SECTION 43 32 56

REVERSE OSMOSIS (RO) SYSTEM
04/08

PART 1 GENERAL

1.1 GENERAL

a. This section covers the work to be performed by the RO Equipment Manufacturer (ROEM) under contract to the Contractor. The Reverse Osmosis (RO) membrane system consists of two 1.5 mgd (permeate capacity) membrane trains with provisions for 1 future train (1.5 mgd), complete with valves and piping as specified herein and as shown on the Drawings. The membrane system permeate will be blended with a controlled bypass flow stream resulting in the total membrane system product. The ROEM shall design, fabricate, ship to the Site, install, startup, and test the RO membrane system. The ROEM shall provide the RO system complete with membrane elements. The design shall meet all membrane manufacturer warranty requirements.

b. The Contractor and the ROEM shall furnish to the Owner all certifications and warranties specified herein.

c. The ROEM and the Contractor shall coordinate with suppliers and subcontractors for integration of all equipment and facilities, as appropriate, to provide a complete and operating system.

d. The ROEM or qualified subcontractor to the ROEM shall provide all process-related equipment, piping and appurtenances located on the membrane trains and within the limits of supply, as shown on Drawings. All other items shall be provided by Contractor, as specified or as shown on the Drawings. Although not a complete listing, the following items are specified in other sections and shall be provided by the Contractor and its subcontractors:

1. Cartridge filters.

2. RO feed pumps.

3. RO flush tank and pump.

4. Cleaning-in-place (CIP) tank and pump system.

5. RO feed, concentrate, permeate, and cleaning solution headers to/from the Membrane trains via pipe trenches or as shown on the Drawings.

6. Process Instrumentation and Control Systems (PICS), including instrumentation and computer hardware and software, that is not specified as to be provided by the ROEM.

7. Electrical and control wiring and conduits, except on the RO membrane trains specified as to be provided by the ROEM.

e. The work performed under this section shall comply with all of the applicable requirements of Section 09 90 00.00 40, PAINTING AND COATING;

Section 40 95 00, PROCESS CONTROL; Section 40 05 13, PIPELINES AND LIQUID PROCESS PIPING; and Division 26, Electrical.

f. Patents:

1. The ROEM shall warrant that the use of the membrane elements, in the process for which the system has been expressly designed by the ROEM hereunder, will not infringe on any U.S. or foreign patent recognized by the U.S.A.

2. The ROEM shall grant Owner in perpetuity a paid-up license to use any inventions covered by patent or patents pending, owned, or controlled by the ROEM in the operation of the facility being constructed hereunder, without the right to grant sublicenses.

g. The system specified herein shall be the end product of one approved ROEM and like items of equipment shall be the product of one manufacturer to achieve standardization of performance, operation, spare parts, maintenance and manufacturer's service. Membrane train instrumentation shall be coordinated with instrumentation supplied by the Process Instrumentation and Control System (PICS) Subcontractor and the Contractor. Where applicable, the ROEM shall supply similar types/models/manufacturers for instruments being provided by the PICS Subcontractor/Contractor.

h. The RO membrane trains provided under this Specification shall be complete and operable in all respects including, but not limited to, connections to other facilities, lubricants, component and system tests, calibration, alignment, and adjustments as necessary to place the system in operation to perform its intended function, and meet all the requirements specified herein.

i. See General Conditions of the Contract and Division 1, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 36	(1992) Structural Steel
ASTM D 4189	(2001) Standard Test Method For Silt Density Index (SDI) of Water
ASTM D 4516	(2007) Standard Practice for Standardizing Reverse Osmosis Performance Data

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G, AE

General train plan and elevation Drawings (all four sides) showing first and second stage pressure vessel locations, piping headers and manifolds, instrumentation sampling/pipe tap points, overall dimensions, approximate piping interface points, and panel location. Plan should show relationship to trench walls and building walls and Drawings shall show flow stream ID and flow directions.

Drawings and descriptions of all items of equipment, showing all dimensions, parts, construction details, materials of construction, and bill-of-materials.

Control panel layout, schematics and wiring Drawings.

SD-03 Product Data

Membrane Element and Pressure Vessel; G, AE

Membrane element and pressure vessel catalog cut sheets, including a certified statement from the membrane manufacturer specifying the active membrane area for the proposed membrane element model.

Technical bulletins from the membrane manufacturer describing chemical solutions and protocols for membrane cleaning, short-term storage, and long-term storage.

Review comments of loop descriptions and sequence of operation specified in Section 40 95 00, PROCESS CONTROL.

SD-05 Design Data

calculations; G, AE

Submit computer membrane performance projections for a 1.5 mgd permeate capacity train. The projections shall be based on the three "cases" of raw water quality criteria specified herein in Table 1 (Article 3.6, DESIGN RAW WATER QUALITY), the permeate criteria in Table 2 (Article 3.7, RO PERMEATE WATER QUALITY REQUIREMENTS) and the Bidder's proposed design, as constrained herein. Projections shall be made for 0, 1, 3, and 5 years of operation at the design flux and recovery for each raw water quality case. Water quality of the permeate/bypass blend (system product) at the design bypass ratio shall be included in a separate summary table based on 3 years' operation membrane performance projection for each raw water quality.

Field and installation information, including mounting requirements, sampling locations, access, approximate total weight of each major piece of equipment, and required conduit size and routing.

Seismic calculations for equipment anchorage, pipe supports, and RO framework, stamped and signed by a Registered Civil or Structural Engineer currently licensed in the State of California,

using design criteria as stated on Drawing G-10, Structural Construction Notes.

SD-06 Test Reports

Test Data; G, AE

All membrane element test data for the manufacturer's standard factory tests for each membrane element.

SD-07 Certificates

manufacturer's certificate

Provide Manufacturer's Certificate of Proper Installation

SD-08 Manufacturer's Instructions

start-up procedures; G, AE

Field and installation information, including mounting requirements, sampling locations, access, approximate total weight of each major piece of equipment, and required conduit size and routing.

Detailed startup procedures and timetable to include membrane train disinfection, membrane loading and flushing, and testing.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual; G, AE

As specified in Section 01 78 23, OPERATION AND MAINTENANCE DATA.

Manuals for the complete membrane treatment system and recommended spare parts list with manufacturer's name, address, telephone numbers, and manufacturer's part number at least 30 days prior to the membrane system startup.

1.4 RO EQUIPMENT MANUFACTURER

The ROEM shall be one of the following companies:

1. Membrane Systems Inc., (Goleta, CA).

2. Lane Christensen (New Berlin, WI).

3. Doosan Hydro Technology, Inc. (Tampa, FL).

1.5 DEFINITIONS

a. Applied Pressure: Membrane train feed pressure minus permeate pressure.

b. Concentrate Pressure: The hydraulic pressure of the concentrate flow stream at the inlet of the membrane train concentrate flow control valve.

c. Delta P or Differential Pressure (for a Membrane Train): Feed pressure minus concentrate pressure for overall membrane train; feed pressure minus interstage pressure for Stage 1 Delta P; interstage pressure minus

concentrate pressure for Stage 2 Delta P.

d. Feed Pressure: The hydraulic pressure at the feedwater supply inlet of the membrane train downstream of the feed water-throttling valve, if applicable.

e. Flux: Permeate flow rate divided by active membrane area of all membranes contributing flow.

f. Interstage Pressure: The hydraulic pressure of the first stage concentrate which equals the second stage feed pressure.

g. Membrane: Reverse osmosis element in spiral wound configuration (membrane and membrane element are used synonymously).

h. RO Train or Membrane Train: A grouping of membrane elements and pressure vessels and associated piping, valves, electrical and control facilities, as applicable, which operate as a unit control block with single feed, permeate, and concentrate flow streams.

i. Normalized salt passage, normalized permeate flow rate, and normalized Delta-P: A numerical adjustment of salt passage, permeate flow rate, and Delta-P to a constant set of standard conditions (standard factory test conditions for performance testing report and actual plant operating conditions at the 24-hour operation for plant historian computer) using computer programs approved by the Engineer as specified herein.

j. Online Factor: The volume of permeate produced by the treatment system since commissioning divided by the potential volume of permeate that would be produced if the system operated at rated production rate 24 hours per day, 365 days per year since commissioning.

k. Permeate Pressure: The hydraulic pressure at the permeate outlet of the membrane train.

l. Recovery (or Permeate Recovery): The permeate flow rate divided by the feedwater flow rate; typically expressed as a percentage.

m. RO Permeate: The portion of the feed stream that passes through an RO Membrane.

n. Salt (or Specific Solute) Passage: The permeate total dissolved solids (TDS) (or solute) concentration divided by the feedwater TDS (or solute) concentration; typically expressed as a percentage.

o. Salt (or Specific Solute) Rejection: Feedwater TDS (or solute) concentration minus permeate TDS (or solute) concentration then divided by the feedwater TDS concentration; typically expressed as a percentage. Also equal to 100 percent minus the percent salt (or solute) passage.

p. Solute: One or more substances dissolved in the solvent (water).

q. Stage: In a membrane train, the parallel group of pressure vessels containing membrane elements that receive a common water supply to treat; Stage 1 receives the membrane train feedwater and Stage 2 receives the Stage 1 concentrate (also called interstage) water for treatment.

r. Train and Process Train: Synonymous with membrane train.

1.6 DESCRIPTION OF OVERALL TREATMENT PROCESS

a. The Perris II Desalination Facility will be located southwest of the existing Perris Valley Regional Water Reclamation Facility (PVRWRF). It is planned that the overall treatment process will be expanded in the future by adding a Fe/Mn filter, RO train, pumps and associated pipes and valves as shown on the Drawings to meet additional potable water needs.

b. Groundwater from wells will be pumped to the supply pipeline network and then to the new treatment facilities at the plant site. Raw water in a common supply line will be chlorinated and pass through an Iron and Manganese (Fe/Mn) Removal System. The Fe/Mn Removal System product water will be dechlorinated before entering the membrane trains.

c. Additional RO system pretreatment processes include sulfuric acid for pH adjustment (as needed), threshold inhibitor chemical addition for membrane system scale prevention, and cartridge filtration for particle removal. Three parallel cartridge filters shall be installed and sized for 3 RO trains. Pretreated water shall flow in a common feed header to the membrane feed pumps. Furthermore, a membrane feed bypass line shall be installed to blend with combined membrane permeate in a ratio dependent on water quality criteria.

d. Each train shall have a dedicated membrane feed pump. An additional membrane feed pump will be added in the future when the plant is expanded. Each membrane feed pump motor shall be driven by a Variable Frequency Drive (VFD).

e. Initially two RO membrane trains shall be installed, including pressure vessels, support frames, piping, valves, and electrical and instrumentation facilities. Header piping and other facilities shall be constructed to accommodate one additional train that is planned for the plant. Each membrane train shall be identical and shall be designed to remove salts, soften the pretreated water, and meet all specified performance requirements. The membranes installed in the trains will be thin film composite type and, therefore, should not be exposed to chlorine or other strong oxidants, which may cause membrane damage.

f. The trains shall be automatically controlled using a programmable logic controller (PLC) based control system. The permeate and concentrate flow rates (and thus, recovery) of each train shall be controlled primarily by automatic adjustment of the appropriate feed pump VFD and concentrate throttling valve. In each train, an energy recovery turbocharger shall be installed as well as an automated permeate backpressure throttling valve for Stage 1 for "flux balancing."

g. Permeate (product) water from each train shall be combined in a header, and piped through a common line from the membrane building to the decarbonator tower. The design of the RO System is based on a blend where 80-90 percent of the finished water is membrane permeate and 10-20 percent is membrane bypass.

h. One decarbonator tower with blower shall be installed to remove carbon dioxide. Water will fall by gravity through the decarbonator packing into a clearwell and then gravity flow to a Chlorine Contact Tank (CCT) after blending with membrane bypass water. The product water shall be pumped to distribution system.

i. RO concentrate from each membrane train shall be piped through a

common line from the membrane building to a concentrate pump station and then discharged into EMWD's brine collection system.

j. The RO trains shall be cleaned by a membrane Cleaning-In-Place (CIP) System, which is sized to clean each membrane train stage in a single step (two steps per train per cleaning solution type). The two RO trains will be connected to RO cleaning headers (CPR, CCR, and CF), that will be installed in a trench running under the trains. The trains will have "hard-piped" cleaning lines with isolation spools.

k. The RO trains shall be flushed by an automatically-initiated and SCADA-controlled RO permeate flush system in the event of an unplanned shut down. The trains shall also be able to be flushed by a manually-initiated and SCADA-controlled permeate flush.

1.7 MEMBRANE SYSTEM PERFORMANCE CRITERIA

a. Water Quality Analyses:

1. Water analyses shall be conducted in accordance with the appropriate approved methods in the latest edition of "Standard Methods for the Examination of Water and Wastewater (Standard Methods)," except as otherwise approved by the Engineer.

2. The total dissolved solids (TDS) concentration (for warranty purposes) shall be calculated by adding the concentrations of calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, strontium, and silica.

3. Total trihalomethane formation potential (TTHMFP) shall be determined by measuring the total trihalomethane concentration per EPA Method 502.2 or Standard Methods 6232.B of a chlorinated sample, prepared per Standard Methods 5710B at a buffered pH 7.0, at a temperature of 25 degrees C, and by exposure to the specified free chlorine residual for a 7 day contact period.

4. Total haloacetic acid formation potential (THAAFP) shall be determined by measuring the total haloacetic acid concentration per Standard Methods 6233.B of a chlorinated sample, prepared per Standard Methods 5710B at a buffered pH 7.0, at a temperature of 25 degrees C, and by exposure to the specified free chlorine residual for a 7-day contact period.

b. The RO system shall be designed based on the three raw water quality cases shown in Table 1, (Article 3.6 DESIGN RAW WATER QUALITY).

c. Each RO train shall meet the RO permeate quality criteria specified in Table 2, (Article 3.7 RO PERMEATE WATER QUALITY REQUIREMENT) throughout the 3-year membrane element performance warranty period when operating at 72 percent recovery and 1.5 mgd permeate flow rate and when treating pretreated raw water with TDS, chloride, and nitrate-nitrogen less than or equal to 3,500, 1,850, and 11.3 mg/L, respectively.

d. Throughout the 3-year membrane element performance warranty period, each membrane train shall produce 1.5 mgd of permeate water at 72 percent recovery rate at an applied pressure between 125 and 185 psig (equivalent to 150 psig and 200 psig, respectively with an assumed overall train (Stage 2) permeate pressure of 15 psig) when treating pretreated raw water with TDS less than or equal to 3,500 Mg/L at water temperature no less than 19

degrees C. The maximum applied pressure while operating at design conditions after 24 hours of operating time shall not exceed 160 psig.

e. The ROEM shall install membrane elements in positions determined after review of factory test data (by element serial numbers). The permeate conductivity from each pressure vessel shall be within plus or minus 20 percent of the average conductivity of the combined permeate for the stage of the train in which it is installed.

f. Each train shall allow flux balancing (between the two stages) using an automated Stage 1 permeate throttling valve as specified herein. The average train flux shall not exceed 13.9 gallons per day per square foot of active membrane area (gfd).

g. When tested under the manufacturer's published standard test conditions, each individual membrane element shall have a rejection equal to or better than the minimum rejection specified in the membrane element's product bulletin and shall have permeate flow as stated in the membrane element's product bulletin for average (or design) productivity plus or minus 15 percent, or less variance if specified in the RO element product bulletin. The average rejection and productivity of all membrane elements in each process train shall meet or exceed average (or design) specifications published in the standard membrane element's product bulletin when tested at standard test conditions.

1.8 DELIVERY, STORAGE, AND HANDLING

a. Delivery of equipment, spare parts, and special tools shall be properly marked to identify the associated equipment by name, P&ID tag number (if applicable), and manufacturer part number. Parts shall be packaged in a manner for protection against damage from the elements during shipping, handling, and long term storage. All spare parts and special tools shall be packaged complete and shipped at one time in appropriately sized, hinged, covered, hard plastic or metal boxes. The boxes shall be marked to indicate all contents by name and part number. Parts shall be numbered and named in accordance with Operation and Maintenance Manual identification system.

b. Insofar as is practical, the equipment specified herein, shall be factory assembled. The parts and assemblies that are shipped unassembled shall be packaged and tagged in a manner that shall protect the equipment from damage and facilitate the final assembly in the field. Generally, machined and unpainted ferrous metal parts shall be protected from the elements by the application of a strippable protective coating.

c. Weight, handling instructions, type of storage required, and instructions for protective maintenance during storage shall be included with each shipment to the Construction Site.

d. Membrane Element and Pressure Vessel: The membrane elements shall be loaded into the pressure vessel after the trains (without membranes) are installed at the Site and after the simulated test using orifice plate and as approved by the Owner. The membrane elements shall not be shipped to the Site more than 1.5 months prior to loading into the pressure vessels.

1.9 SEQUENCING AND SCHEDULING

a. See GENERAL CONDITIONS.

b. Coordinate projected RO feed flow and pressure requirements with the RO feed pump supplier.

1.10 WARRANTY

a. Workmanship and Materials: The ROEM and Contractor shall warrant the system provided hereinunder as specified in the General Conditions and herein. The membrane system components shall be manufactured from all new materials and designed and constructed for potable water production and shall be free of defects in material and workmanship under normal conditions for 1 year after acceptance and free from liens and encumbrances. Should any defect in material and workmanship be discovered within 1 year, the deficient item(s) shall be repaired or replaced by the ROEM, at no cost to the Owner. Should there be any defect in material and workmanship in the membrane element(s), the membrane element(s) shall be removed and replaced by the ROEM with new elements at no cost to the Owner.

b. Special Membrane Element Performance Warranty: ROEM and RO element manufacturer shall warrant directly to the Owner that the provided membrane elements in each train will meet all membrane system performance criteria specified herein for a period of 3 calendar years from the date of Substantial Completion of the Membrane System at the water treatment plant site and acceptable production (permeate quantity and quality) at the design flux and recovery rate. It is understood that the Owner is obligated to operate the membrane system within critical operating criteria (submitted by the ROEM and approved by the Engineer and Owner prior to initial startup) which shall be clearly defined in the Operations and Maintenance Manual. Should the actual performance for a train fail to meet all system performance criteria, as specified, the ROEM shall provide new replacement elements on a prorated cost basis to restore performance to warranted levels. The Owner's cost for said replacements shall be limited to the standard commercial price per element at that time, or $450 base price per 8 inch diameter, 40 inch long element (adjusted by the Federal Consumer Price Index at the time of the warranty claim) whichever is less. The prorated rebates shall be based on 1/36 of the cost per month for each month remaining in the 3 year warranty period.

c. The guaranteed RO system performance shall be based on "case 3" design raw water quality specified in Table 1 (Article 3.6 DESIGN RAW WATER QUALITY) with a concentrated stream LSI no greater than plus 2.0. For the constituents specifically listed in the membrane system product water quality criteria specified herein, if the actual raw water has constituent concentration(s) greater than the "case 3" design value(s) shown in Table 1 (Article 3.6 DESIGN RAW WATER QUALITY) then for purposes of determining compliance with this performance warranty, the corresponding RO permeate quality concentration(s) for the constituent(s) shall be increased in the same proportion that the raw water constituent(s) exceeds the design concentration(s). If the required applied pressure to produce the specified permeate flowrate exceeds the maximum allowable applied pressure specified herein and the actual raw water TDS exceeds the design value or raw water temperature varies from the design for purposes of determining compliance with this performance warranty, an "adjusted" applied pressure shall be used based on ASTM D 4516, Standard Practice for Standardizing Reverse Osmosis Performance Data.

1.11 OPERATIONS AND MAINTENANCE MANUAL

a. Provide in accordance with GENERAL CONDITIONS.

b. The ROEM shall prepare a comprehensive operations and maintenance manual for the system specified herein. Manual format and contents shall comply with the requirements of the Section 01 78 23, OPERATIONS AND MAINTENANCE DATA. The manual shall include information on the operation and maintenance of the individual components of the system and start-up procedures, and on the operation of the overall package system. The manual shall also include clearly defined critical and reasonable operating criteria that may, if not met, result in irreversible membrane damage. Operating criteria shall be based on membrane manufacturer's requirements, typical industry practices, and procedures for approval by Engineer and Owner. Manual shall be provided as hard copies and electronic files (MS Word and PDF).

PART 2 PRODUCTS

2.1 GENERAL

a. The use of manufacturer's model or catalog numbers herein is for the purpose of establishing item quality and configuration desired. Equipment by others must be evaluated and approved by the Engineer before acceptance for use on this project.

b. All components that come into contact with drinking water or drinking water treatment chemicals shall be in conformance with NSF International (NSF) Standard 61.

2.2 EQUIPMENT DESCRIPTION

A. Cartridge Filters:

1. Equipment Numbers:

a. CF-10110

b. CF-10120

c. CF-10130

2. Cartridge filter vessels shall be the horizontal type, and provided as shown on the Drawings and shall have a hydraulic capacity of 3.35 mgd, each.

3. Each filter vessel shall be of Alloy 2205 duplex stainless steel construction. The vessel shall be rated for 150 psi working pressure maximum and constructed to Section VIII of the ASME Boiler and Pressure Vessel Code. Filter element guides, compression springs, and sealing components shall be Alloy 2205 duplex stainless steel. Filter O-rings and vessel cover seal shall be EPDM.

4. The vessel shall have stainless steel hex nuts, swing bolts and cover-lift assembly.

5. Each cartridge filter vessel shall have the following connections:

a. One each, 12-inch Class 150 flanged inlet located on top of the vessel.

b. One each, 12-inch Class 150 flanged outlet.

c. Two ½-inch NPT couplings, one on either side of the separation plate, for manual measurement of differential pressure and sampling and venting.

d. Two outlets, one 2-inch NPT on the filter side of the separation plate (unfiltered water zone) and one 2-inch NPT in the filtrate plenum (filtered water zone), for draining the vessel.

6. The cartridge filter vessels shall be Model 6LMP118H-4-12FK1 as manufactured by Commercial Filters Division of Parker Hannifin or equal.

7. The filter cartridges shall be 2-1/2-inch nominal O.D., 1-inch nominal I.D. wound type of all food grade polypropylene construction. They shall have a nominal rating of 5 microns and shall be 40-inches long. The Contractor shall supply 354 of these filter cartridges to load the three filter housings and provide a spare load of 354 replacement cartridges.

B. RO Feed Pumps and Variable Frequency Drives:

1. Equipment Numbers:

a. P-10210.

b. P-10220.

2. The RO feed pumps and variable frequency drives (VFD), are specified in Section 43 21 39, PUMPS: WATER, VERTICAL TURBINE Section 26 29 23, VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS and Section 26 60 13, LOW-VOLTAGE MOTORS.

3. The VFD's shall be furnished by Electrical Subcontractor.

C. RO Trains (by ROEM):

1. The ROEM shall be responsible to provide two identical two-stage membrane trains and shall provide all equipment and other components required for a complete integrated system as described herein.

2. The following subsystems and components are included in each membrane train:

a. Membrane elements and pressure vessels (8-inch nominal diameter); support frame; piping and valves for feed, interstage and final concentrate, permeate, permeate to waste, membrane flushing and cleaning; piping and valves; hydraulic turbocharger, sample valves, tubing and sample panel; instrumentation; and I/O panels.

b. All required components for a complete installation, including but not limited to, appropriate anchor bolts, piping supports, hardware, surface preparation, and shop and field painting.

D. The proposed RO system shall be designed by the ROEM and meet the following criteria:

1. Two 2 stage trains, 1.5 mgd permeate each (3 mgd total permeate).

2. The average train membrane flux rate shall not exceed 13.9 gallons per square foot per day (gfd). The average flux of the membrane elements in an individual stage shall be between 8 and 18 gfd over the first 5 year operating period. Stage 1 permeate throttling may be used, in addition to the turbocharger system, to control the individual stage flux rates within the specified range (e.g. flux balancing).

3. The maximum allowable feed pressure at startup (24 hours of operating time) shall be 175 psig and the maximum allowable projected feed pressure at 5 years' operation shall be 205 psig under the same condition, assuming 15 psig overall train (Stage 2) permeate pressure.

4. Provide an automatically-controlled (Stage 1 permeate backpressure throttling valve) in each train to "balance" flux rates between the stages.

5. Raw water in Table 1, (Article 3.6, DESIGN RAW WATER QUALITY), and RO permeate in Table 2, (Article 3.7, RO PERMEATE WATER QUALITY REQUIREMENTS), water quality shall be used as basis of the design for the RO system.

6. Meet RO permeate water quality criteria shown in Table 2.

7. Membrane system product water (permeate/bypass blend) quality criteria is using a membrane bypass flow of up to 20 percent of the blended product (total permeate plus membrane bypass flow).

8. Each train shall be designed using the specified feed water qualities (see Table 1 of this Section) and have a concentrate stream meeting the following criteria:

a. Langelier Saturation Index (LSI) plus 2.0 or less.

b. Calcium sulfate - ion product not to exceed 1.5 times solubility product.

c. Strontium sulfate - ion product not to exceed 8 times solubility product.

d. Barium sulfate - ion product not to exceed 40 times solubility product.

e. Silica - not to exceed 2.0 times theoretical solubility.

9. All piping shall be rated as a minimum to withstand a test pressure of 1.5 times the maximum operating pressure.

10. Each membrane train shall be designed to operate at a recovery ranging from 70 percent to 75 percent. The operating recovery will be dependent on the actual raw water quality.

11. The design shall assume a Stage 2 (overall train) permeate pressure of up to 5 psi.

12. The design shall assume that each train will have a concentrate pressure downstream of the control valves at the connection to the concentrate header of at least 5 psi.

E. Nominal 8-inch diameter membrane elements shall be designed to be

loaded into 8-inch (nominal) diameter pressure vessels capable of holding seven 8 inch diameter, 40 inch long (approximate) elements and meet the following criteria.

1. The membrane elements shall be spiral wound with the feed and concentrate flow through the element parallel to the central product water tube of the element. Each element shall have nominal dimensions of 8 inches in diameter and 40 inches in length. Elements shall be designed to operate at pressures up to 250 psig minimum. The membrane elements shall be complete with brine seals, interconnectors, O-rings, spacers, and any adapters necessary to make the membrane fully compatible with the pressure vessels. The brine seal and O-rings shall be made of ethylene propylene rubber. Membrane element shall have a fiberglass reinforced plastic outer wrap.

2. The membrane elements shall be thin film composite and be standard low pressure reverse osmosis commercial products of one of the following manufacturers (listed in alphabetical order):

a. DOW/FilmTec.

b. Hydranautics.

c. Toray Americas.

3. The active membrane area of each membrane element shall not exceed 440 square feet.

4. The membrane elements shall have a nominal feed-concentrate channel spacer with a thickness of 26 mils or greater.

a. Membrane types must be compatible with and may use identical cleaning and storage solutions.

b. Only one membrane element type will be allowed in each train.

F. Provide each membrane train as follows:

1. Each RO membrane train, including train piping, shall fit within the space limits shown on the Drawings and shall not exceed the following overall dimensions: (1) length = 26 feet maximum, (2) width = 12 feet maximum, and (3) height = 12 feet maximum.

2. The RO membrane trains shall be designed to allow pressure vessel installation/removal inside the facility once each train is installed, without complete train disassembly.

3. Each RO membrane train frame shall be designed and constructed to support all loads, including, but not limited to, full-rack quantity of membrane elements and pressure vessel, valves and piping when filled with water, and panels. Each train framework shall be designed to support "7M" pressure vessels (which hold seven nominal 8-inch by 40-inch membrane elements) at three points per manufacturer's recommendations. The centerline of the bottom pressure vessels in the framework shall be 2 feet 6 inches above the floor, minimum, assuming the frame is mounted on 1-inch thick grout pads (refer to the Drawings).

4. The membrane pressure vessels shall be designed and constructed in accordance with the latest edition of the ASME Boiler and Pressure

Vessel Code, Section X, Fiberglass - Reinforced Plastic Pressure Vessels and shall be code-stamped. As a minimum each vessel shall have the following features:

a. Pressure vessels shall have a diameter and length so as to contain multiple nominal 8-inch diameter, 40-inch length spiral wound membrane elements. Each vessel shall be of sufficient length to house seven, according to Membrane Element Supplier specifications (i.e., 7M pressure vessel).

b. The shell of the vessel shall be the side port entry type and shall be fabricated of filament wound fiberglass reinforced plastic (FWFRP) using continuous glass roving impregnated with an elevated temperature cure epoxy resin system. Materials of construction shall be lot traceable to vessel serial number. All wetted components in continuous contact with the pressurized process water shall be made from plastic or metal proven to have long-term resistance to corrosion in the service intended. All other materials of construction shall be of appropriate strength and corrosion resistance for the operating conditions.

c. Vessels shall be designed for a working pressure of 250 psi, minimum, at 120 degrees F.

d. Each shell inside diameter shall be free of pits or voids and shall conform to acceptance Level 1 criteria as defined in ASME Section V, Article 28, SD2563. The bore diameter shall be a mirror-like smooth surface and meet the following measurement criteria throughout the membrane interface area: 7.955 plus or minus 0.005 inch for nominal 8 inch diameter vessels.

e. The shell exterior surface shall be smooth with polyurethane enamel (which blocks light) and shall be free of grinding and sanding marks.

f. The vessels shall be designed to allow industry-standard sized nominal 8-inch by 40-inch membrane elements to be easily accommodated by changing end connectors (outboard adapters) and spacers (to prevent movement of the elements within the vessels). The ROEM shall furnish the appropriate end connectors (outboard adapters and spacers).

g. Vessels shall be so designed as to allow membrane elements to be connected to the permeate port at either end of the vessel so that permeate can be taken from either end.

h. Pressure vessels shall be painted white, and shall match the system support color.

i. End closures shall incorporate an approved quick-opening locking mechanism and shall be so designed as to minimize the force required to install and remove the head. The locking mechanism shall be so designed that the failure of any one component of the mechanism shall not allow the mechanism to release. The locking mechanism shall incorporate a safety interlock, which secures the primary locking components and provides a measure of tamper resistance. The locking mechanism shall be so designed as to allow easy visual assurance that all components are in serviceable condition, in place, and fully

engaged.

j. One set of special tools available from the Pressure Vessel Manufacturer shall be provided which aids end cap and/or membrane element installation and removal.

k. Pressure vessels shall be as manufactured by Bekaert Progressive Composites, or Pentair Water Treatment/CodeLine.

5. "High" pressure (90 psig or greater process stream pressure) feed, interstage, and final concentrate piping as well as cleaning solution feed (CF) and cleaning solution concentrate return piping (CCR) and isolation Victaulic caps as necessary on the "train side" of the isolation piping spools, shall be constructed of welded Type 316L stainless steel pipe in accordance with Section 40 05 13, PIPELINE, LIQUID PROCESS PIPING.

6. Low pressure piping (below 90 psi maximum process stream pressure) shall be either Type 316L stainless steel for sizes 8 inch diameter or larger, PVC for sizes less than 8-inch diameter, in accordance with Section 40 05 13, PIPELINE, LIQUID PROCESS PIPING, as appropriate. Membrane train permeate manifolds and piping to pressure vessel permeate connections shall be Type 316L stainless steel only.

7. Each membrane train shall have stainless steel panel-mounted sample valves to permit collecting representative samples from each high and low pressure manifold and all pressure vessel permeate streams (from the end of the vessels where permeate is collected during service). Sample valves shall be as specified in Section 40 05 13, PIPELINES, LIQUID PROCESS PIPING; 1/4-inch-V308. All sample lines, except for individual pressure vessel permeate streams, shall have Type 316 stainless steel (maximum pressures equal to or greater than 90 psig) or PVC (maximum pressures less than 90 psi) isolation valves at the pipe connections (in addition to the panel mounted valves). All high pressure tubing and fittings (90 psig or greater) shall be as specified in Section 40 05 13, PIPELINES, LIQUID PROCESS PIPING. Low pressure tubing and fittings (less than 90 psig) shall be PVC or other suitable plastic manufactured by Imperial Eastman Division, Imperial Chevite, Inc., or equal. All sample valves shall be mounted in a sample panel mounted to the side of each membrane train with a tray and drain, as shown on the Drawings. All valves in the panel shall be appropriately labeled.

8. The feed and concentrate manifolds shall be connected to the pressure vessel ports with Type 316L stainless steel pipe spools, each using Victaulic-type connectors. These manifolds shall be designed with inlets/outlets for each pressure vessel (including possible future pressure vessels, as defined herein). The "unused" manifold parts shall be plugged with removable Type 316L stainless steel Victaulic caps.

9. Permeate manifolds shall be designed with inlets for each pressure vessel (including possible future pressure vessels). The permeate manifold shall be connected to the pressure vessel permeate port using Type 316L stainless steel or PVC U-bends with Victaulic type connectors. Unused manifold parts shall be plugged with removable Type 316 stainless steel plugs or caps. For each pressure vessel the permeate connector not used (opposite end from permeate header) shall be equipped with a PVC ball valve assembly designed to permit pressure vessel probing without removing any piping or equipment.

10. Victaulic-type connectors shall be 316 stainless steel with Type 316 stainless steel bolts and washers and silicon-bronze nuts.

11. Provide Stage 2 permeate, total permeate and concentrate flow meters for each train with meter manufacturer-recommended straight lengths of piping upstream and downstream of the meters.

12. Each train shall have a concentrate throttling valve downstream of the turbocharger for automatic control of each train. The valves shall be electrically-operated and designed to prevent cavitation under all design operating conditions and as specified in Section 40 05 13, PIPELINES, LIQUID PROCESS PIPING. The valves shall provide concentrate flow control of each train to meet a target flow rate. The piping and concentrate valve for each train shall be designed to produce a noise level of 60 dBA or less at a distance of 5 feet. The throttling valve shall be designed assuming a minimum downstream pressure at the connection point of the concentrate header of 5 psig.

13. Each train shall have a Stage 1 permeate throttling valve.

14. Turbocharger (by ROEM):

a. Equipment Numbers

1. IT-31150.

2. IT-32150.

b. One spare and two duty interstage turbochargers shall be provided. Each duty turbocharger shall be integrated in the RO trains to boost the pressure of the stage 2 feed flow utilizing the concentrate pressure from second stage.

c. The ROEM shall be responsible for and shall furnish turbochargers that meet the design intent of these contract documents and are fully functional under all operating scenarios. The ROEM shall provide additional instrumentation and control as it may be necessary to ensure a fully functional and smoothly operating RO treatment system. The ROEM is required to coordinate the turbocharger associated instrumentation and control with PICS subcontractor to ensure a complete, integrated and fully operational RO treatment system.

TYPE	Brine driven interstage booster pump
MANUFACTURER:	Pump Engineering, Inc.
BEARINGS	
- Radial	Sleeve - internally lubricated by feed water
- Thrust	Hydrostatic/hydrodynamic - internally lubricated by feed and turbine flow
SHAFT SEAL	None required - unit has no shaft penetrations to atmosphere
PIPE JOINTS	
- Feed	6 inch - Victaulic Style 77 (inlet and outlet)
- Brine	4 inch - Victaulic Style 77 (inlet and outlet)

MATERIALS

- Bearings	Graphite
- External bolting	316 SS
- External tubing	316L SS

The turbocharger shall be designed to produce a noise level of 60 dBA or less at a distance of 5 feet in any direction. Each turbocharger shall have an automatically-controlled bypass throttling valve, which opens during permeate flushing and during normal operation, as needed for train process control.

15. Each RO train shall have a RIO panel and instrument panel.

16. Provisions shall be made to prevent dewatering of the train when not in service.

17. The permeate header for each train shall be piped to an elevation above all pressure vessels in the train. Vacuum breakers shall be provided on the high elevation point of each train permeate header. The ROEM shall size these valves to protect the membrane system and piping using typical industry criteria, submit the sizing calculations to the Engineer, and provide the valves after Engineer's approval.

18. Each membrane train shall have a fouling prewarning monitoring vessel assembly as follows:

a. A single 4-inch diameter two membrane element pressure vessel assembly, complete with necessary piping, valving, and instrumentation, shall be provided for each train. The pressure vessel assembly shall be used as a simulated "3rd RO Stage" to further concentrate the RO concentrate stream to provide for early detection of scale formation in the membrane elements.

b. The membrane elements shall be 4-inch diameter by 40 inches long spiral wound RO elements of identical composition and performance as those used in the membrane trains.

c. Feedwater to the fouling prewarning pressure vessel assembly shall be concentrate from the second stage. The assembly shall be plumbed to receive the concentrate from the corresponding train.

d. Valves shall be provided for manual adjustment and control of vessel assembly feedwater flowrate and permeate flowrate and recovery. Valves shall be 316 stainless steel.

e. Vessel differential pressure transmitter shall be provided for monitoring of vessel assembly operation and performance as required per the P&ID in the Drawing.

19. A pressure relief valve shall be provided on the permeate header from each stage to protect the membrane system and piping. Sizing calculations and valve material selection for corrosion resistance shall be provided to the Engineer for approval prior to supply of the pressure relief valves. The pressure relief valves shall be designed to flow into well-secured PVC or PE pipes discharging to appropriate locations in the pipe trench under the trains.

20. Each train shall have "hard-piped" PVC cleaning lines, with

stainless steel and PVC valves and victaulic-type PVC piping spools, with 2 inch drain valve as specified herein and/or shown on the Drawings. The design shall allow cleaning without the need for operation's staff to insert blind flanges, manually turn valves, or manually operate other devices above 6 feet from floor level. The design shall include cleanout/drainage of the piping at low spots.

21. Two sets of permeate orifice plugs, sized to simulate the hydraulic design of the membranes, shall be provided, one set for each membrane train for functional testing before membrane loading.

22. Framework:

a. Frames, racks, or skids that hold membrane assemblies, valves, piping, etc., shall be of welded steel or fiberglass reinforced plastic (FRP) and shall be designed for the seismic design criteria as noted on Drawing G-10, Structural Construction Notes. Perform seismic calculations for the framework.

b. Design frame weldments to be supported from two bearing points, located as shown on Drawings. Frame weldments shall support each pressure vessel at three locations per pressure vessel manufacturer's requirements.

c. Structural Steel:

1) All steel plates and shapes shall be ASTM A 36. The technique of steel welding employed, appearance, quality of welds made, and the methods of correcting defective work shall conform to codes for Arc and Gas Welding in Building Construction of the AWS and AISC. All welding operators shall be qualified in accordance with the current AWS requirements. Finished members shall be true to line and free from twists. Remove all weld spatter. Grind all welds smooth. Bolt holes, mounting holes, etc., shall be drilled prior to painting wherever possible.

2) Thoroughly clean all ferrous metal items and give a shop coat of primer and finish coating system in accordance with System No. 5, Section 09 90 00.00 40, PAINTING AND COATING. Allow paint to dry before shipment of material. Protect painted surfaces during installation. Prepare and touchup marred surfaces per paint manufacturer's instructions.

d. FRP:

1) All FRP frames shall be constructed with square-shaped tubes, flanges, angles, plates, and beams.

2) Joints shall be glued and riveted.

3) Clean and paint assembly according to standard manufacturer requirements.

e. The membrane skid framework will be anchored to the floor using leveling nuts so that the base is 1/2 inch minimum above the finished floor. Nonshrink grout shall be packed beneath the skid frame.

23. All membrane train piping shall be sized to keep flow velocities

less than 10 feet per second at the maximum design flow rates and maximum membrane cleaning solution flow rates of 40 gpm per pressure vessel.

2.3 RO MEMBRANE CLEANING AND FLUSHING SYSTEM

A. RO membrane cleaning and flushing system shall be provided as follows:

1. RO cleaning and flushing system shall consist of:

a. Cleaning Solution Tank: TK-50010

b. Cleaning Pump: P-50020.

c. Cartridge Filter: CF-50030.

d. Tank Heater Panel and Heater Control: LCP-50000.

e. Local Control Panel: LCP-50010.

f. FRP Access Stairs And Platform.

g. RO Flush Tank: TK-55010

h. RO Flush Pump: P-55020

i. Local Control Panel: LCP-55010

2. Provide designed, a complete and operable RO membrane cleaning and flushing systems, including, but not limited to, tanks, pumps, cartridge filter, heater and controls, piping, valves, FRP chemical loading platform, instrumentation and controls (by PICS subcontractor). The cleaning system shall be designed to be manually operated for membrane cleaning cycle and the flushing system shall be fully automated for membrane flushing.

3. The cleaning tank and flush tank type, materials of construction, and capacities shall be in accordance with Section 43 40 02, FIBERGLASS REINFORCED PLASTIC TANK.

4. Two pumps shall be provided (one operational and one uninstalled spare) for each service (cleaning system and flush system). Pump type, materials of construction and capacities shall be chemical corrosion resistant in accordance with Section 43 21 13, PUMPS: WATER, CENTRIFUGAL. The cleaning pump shall be piped to pump cleaning solution from the cleaning tank to RO trains, recirculate cleaning solution back to the tank (for mixing and flow balancing), and to discharge of spent cleaning solution from cleaning tank to the concentrate pump station. The flush pump shall be piped as shown on the contract drawings and P&ID.

5. Piping and valving shall conform to Section 40 05 13, PIPELINES, LIQUID PROCESS PIPING.

6. Provide NEMA 4X stainless steel cleaning and flushing system local control panels and instrumentation meeting applicable requirements specified in Sections 40 95 00, PROCESS CONTROL and 40 99 90, PACKAGE CONTROL SYSTEMS.

7. The RO cleaning tank shall be equipped with a heater to maintain the contents of the tank and recirculated cleaning solution within the optimum temperature range recommended by the RO membrane manufacturer for cleaning.

a. The heater shall be 200 kW, 480 volts, 3 phase flanged immersion type. The heater shall have a Type E-2 moisture tight terminal enclosure, (18) Incoloy sheathed elements and an 8-inch ANSI Class 150 316 stainless steel mounting flange. Protective wells shall be included for temperature control and overtemperature protection. The heater shall be a Chromalox Catalog No. TMIS-1812HXX or equal.

b. One control panel shall be provided for the heater. The enclosure shall be NEMA 4X stainless steel with a stainless steel 12-inch leg set. A door mounted disconnect shall be interlocked to prevent ingress while the disconnect is in the ON position. The control panel shall house the heating contactor, a single step temperature controller, an overtemperature controller and a 120-volt secondary control power transformer. A remote 12- volt, 5-amp dry contact will close to switch the heaters ON and open to switch heaters OFF. Panel mounted controls shall be rated NEMA 4 or better. This control panel shall be a Chromalox Model No. 4431-59111 configured as above or equal.

8. The cleaning and flushing tank systems shall be as shown in the tank data sheets and shall include, but not necessarily be limited to, solution tanks, dry chemical bag loading hopper, liquid receiving hopper with down spout, tank inspection port and necessary piping and controls.

9. The Cleaning System shall be designed for the following design criteria:

Cleaning Tank:

Diameter, ft	10'
Shell Height, ft	10' 3"
Working Capacity, gallons	4,000
Tank Material/Type	FRP/Closed Top with access hatch
Accessories	Level Indicator w/ pressure transmitter on tank side walls
Number of Heater and Size	1 @ 200 kW

See Specification Section 43 40 02, FIBERGLASS REINFORCED PLASTIC TANK, for details

Cleaning Pump:

Type of pump	Horizontal End Suction Centrifugal
Capacity, gpm	1200
Head, psi	65
Number of pumps	One (plus one shelf spare)
Pump Motor	Variable Frequency Drive
Break Horsepower @ 75% Eff.	61
Motor Horsepower	75
Pump material	316L SS

See Specification Section 43 21 13, PUMPS: WATER, CENTRIFUGAL for

details.

CIP

Cartridge Filter:	Horizontal type, ASME coded vessel, 150 psi working pressure. The cartridge filter shall be the model of 6LMP86H-4-10FK1 as manufactured by Commercial Filters Division of Parker Hannifin or equal.
Capacity, gpm	1200
Material:	316L Stainless steel housing and hardware, EPDM Filter o-rings and vessel seal.
Connection:	10"-150 # flanges
Accessories:	as shown on drawings

See Specification Section 43 40 02, FIBERGLASS REINFORCED PLASTIC TANK, for details

RO Flush Tank:

Diameter, ft	12'
Shell Height, ft	16' 4"
Working Capacity, gallons	12,000
Tank Material/Type	FRP/Closed Top with access hatch
Accessories	Level Indicator w/ pressure transmitter on tank side walls

Flush Pump:

Pump Type	Horizontal End Suction Centrifugal
Capacity, gpm	400
Head, psi	65
Number of pumps	One (plus one shelf spare)
Pump Motor	Variable Frequency Drive
Break Horsepower @ 75% Eff.	20.2
Motor Horsepower	30
Pump material	316L SS

See Specification Section 43 21 13, PUMPS: WATER, CENTRIFUGAL for details.

2.4 MANUAL AND ACTUATED VALVES

Provide all check valves, control valves, and isolation valves required for a completely functional system (shipped loose and properly labeled, if not provided as part of each membrane train or pipe rack. Comply with Specification Section 40 05 13, PIPELINE, LIQUID PROCESS PIPING:

2.4.1 Ball Valves

Ball Valves, 2-Inches and Smaller: V307

2.4.2 Butterfly Valves

Butterfly Valves, 2-Inches to 36 Inches: V514

2.4.3 Check Valves

Check Valves, 2-Inches to 36-Inches: V613

2.4.4 Solenoid Valves

Solenoid Valves: Seller's standard, 120V, 60 HZ ac.

2.4.5 Other Valves

Other valves required for the RO train: See Section Section 40 05 13, PIPELINE, LIQUID PROCESS PIPING.

2.4.6 Electric Actuators

See Section 40 05 13, PIPELINES, LIQUID PROCESS PIPING.

2.4.7 Sample Valves, V306

Provide 1/2-inch stainless steel ball valve sample taps.

2.5 INSTRUMENTATION AND CONTROL SYSTEM

a. Provide the instrumentation and control system in accordance with Section 40 95 00, PROCESS CONTROL and Section 40 99 90, PACKAGE CONTROL SYSTEMS, as specified herein.

b. Review and comment on the suitability and accuracy of the loop descriptions and sequence of operation specified in Section 40 95 00, PROCESS CONTROL. Coordinate with SCADA Software Supplier and Process Control System Integrator for any changes required in the Loop Descriptions. The supply of programmable logic controllers (PLCS) and computer and software programming is not in the scope of work of the ROEM.

c. Provide the instrumentation identified as supplied by the ROEM on the Drawings (P&ID), including local control panels. All instrumentation and Control Panels shall be NEMA 4X stainless steel.

d. The Process Control System Integrator provides all instrumentation and control hardware not specifically identified for supply by the ROEM as specified in Section 40 95 00, PROCESS CONTROL. RO control system software including PLC programming and HMI screens will be provided by SCADA Software Supplier under separate contract.

e. Attend the Process Control System Integrator's Factory Demonstration Test (FDT) for the control of the membrane systems and recommend modifications as appropriate.

f. At the water treatment plant site, witness the Process Control System Integrator's Performance Acceptance Test (PAT) for the membrane systems control and approve the final system, as appropriate.

2.6 INTERFACE POINTS BETWEEN ROEM SCOPE OF SUPPLY AND ITEMS BY OTHERS

a. All interface points shall be coordinated with the Contractor and subcontractors.

b. Process and Cleaning Piping (All): Flange interfaces shall be located vertically downward 6 inches above floor level.

c. I&C Conduits/Wiring: Provided by the ROEM for all instrumentation on the membrane trains between the primary elements and local panels, as applicable, and provided by the Contractor from local panels to other locations. For instrumentation supplied by the ROEM whose output signals are not being routed to local control panels, I&C conduits and wiring shall be provided by the Contractor.

2.7 MISCELLANEOUS COMPONENTS

a. Silt Density Index (SDI) Test Apparatus: Provide two corrosion-resistant SDI test apparatus per ASTM D 4189. As part of the SDI test apparatus, provide a Pall-Gelman 47-mm polycarbonate (clear) filter holder with Laser-Lok vent plug for removing air bubbles, polysulfone screen and silicon O-ring. One shall be given to the PICS subcontractor for installation in the feed water panel and one shall be provided in an appropriate carrying case. Provide 200 membrane filters.

b. Equipment Identification Plates: 16-gauge, Type 316 stainless steel identification plates shall be securely mounted on all valves and equipment in a readily visible location. The plates shall bear the 1/4-inch die-stamped equipment tag numbers indicated in the Specification and/or as shown on the Drawings. All panels and I/O racks shall have panel titles and numbers on nameplates.

c. Lifting Lugs: Equipment weighing over 100 pounds shall be provided with lifting lugs.

d. Anchor Bolts: Anchor bolts shall be Type 316 stainless steel and at least 1/2 inch in diameter. Coordinate required size with final shop Drawings.

e. Spare Parts and Special Tools: Provide the following spare parts and special tools:

1. One spare set of expendable material such as gaskets, seal, and packing as recommended by the manufacturer for the first year's operation; including, as a minimum, one complete train set of membrane element/pressure vessel gaskets, O rings, seals, and one complete train set of element connectors.

2. One set of new and unused special tools required for installation, operation, and maintenance.

3. All jigs, fixtures, clamps, lifting beams, hooks, and other apparatus shall be provided as part of the system as required to facilitate the complete removal, disassembly, renewal, assembly, and installation of each item of equipment within the system.

4. Tools for the membrane pressure vessels, as specified herein.

PART 3 EXECUTION

3.1 MEMBRANE ELEMENT MANUFACTURING AND FACTORY TESTS

a. Membrane elements shall not be manufactured more than 9 months prior to the startup of the membrane train in which they are installed.

b. Prior to shipment of the RO membrane elements by the element

manufacturer, the ROEM shall submit the required test data for the elements at the membrane element manufacturer's standard test conditions, as specified herein, and the serial number and manufacturing date of all elements. For membrane elements that are manufactured and assembled using a fully-automated process, a minimum of six (6) elements shall be factory-tested (three per train; to be installed in lead and tail-end positions of a Stage 1 vessel and a tail-end position of a Stage 2 vessel for each train). For membrane elements that are not manufactured and assembled using a fully-automated process, all elements shall be factory-tested. The factory test shall be a "wet test" under the manufacturer's published standard test conditions (feed water composition and temperature, applied pressure, recovery, pH, and testing time) for the specific element.

3.2 INSTALLATION

The ROEM shall be responsible for the installation of all membrane system components. Location of system components and interconnections between system components and to other plant systems shall be in accordance with Article 2.6 INTERFACE POINTS BETWEEN ROEM SCOPE OF SUPPLY AND ITEMS BY OTHERS and the Drawings coordinated with the Contractor and subcontractors. Installation Drawings and Specifications shall be prepared using general component locations where shown, and shall be approved prior to the start of installation.

3.3 PAINTING

Shop and field (touch-up) painting shall be in accordance with and as specified in Section 09 90 00.00 40, PAINTING AND COATING, System No. 5.

3.4 TESTING

a. All major system components shall be factory tested insofar as practicable for compliance with the construction and functional requirements specified herein, and a certification of the results of these tests shall be submitted to the Engineer.

b. Prior to system startup, all system components shall be inspected for proper alignment, proper noise levels, proper connection, and satisfactory performance. The manufacturer's representative for all system components shall provide written certification to the Engineer that furnished equipment has been installed in accordance with the approved method and is ready for permanent operation.

3.4.1 Operational Readiness Testing (ORT)

Prior to Functional Testing, specified below in this Section, the ROEM shall calibrate all instruments and verify proper signal integrity for all ROEM-provided items having process monitoring and control. Additionally, the ROEM shall confirm proper display of process variables on HMI and proper operation of control valves, variable speed feed pumps, and other equipment related to the membrane system by coordination with the Contractor, Process Instrumentation and Control Systems (PICS) Subcontractor, and SCADA Software Supplier. Contractor, Process Instrumentation and Control Systems (PICS) Subcontractor, and SCADA Software Supplier requirements for process control are specified in Section 40 95 00, PROCESS CONTROL, and four supplements, Supplements 40 95 00 S1 through 40 95 00 S4. The ORT includes Testing, Adjusting, Commissioning, and Performance Verification Test (PVT) specified in Section 40 95 00,

PROCESS CONTROL, Article Testing, Adjusting and Commissioning and Article Performance Verification Test (PVT).

3.4.2 Functional Testing

1. Functional testing includes hydraulic, electrical, and instrumentation control system checks to verify that the entire membrane system and membrane cleaning system will start up, operate, and shut down properly and shall be conducted with the PICS Subcontractor. This testing includes verification of all emergency and alarm conditions. Documentation in the form of detailed check-off sheets shall be submitted at the conclusion of the successful functional test. Functional tests and documentation shall be coordinated with other testing of related equipment and facilities to ensure proper operation of the complete integrated system.

2. Membranes shall not be loaded during the functional test for each train and the complete integrated system. Permeate orifice plugs sized to simulate the hydraulic design of the membranes shall be used.

3. RO system functional tests shall include:

a. Functional and performance tests of all treatment process equipment and systems (excluding membranes).

b. Membrane train testing for a minimum of 24 hours (for each train), including at least two startups and two shutdowns, to demonstrate the correct adjustment and performance of all system components (without membranes installed) with RO feed pumps.

4. RO system testing for all trains running simultaneously for 24 hours at reduced flow rates (controlled by disposal capability), including at least one sequenced train startup, one sequenced train shutdown, and simultaneous shutdown of all trains (simulating loss of power supply during emergency conditions).

5. RO cleaning system testing by connecting the three cleaning piping headers to each stage of each train, one at a time, and circulating dechlorinated tap water through the RO trains using the cleaning tank and the RO cleaning pump for a minimum of 15 minutes for each step. This testing shall follow individual cleaning system component functional and performance tests specified elsewhere. Finally, the water from the last cleaning system testing shall be pumped to the spent cleaning system for disposal.

6. The RO cleaning systems, and associated piping shall be disinfected as specified in Section 33 13 01, DISINFECTION OF WATER SYSTEM.

3.4.3 Performance Testing

1. Performance testing, which shall be conducted with the PICS subcontractor, includes testing each individual train with membranes installed in the normal operating mode to verify conformance with the performance aspects of this Specification. Performance testing shall not commence until all functional tests have been completed and approved by the Owner and Engineer, and also a detailed performance testing plan has been approved by the Owner and Engineer. Furthermore, membrane elements shall not be installed until after all chlorinated water used for disinfection has been flushed from the systems.

2. Performance Tests:

a. To demonstrate that the units furnished hereunder, installed with membranes, perform in accordance with all provisions of these Specifications, the ROEM shall conduct a 4 day acceptance test for each train according to approved test procedures as outlined below. The performance test for only one train may be started in a 24 hour period. All trains shall be operated simultaneously for at least 24 hours as part of the performance testing. No more than 12 hours of downtime shall be allowed during the acceptance test for each train for work on materials, piping, and equipment provided by the ROEM. If 12 hours of downtime is exceeded, the test shall be restarted for a new 4-day test period. Included in the Acceptance Tests shall be a demonstration of the performance as defined in this Section, Article, RO System Performance Criteria. A qualified representative shall direct the system test, analyze performance data, and certify the system performance during the test. The ROEM shall have a qualified laboratory, approved by the Owner, analyze water quality not being conducted onsite.

b. The ROEM shall present a written report to the Owner within 14 calendar days after the performance testing. The report shall include all data taken during the acceptance testing period including water analysis of the pretreated feedwater, permeate, and concentrate. The data taken during the testing period shall be presented in graphical and tabular forms. The report shall also have a summary of the analyses stating if the membrane systems meet the requirements as specified.

c. If, in the opinion of the Engineer, the system meets the requirements specified herein, the system will be classed as conforming for purposes of the guarantee provisions of these Specifications. If, in the opinion of the Engineer, the system performance test results do not meet the requirements specified herein, the system will be classed as nonconforming.

d. In the cast of a nonconforming system, the Owner may at its option, withhold final payment to the Contractor until the system is reclassed as conforming. If final payment is made with the system specified herein classed as nonconforming, the provisions of the warranty sections of these Specifications shall be in effect, except that the 3 year performance warranty period, as applicable, shall not commence until the system has been corrected and retested by the ROEM and the system has conformed to these Specifications.

3.5 MANUFACTURER'S SERVICES

a. A technical representative of the ROEM and other manufacturers shall be present at the Job Site or classroom designated by the Owner for the minimum person-days listed for the services hereinunder, membrane system installation and travel time excluded:

1. 2 person-days for attending the PICS Subcontractor coordination meeting at the office of the Engineer.

2. 2 person-days for attending the PICS Subcontractor's Factory Demonstration Test (FDT) for the control of the membrane systems and recommend modifications as appropriate.

3. 2 person-days at the water treatment plant site to witness the

PICS Subcontractor's Operational Readiness Test (ORT for the membrane systems control.

4. 2 person-days at the water treatment plant site to witness the PICS Subcontractor's Performance Acceptance Test (PAT) for the membrane systems control.

5. 4 person-days for functional testing for each RO train.

6. 8 person-days for performance testing.

7. 2 person-days for prestartup classroom or Job Site training.

8. 2 person-days for post-startup training and operations assistance.

b. Training of Owner's personnel shall be performed by qualified technical representative(s) of the ROEM acceptable to the Owner and shall be at such times as requested by the Owner.

c. Manufacturers' Certificate(s): Provide manufacturer's certificate(s) in accordance with Division 1, General Requirements.

3.6 DESIGN RAW WATER QUALITY

Table 1
Design Raw Water Quality [1,2]

	Case 1	Case 2	Case 3
Calcium (Ca++)	278	350	470
Magnesium (Mg++)	76	83.1	108
Sodium (Na+)	127	449	555
Potassium (K+)	7.2	8.4	11
Barium (Ba++)	0.25	0.13	0.2
Strontium (Sr++)	1.53	2.42	3
Bicarbonate (HCO3-)	276	158	200
Sulfate (SO4--)	129.7	154.3	195
Chloride (Cl-)	593	1,351	1,850
Fluoride (F-)	0.2	0.2	0.3
Nitrate (NO3-)	28.5	38.6	50
Silica (SiO2)	56.7	33.2	55
Temp(C)	21.6	21.4	19
pH (units)	6.86	7.1	7.0
TDS (mg/L)	1,576	2,630	3,500

Note:

[1] Design Iron and Manganese concentrations after pre-treatment are less than or equal to 0.3 mg/L and 0.05 mg/L, respectively.

[2] Design ammonia concentration is less than or equal to 1.1 mg/L NH_3-N.

NOTE: The design raw water quality data as shown in this table are assumed data based on preliminary operating well testing results. The quality of the RO feed water from actual production wells may be different. Exact

water quality shall be established by the DISTRICT based on full-scale production wells at the time when performance tests will be conducted.

3.7 RO PERMEATE WATER QUALITY REQUIREMENT

Table 2
RO Permeate Water Quality Criteria[1]

Permeate	Value
Chloride (mg/L)	<50
Nitrate as Nitrogen (mg/L)	<10
TDS (mgL)	<110

Note:
[1] Other California Primary Drinking Water Standards shall also be met.

-- End of Section --