be disassembled at the site to allow for installation in a limited space, the unit shall be reassembled and tested for intended operation by a factory authorized technical representative.

2.2 PRE-FILTER

- A. Single multi-media filter sized for the RO machine inlet flow rate. Filter designed for suspended solids removal down to 10 microns and automatic backwash cycle.
- B. Media Tank: FRP designed for 1035 kPa (150 psig). Pre-piped internal backwash distributor and filtered water collector.
- C. Filter Media: Top layer of anthracite, middle layer of silica sand, bottom layer of multi-grade garnet. Install filter media at job site.
- D. Backwash Cycle: Top-mounted, piston-operated control valve with pre-sized drain line flow control orifice. The cycle shall be initiated by and adjustable seven day electronic time clock. Include RO lockout switch.
- E. Replacement Filter Media: Provide elements for one complete replacement.

2.3 ACTIVATED CARBON FILTER

- A. Single filter sized for the RO machine inlet flow rate. Designed to remove chlorine and prevent RO membrane damage.
- B. Media Tank: FRP designed for 1035 kPa (150 psig). Pre-piped internal backwash distributor and filtered water collector.
- C. Filter Media: 12 x 40 mesh bituminous coal-based activated carbon. Install media at job site.
- D. Backwash Cycle: Top-mounted, piston-operated control valve with pre-sized drain line flow control orifice. The cycle shall be initiated by and adjustable seven day electronic time clock. Include RO lockout switch.

2.4 RO WATER STORAGE TANK

SPEC WRITER NOTE: Insert storage tank volume.

- A. Free-standing, closed-top, flat-bottom, // // cubic meters (// // cubic feet) total volume. Top access manway, PVC bulkhead fittings for high and low level alarm switches, RO permeate inlet, RO permeate discharge and drain. Install 0.2 micron tank vent filter at the top head. Vented to atmosphere.
- B. Materials of Construction: Linear polyethylene in one piece.
- C. Tank Water Level Control: Adjustable float switch that signal starting and stopping RO pump. High and low level alarm switches.

2.5 PRESSURE GAGES

- A. ASME B40.100, Grade A, 1 percent accuracy, 115 mm (4-1/2 inches) diameter, all metal case, bottom connected. White dials, black hands, graduated from 0 to 690 kPa (0 to 100 psig) and identity labeled.

2.6 WATER TESTING EQUIPMENT

- A. Furnish water testing equipment in a portable cabinet specially made for the installed equipment. Include sufficient materials for 6 months of normal testing procedures.
- B. Silt Density Index (SDI) apparatus to measure degree of suspended solids feeding the RO membranes. Include pressure regulator, pressure gage, filter holder, 600 mL (20 ounce) beaker, sample valve, tubing and 0.45 micron filter papers.
- C. Test kit to measure total water hardness, total iron, free chlorine, pH.

PART 3 - EXECUTION**3.1 REQUIRED TECHNICAL SERVICES**

- A. Provide services of a qualified manufacturer's representative to check complete installation for conformance to manufacturer's recommendations, put system into service, make all adjustments required for full conformance to design and specified requirements, and perform all demonstrations and tests.

3.2 FLUSHING AND DISINFECTING

- A. Flush and disinfect new water lines and RO system and tank interiors in accordance with AWWA C651.
- B. Material:
 - 1. Liquid chlorine: AWWA B301.
 - 2. Hypochlorite: AWWA B300.

3.3 STARTUP AND TESTING

- A. Operating: Tests shall be run in presence of COR.
- B. Procedure:

SPEC WRITER NOTE: See Article, PROJECT
CONDITIONS for required flow rates.

- 1. Operate RO system at constant maximum required capacity for one hour after demineralized RO product water is produced. When necessary, waste product water to sewer to maintain above flow rate. Product water production shall begin when a sample shows that demineralization complies with requirements.

2. Demonstrate all features of the control system including diagnostics and flow and cycle indications.

C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to startup and testing.

//3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.//

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for //four// // // hours to instruct VA Personnel in operation and maintenance of the system.

//B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.//

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