

SECTION 15545

HIGH PURITY DEIONIZED WATER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Requirements of the Contract, including Conditions of the Contract, Drawings and Division 1 - general requirements of the Specification, apply to the work of this section.
- B. Related work included in Section 15050 – Piping Systems, Section 15206 – Deionized Water Piping - PVC and under other related sections of the specifications not listed herein are hereby made a part of this section and shall be referred to as required by the contractors and the equipment manufacturers.
- C. Where a conflict occurs between this section and Section 15050 - Mechanical Materials and methods, the technical section of the specification shall take precedence.

1.2 SECTION INCLUDES

- A. Provide a complete deionized water system providing semiconductor grade water meeting the requirements for water quality specified in Appendix A. Work shall include component selection and arrangement to achieve the required water quality. All components with the exception of the storage tank shall be skid mounted. System shall provide point of use pressure of 12 psig or greater at the process tools, assuming pipe loop pressure loss of 0.25 psig.
- B. Provide all meters and controls for an adequately supervised system. Indicate recommended locations for various instrumentation equipment.
- C. As part of the base bid, include use of portable primary and polish mixed beds.
- D. As part of the base bid, provide onsite factory trained technician(s) or engineer(s) during field installation, start-up, and qualification.
- E. As an add-alternate, provide replacement parts for a second year, including labor warranty for all skid mounted components utilized.
- F. Vendor shall provide for sanitization of the entire high purity deionized water system prior to acceptance by the owner. All consumables required for this operation shall be provided by the vendor.
- G. Vendor shall provide for all DI water testing to meet acceptance conditions indicated herein.

1.3 REFERENCES

- A. Equipment provided per this specification shall be in compliance with all applicable specifications of the following bodies:
 - 1. American National Standards Institute (ANSI)
 - 2. American Society for Testing and Materials (ASTM)
 - 3. American Society of Mechanical Engineers (ASME)
 - 4. American Water Works Association (AWWA)
 - 5. Hydraulic Institute (HI)
 - 6. Institute of Electronic and Electrical Engineers (IEEE)
 - 7. Instrument Society of America (ISA)

8. National Electrical Code (NEC)
9. National Electrical Manufacturer Association (NEMA)
10. National Fire Protection Association (NFPA)
11. Occupational Safety and health Administration (OSHA)
12. Semiconductor Equipment and Materials International (SEMI)
13. Steel Structures Painting Council (SSPC)
14. Uniform Plumbing Code (UPC)
15. Other agencies as applicable

1.4 SUBMITTALS

- A. Submit 6 sets of the following to the Owner for approval.
 1. As part of the bid proposal, provide a flow diagram indicating all proposed components. In addition, the vendor shall provide an equipment matrix with the following information:
 - a. Design and operating flowrates (percent of capacity)
 - b. Recommended or required maintenance schedule (i.e., periods between backwashes, regenerations)
 - c. Recommended or required annual quantities for consumable materials (i.e., membranes, salt, reagents)
 2. Manufacturer's Data: Preliminary submittal data, within 15 days after receipt of a letter of intent, shall include a P&ID, process control parameters, written sequence of operation stating of control, process interfaces (water, waste, etc.) and preliminary skid layouts indicating overall dimensions. Submit component catalogue data, shop/installation drawings including dimensions, internal piping and valving, schematics and controls, as well as rigging and foundation bolt locations, within 15 days after receipt of letter of intent for the deionized water skid(s).
 3. Equipment lockout/tagout procedure/checklist.

1.5 SHIPMENT OF PRODUCT / ASSEMBLIES

- A. Manufacturer shall ship units to the job site using packing that will ensure no damage occurs in transit. Ship from factory to site direct via "air ride" enclosed suspension truck, e.g., moving van. Owner desires just-in-time delivery of units. Coordinate with the Owner for delivery schedule.
- B. Units shall be double-wrapped in polyethylene film to eliminate potential contamination while in transit. All pipe ends shall be capped. Submit cleaning and shipping procedure to the Owner for approval. All defective parts shall be returned to the manufacturer at his expense.

1.6 WARRANTY

- A. Manufacturer shall provide a two-year warranty beginning on a date agreed to by the manufacturer and the Owner.

1.7 TRAINING

- A. To be held at the Owner's site and shall address basic operations, maintenance and troubleshooting. Training times shall be scheduled with the Owner 2 weeks in advance of training. Training shall be for a minimum of 4 days with 2 days of classroom training and 2 days of hands-on equipment training.
- B. As a separate priced option, provide training at the factory to address advanced maintenance and troubleshooting.

1.8 WELDER QUALIFICATIONS

- A. All welders shall be certified under ASME Section IX. Submit completed forms QW482, "Welding Procedure Specification" and QW482, "Procedure Qualifications Tests" for approval. In addition to ASME certification, each welder shall provide traceable references indicating that they have installed high purity piping with the use of orbital welding equipment on at least three previous projects. Provide 1 sample weld from each orbital welder daily. Sample welds shall be performed for tubing sizes and positions to be performed by that welder on that day. Coupons shall be developed for the proposed combination of orbital welder and operator. Each coupon will be dissected for interior inspection. Each coupon shall be identified with the welder's mark and welding machine number. Coupons will be used during inspections as a pass/fail comparator. Acceptable welds (minimum standards) shall be: no visible surface discoloration; weld width to be 2-3 times the tubing thickness; weld height above surface to be 2 to 5 percent of tubing outside diameter; and bead track shall be less than 5 percent of weld width. Purge gas shall be argon from a cryogenic source with an analysis of not more than 1 ppm moisture, 1 ppm oxygen and 0.2 ppm total hydrocarbon for the purge. Do not use welding grade argon. Use 0.02 micron filtered argon for the exterior purge. Use a filter at the effluent side of the welding machine for this purpose. A dewar should also be used for this source. Under no circumstance should the interior of the tube be purged through the welding machine. At the tubing installer's option, welding grade argon with point-of-use purification achieving at least electronic grade argon may be utilized. Pre-purge and post-purge durations shall be 3 to 5 minutes. Causes for rejection shall include lack of penetration, interior surface discoloration or misalignment. These coupons shall be given to the Owner or the Owner's Representative to be inspected and saved. The Owner's Representative reserves the right to disqualify any welding operator whose sample welds do not meet specifications and/or match accepted coupons. All welds shall be subject to review and approval by Owner/Owner's Representative and are subject to coupon welding criteria.
- B. All welders shall label each weld with an etched identifying mark for easy reference. The mark shall include the welder's identification and the date the weld was made.

1.9 EQUIPMENT LOCKOUT/TAGOUT

- A. In order to be in compliance with OSHA regulatory requirements (29 CFR 1910.147, 1910.333(b)(2)(iii)(D) and (b)(2)(iv)(B)), it is required that all equipment shall be locked out or tagged out to protect against accidental or inadvertent operation which could cause injury to personnel. The supplier shall assist in determination of these associated procedures.
- B. The creation of the specific equipment lockout and tagout procedures and checklists are to be provided by the equipment supplier and are to be in a format that is agreeable to the Owner. Attached as Figure 3 is a checklist to be completed by the supplier as part of the submittal package. In addition, attached as Figure 8C is an illustration as to the detail to be provided by the equipment supplier after completion of the installation.

1.10 NOISE GENERATION

- A. Operating noise levels shall be less than 80 dBA when measured at 10 feet from any skid.

PART 2 - PRODUCTS

2.1 DEIONIZED WATER SYSTEM

- A. This part of the specification covers the design, fabrication and performance of the ultra-high purity water system. It is not the intent of this specification to completely specify all details of design and fabrication of each component. Nevertheless, the total package shall be able to deliver water which meets or exceeds the specification provided below.

1. The system shall be configured to supply a 3,000 gallon high purity water storage tank. One polish loop will be extended from the storage tank.
 2. All components within the recirculation loop shall be designed and sized to achieve, as a minimum, the following maintenance schedule:
 - a. Water Softeners: Regeneration not more than once per day
 - b. Primary Mixed Beds: Change-out not more than once per month
 - c. Polish Mixed Beds: Change out not more than once per year
 - d. RO Service: Cleanings not more than once every three months
 - e. Cartridge Filters Within Recirculation Polish Loop: Life expectancy of greater than 1 year
- 2.2 Water sample quality parameters provided as an attachment. Local water quality is known to change dramatically during the year. Pretreatment equipment shall be designed to accommodate such changes. Vendor shall perform additional water quality analyses as necessary to properly design the system. (Location of site: Oak Ridge, Tennessee.)
- 2.3 The flow requirements are as specified below:
- A. Pre-Treatment System: 10 gpm
 - B. RO Unit: 10 gpm product water
 - C. Polish Train and Recirculation Loop: 25 gpm
- 2.4 Component Specifications: The following component specifications are issued as a general guide and should be used as a minimum specifications if such equipment is specified in the proposal. Supplier shall identify components with the initial proposal.
- A. Multimedia Filter: Multimedia filters shall be provided for the removal of suspended particles greater than 20 microns from the municipal water supply. Filters provided shall meet the following specifications:
 1. Vessel:

Construction	ASME rated, Carbon steel
Pressure rating	100 psi minimum
Lining	Baked epoxy or rubber lined
Internal headers	PVC
Face Piping	PVC
Exterior Finish	Primer base with epoxy or urethane paint
 2. Operating:

Backwash	Automatic sequencing with manual initiation
Electrical Requirement:	Local instrumentation panel (120 VAC, single phase, 60 Hz)
Pressure gauge type:	0-160 psig liquid filled, 4 inch dial

- B. Softener: Water softeners shall be provided for removal of hardness (calcium and magnesium) from the municipal water supply prior to the RO units. Softeners shall meet the following specifications:

1. Vessel:

Construction	ASME rated carbon steel
Pressure rating	100 psi minimum
Lining	Baked epoxy or rubber lined
Internal headers	PVC
Face Piping	PVC
Exterior Finish	Primer base with epoxy or urethane paint

2. Operating:

Regeneration	Automatic sequencing with manual initiation
Electrical Requirements	Local instrumentation panel (120 VAC, single phase, 60 Hz)

- C. Brine Feed Tank: Tank shall be of FRP construction with lid. Tank shall be designed to hold, at a minimum, a one month supply of salt. Brine feed piping and eductor shall be of PVC construction.

- D. Activated Carbon Units: Activated carbon may be used to remove halo-methanes, chlorine and other organics from the filtered city water.

1. Vessel:

Construction	Carbon Steel, ASME rated
Pressure Rating	100 psi minimum,
Lining	Baked epoxy or rubber lined
Internal Headers	PVC
Face Piping	PVC
Exterior Finish	Primer base with epoxy or urethane paint

2. Operating:

Backwash	Automatic sequencing with manual initiation or automatic initiation based on pressure differential
----------	--

Electrical Requirement	Local instrumentation panel (115 VAC, single phase, 60 Hz)
Pressure gauge type:	0-160 psi liquid filled, 4 inch dial

E. RO Prefiltration: Filtration of treated water prior to the RO shall be provided to remove particulates, colloids, and organics to achieve a Silt Density Index (SDI) of 0.5 or less.

1. Filter Vessel:

Materials of Construction	304 Stainless Steel
Clean Pressure loss:	3-5 psig
Pressure Rating:	100 psig
Vents	Vents shall be provided for each vessel
Gauges	0 - 160 psig liquid filled gauges will be provided on the inlet and outlet of each bank of filters.

2. Filters:

Materials of Construction	Polypropylene or Nylon
Micron rating:	1 micron absolute (99.9%)
Style	Double open end

F. RO Units: Water shall be processed through a two-pass RO unit which shall be delivered completely assembled, tested, and skid mounted. RO output shall be controlled by throttle valves on the pump outlet and reject outlet which shall be adjustable by the operators. The RO system shall utilize one pump for each pass and shall allow either pump to operate independently to supply RO product water to the DI storage tank. The RO system shall direct second pass reject to the first pass to improve overall recovery of the RO system. The RO shall be designed to flush product water to drain at start-up until acceptable product water quality levels are achieved.

1. Design Parameters:

Design temperature	70 degrees F
Feed pressure	30 psig minimum
Overall salt rejection	>99 percent
Overall recovery	84 percent (two pass recovery)

2. RO Membranes

Materials of Construction	Thin film composite polyamid
---------------------------	------------------------------

- | | |
|------------------------|-------------|
| Typical salt rejection | >99 percent |
|------------------------|-------------|
3. High pressure pumps
- | | |
|--------------------------|-------------------------|
| Quantity | 1 each per pass |
| Type | Multistage Centrifugal |
| Material of Construction | 304 Stainless Steel |
| Electrical | 460 VAC, 3-phase, 60 Hz |
4. RO Instrumentation and Standard Accessories
- a. 3 each flow sensor assemblies (feed, product, and reject)
 - b. Automatic inlet shutoff, motor operated butterfly valve
 - c. Low feed pressure switches for RO pump for pump protection
 - d. 1 each rejection/conductivity meter for each RO pass
 - e. All high pressure piping, valves, pump throttle, check valve and reject control valve will be electropolished 316 stainless steel with all welded connections, except flanged or victaulic connections at maintenance connections (to equipment). High pressure liquid filled stainless steel pressure gauges will be provided for the inlet and outlet of each stage in the membrane including feed and reject manifolds.
 - f. All low pressure piping will be Schedule 80 PVC.
 - g. A fully assembled and tested NEMA rated (outdoor rating) electrical panel will be provided with required motor-starters, overloads, transformers and all circuitry for complete automatic operation.
 - h. A local instrumentation panel will be provided and mounted on the RO skid and shall contain, at a minimum, the following:
 - 1) flow meters
 - 2) elapsed time meters
 - 3) indicator lights
 - 4) percent rejection indication
 - 5) conductivity monitors
 - 6) audible alarm for low RO pump feed pressure and high RO pump discharge pressure
 - 7) system ready indication
 - 8) low concentrate flow alarm
 - 9) storage tank full indication
 - 10) pump operation indication
 - 11) High/low temperature alarm
 - 12)
 - i. Sample valves will be located on the product side of each RO tube, suction side of each RO pump and other locations as required.

G. DI Water Storage Tank

1. Provide a 3000-gallon capacity vertical FRP storage tank with flat bottom and dome top to store DI water prior to feed to the polish mixed bed units. Tank shall be painted white.

Storage tank shall be complete with:

- a. Lifting lugs, glassed-in holddowns, exterior paint, lower sideshell manway and flanged nozzles as necessary
 - b. Liquid level switches (low level, low low level, high level, high high level)
 - c. HEPA vent filter on vacuum relief line
 - d. Pressure and vacuum relief protection
 - e. Vapor space control for nitrogen regulation and flow sensor for blanketing under normal operating conditions as indicated below.
2. DI Water storage tank shall be complete with nitrogen blanketing valve with integral pressure relief and a vacuum relief valve as follows:
- a. Fisher model number ACE 97-211/C1/L1 nitrogen blanket and relief valve or approved equal. Tank shall have two (2) corrections as follows:
 - 1) 1 inch – 150 lbs RF for above value
 - 2) ½ inch NPT for stainless steel tubing sensing element.
 - b. Varec model number 3500 B vacuum relief valve.

H. DI Distribution Pumps

Quantity	2 each
Manufacturer	Gould or equal
Type	Horizontal, centrifugal
Material of construction	316 stainless steel electropolished, 10 Ra (minimum), pickled and passivated
Operation	2 pumps capable of 70% max. flow.
Motor type	TEFC 1.15 SF
Electrical	460 VAC, 3-phase, 60 Hz
Instrumentation	4 inch (0 - 160 psi) liquid filled gauges with gauge guard, pressure transducer on inlet and outlet with output to PLC

- I. TOC Reduction UV Units: UV units shall be used to reduce the TOC of RO product water prior to demineralization in the polish resin beds. UV units will be sized to allow one unit to be taken off line for maintenance while maintaining 100% UV destruction capability.

Material	316L stainless steel wetted parts, 25 Ra nominal finish
UV output	185 NM wave length
Function	TOC reduction
Electrical	120 VAC, 3-phase, 60 Hz
Protection	Overtemperature thermistor
Instrumentation/accessories	LED display, intensity meter, running time hour meter assembled in a 304 stainless steel NEMA 4X enclosure, lamp out alert circuit.

Material	316L passivated stainless steel wetted parts, 25 Ra nominal finish
Output	254 nm
Function	Bacterial control
Electrical	120 VAC
Accessories	LED display, intensity meter, running time hour meter in a 304 stainless steel NEMA 4 enclosure, lamp out alert circuit
Electrical Protection	Overtemperature thermistor
Piping	Light traps required
Miscellaneous	Stainless steel piping shall be provided on UV inlets and outlets to prevent degradation of UV susceptible piping

O. Final Filtration:

1. Vessel:

Material of construction	316L passivated stainless steel, electropolished 25 Ra nominal internal
--------------------------	---

2. Filter:

Filter Micron rating	0.1 μ absolute (99.999 % efficiency)
Material of construction	Polysulfone
Clean pressure loss	3-5 psig
Type	Single open end, double o-ring

P. System Controls and Instrumentation: All specified controls, alarms, quality monitors, flow indicators, pressure gauges and regulators will be supplied as required for proper system operation. The following instruments are representative of those to be provided.

1. Resistivity Monitor:

Manufacturer	Thornton or equal
Model	Series 770 Max
Range	0-18 Megohms

2. Flow Monitors

Manufacturer	Rosemount or Danfoss
Output signal	4-20 mA

3. Pressure Gauges:

Manufacturer	Ashcroft or equal
Size	4 inch diameter x 1/4 inch stem
Range	0-160 psi
Material	316 stainless steel with gauge guard as necessary

4. Pressure Transducer:

Manufacturer	Rosemount/Weed or equal
Type	Flanged Insert
Material	316 S.S.
Output	4-20 mA
Range	0-160 psi

2.5 CONTROL SYSTEMS

A. Control System:

1. A programmable control system, using programmable logic control (PLC) components, will be supplied to control all DI water system operations. This unit shall be installed in a NEMA 4 enclosure that shall include all necessary electrical components for the PLC to operate. The PLC shall be provided with an additional 20% input/output ports to allow for future needs. The control system panel may be located remote from the DI water system skids (within 200 feet) and shall interface with any local instrumentation panels on any DI water system skid.
2. The control system will receive digital and analog signals from pump skids and monitoring instruments (flow, level, pressure, resistivity, etc.) and send digital and analog signals to equipment (start/stop, change speed, etc.).
3. The control system shall provide a single alarm output (digital or contact closure) to the Owner's central facilities monitoring system.
4. The control system enclosure shall have a face-flush mounted LED type digital display with a minimum 80 character display. The display shall indicate alarm conditions by identifying the DI water system component and the reason for alarm.
5. An audible alarm (horn) and light shall be mounted on the face of the panel to indicate an alarm condition. An acknowledge push button shall be provided to silence and clear alarm.

B. Remote Instrumentation Panels: NEMA 4 instrumentation panels will be provided at each skid. Remote panels will contain all required electrical components and instrumentation as previously specified with each element for proper system operation. Typical elements that may be included in the remove instrumentation panels are as follows:

1. Solenoid valves
2. Air supply inlet pressure regulator

3. Selector switches
4. Indicator lights
5. Flow meters
6. Temperature controllers
7. Differential pressure sensors
8. Conductivity monitors
9. Motor starters
10. Disconnect switches
11. Level indicators
12. Pressure sensors/switches
13. Control transformers
14. Chemical level interfaces
15. Temperature indicators

PART 3 - INSTALLATION

3.1 INSPECTION

- A. An area shall be designated on site to receive all high purity components. It shall be well lighted and provide storage off ground. There shall be controlled and limited access to this area.
- B. One hundred percent of all components shall be inspected in this area prior to installation. Cause for rejection can include, but not be limited to, damaged packing, dented surfaces, inappropriate identification and any other condition that does not otherwise conform to the specifications listed here. Any rejected components will be returned to the supplier for immediate replacement at no charge to the Owner.

3.2 ACCEPTANCE

- A. Each entire skid unit shall be pressure tested to 150% of the normal operating pressure at the factory for a period of 4 hours with no loss in pressure. Testing may be witnessed by the Owner or Owner's Representative.
- B. Startup Sequence: Sequential qualification of equipment skids shall be performed to eliminate the possibility of entire system contamination. Startup sequence will therefore be as follows:
 1. Qualify pre-treatment prior to connection to the RO system.
 2. Qualify RO plant prior to connection to the system.
 3. Qualify each of the primary mixed beds prior to connection to the system.
 4. Similarly, qualify each of the polishing equipment elements of the system prior to connection of the next element or connection to the main piping loop.
 - a. The above sequential qualification requires strategically located diverter valves (dumps to drain) to allow proper rinse down of elements during qualification.
- C. Field Tests: Upon completion of the start-up sequence, the polish and distribution loop system shall be pressure tested at at 150% of the operating pressure for 72 hours to check for pressure loss. Following the pressure test, the system will be sanitized with hydrogen peroxide or other Owner approved material. The vendor shall provide a loop sanitization procedure for approval by the Owner. A 72 hour qualification period shall follow at the end of which samples shall be taken at a point leaving the final DI skid, as well as at 10 point of use locations throughout the system which shall show confirmation of the DI water quality with the requirements of Appendix A.

APPENDIX A - DI WATER SYSTEM WATER QUALITY REQUIREMENTS

SPECIFICATIONS FOR FINAL WATER QUALITY	
TEST	REQUIREMENT
Resistivity @ 25°C	18.1 - 18.2
TOC (ppb) Off Line	<10
TOC (ppb) On Line	<5
Particle/L by SEM	
0.1 - 0.2 1μ	<200
>0.2 - 0.5 1μ	<100
>0.51μ	<1
Particle/L by laser on line counter	
0.05 - 0.1 μ	<100
0.1 - 0.2 μ	<50
0.2 - 0.3 μ	<20
0.3 - 0.5 μ	<10
>0.5 μ	<1
Bacteria count/100mL	
by culture 100 mL sample	<1
1000 mL sample	<0.1
by EPI	<10
Silica (ppb)	
dissolved	<1.0
total	<2.0
Residue (ppm) batch	<0.1
Ions (ppb) by Ion Chromatography	
Cations: Na+	<0.01
K+	<0.02
NH4+	<0.02
Mg++	<0.02
Anions: F-	<0.1
Cl-	<0.02
Br-	<0.02
NO3-	<0.02
NO2-	<0.02
HPO4=	<0.02
SO4=	<0.05

END OF SECTION 15545