

PROJECT ADMINISTRATION DATA SHEET



ORIGINAL



REVISION NO. _____

Project No. E-20-624GTRI/~~GTR~~DATE 8 / 11 / 83Project Director: Dr. Ed ChianSchool/~~Lab~~

Civil Engineering

Sponsor: U. S. Army Medical R&D CommandType Agreement: P. O. DAMD17-83-M-A541Award Period: From 8/1/83 To 10/31/83 (Performance) 10/31/83 (Reports)

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This Change

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Title: Development of Design Specification of an AFFF MEMBRANE Recovery Prototype Plant

ADMINISTRATIVE DATA

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RESTRICTIONS

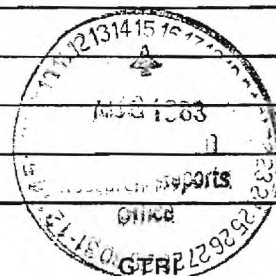
See Attached Gov't Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of \$500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

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SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 11/16/83

Project No. E-20-624 School ~~ATL~~ CE

Includes Subproject No.(s) N/A

Project Director(s) Dr. Edward Chian GTRI / ~~GIT~~

Sponsor U.S. Army Medical R & D Command

Title Development of Design Specification of an AFFF Membrane Recovery
Prototype Plant.

Effective Completion Date: 10/31/83 (Performance) _____ (Reports) _____

Grant/Contract Closeout Actions Remaining:

- ☐ None
- ☒ Final Invoice or Final Fiscal Report
- ☐ Closing Documents
- ☒ Final Report of Inventions
- ☒ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

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GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

SPECIFICATION FOR
AQUEOUS FILM FORMING FOAM (AFFF)
RECOVERY SYSTEM

PREPARED FOR
U.S. NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA

PREPARED BY :

APPROVED BY :

DATE APPROVED :

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1.0 INTRODUCTION

The primary purpose of this project is to develop a prototype membrane treatment system to economically recover the AFFF active ingredients from an AFFF-laden wastewater. This recovered material might then be reused either alone or supplemented with stock AFFF concentrate.

During on-site testing, this pilot plant shall be used to examine the fluid-solid systems by ultrafiltration (UF) and reverse osmosis (RO) separation processes.

Firefighting training for fuel/oil fire extinguishment at military bases consumes considerable amounts of water and a proprietary chemical foaming agent, called Aqueous Film Forming Foam (AFFF).

Preliminary feasibility study has been conducted; it indicated that all the active ingredients of AFFF readily passed through ultrafiltration membrane and were able to concentrate through a polyamide membrane reverse osmosis system.

1.1 SCOPE OF WORK

This specification describes the minimum requirements for the design and manufacturing of a skid mounted modularized AFFF membrane recovery system consisting of the following major units: ultrafiltration unit, reverse osmosis unit, and membrane cleaning unit.

1.2 WORK INCLUDED

The Vendor shall provide the detailed engineering , procurement, fabrication, and furnish the membrane treatment system as described herein with all the necessary instrumentation and controls , and with all the required interconnecting piping .

The omission of any items from these specifications shall not relieve the Vendor of responsibility for providing a complete and operable system. The system shall require minimal field erection.

The process and instrumentation diagram represents the Purchaser's design philosophy of the AFFF recovery system. The Vendor may propose alternate designs for approval; the design shall base on cost effectiveness , and operating and maintenance standpoints.

The equipment shall include but not limited to the following:

- A. Ultrafiltration (UF) Unit
 - Self-Priming Well Pump
 - UF Pretreatment
 - UF System
 - Membrane Cleaning System
- B. Reverse Osmosis (RO) Unit
 - RO Pretreatment System
 - RO System
 - RO Flush Water Supply
- C. Membrane Cleaning Unit
- D. O & M Manuals
- E. Tools

2.0 REFERENCES

- 2.0.1 In case of conflicting requirements between this specification and drawings, the Vendor shall call to the Purchaser's attention, and shall obtain a clarification in writing from the Purchaser before any work is done.
- 2.0.2 Compliance by the Vendor with the provisions of this specification does not relieve the Vendor of the responsibility to furnish equipment and accessories of a proper mechanical design to meet the specified service conditions, agreements, and health and safety requirements.
- 2.0.3 The Specification, Standards & Codes, and the Purchaser's drawings shall serve as guidelines and standards for the Vendor's design and furnished equipment.
- 2.0.4 Military specifications are not required to this prototype membrane treatment system.

2.1 STANDARDS and CODES

AISC - American Institute of Steel Construction
ANSI - American National Standard Institute
ASME- American Society of Mechanical Engineers
AWS - American Welding Society
HI - Hydraulic Institute Standards for Centrifugal, Rotary
and Reciprocating Pumps
IEEE - Institute of Electrical and Electronic Engineers
ISA - Instrument Society of America
NEMA- National Electrical Manufacturing Association
NEC - National Electrical Code

2.2 DRAWINGS

2.2.1 Purchaser Drawing

<u>Drawing No.</u>	<u>Revision</u>	<u>Description</u>
AFFF-1	0	AFFF Membrane Recovery System - Alternative No. 1
AFFF-2	0	AFFF Membrane Recovery System - Alternative No. 2

2.2.2 Vendor Furnished Drawing

2.2.2.1 Proposed drawings shall be furnished with the proposal for the pre-qualify evaluation. The minimum required drawings are listed as follows:

1. Proposed P & I Diagram
2. Proposed Plot Plan
3. Proposed Equipment Layout Drawing
4. Proposed Control Logic Diagram (Detailed Electrical Schematic Diagram is not required with the proposal)
5. Proposed Control Panel Layout

2.2.2.2 For drawings approval after the contract award, the Vendor shall furnish P & I Diagram, Equipment Layout Drawing and Electrical Schematic Diagram for the Purchaser approval. Purchaser approval is required before any work is done.

2.2.2.3 The Purchaser will provide drawing approval, comments and/or information requested by the Vendor within 10 working days.

2.2.2.4 Detailed shop drawings of individual parts of the structure are not required to be furnished by the Vendor.

3.0 ENVIRONMENTAL CONDITIONS

3.0.1 Site Conditions

Site conditions depend on the location of the firefighting schools. The units will be either installed in an electrically unclassified outdoor area or in an electrically unclassified indoor area. The system design temperature is 25°C; the maximum temperature is 42°C.

3.0.2 Aqueous Film Forming Foam (AFFF)

The AFFF chemical constituents consist of fluorochemical surfactant, hydrocarbon surfactant, solvents (such as ethylene glycol and its derivatives, butyl carbitol, acetic acid, etc.) and water.

3.0.3 Firefighting Solution

During firefighting exercises (including equipment testing on ground or shipboard), a 3.5% to 6% (by volume) solution of the AFFF concentrate is used.

3.0.4 Wastewater

Wastewater generated from such firefighting exercises contains the AFFF stock constituents, residual fuel/oil, gasoline, combustion products, and suspended solids.

4.0.0 DESIGN REQUIREMENTS

- 4.0.0.1 The intent of this specification is to present the Purchaser's design philosophy and to describe the functional requirements, features and general construction of the AFFF membrane recovery system specified herein.
- 4.0.0.2 This specification and the Purchaser drawings are not intended to cover all aspects of design and equipment details.
- 4.0.0.3 The Vendor shall accept overall system responsibility for the complete design, manufacturing performance and guarantees of the equipment specified and incorporated in the work.
- 4.0.1 The UF skid, RO skid and membrane cleaning skid shall be designed for containerized shipment, and future equipment relocation; maximum width of each unit skid shall be 90 inches.
- 4.0.2 Delivery schedule shall not exceed 120 days after drawing approval and notice to proceed for manufacturing.
- 4.0.3 Equipment and workmanship warranty period shall be one year from the date of equipment initial startup or two years from the date of shipment from factory.
- 4.0.4.0 RO permeators performance guarantee is not required for this prototype system. RO permeators must not exceed 12 months old from the membrane manufacturing production date and at the date of equipment acceptance by the Purchaser's representative.
- 4.0.4.1 Test certificate of each permeator from the membrane manufacturer shall be provided to certify that each permeator meets standard test conditions.
- 4.0.5 One year UF membrane performance guarantee shall be provided for 10,000 GPD membrane flux guarantee.

4.1 Ultrafiltration (UF) Unit

4.1.0.1 The UF system shall be operated per the following parameters;

- Permeate Flow = 10,000 GPD (Design)
- Average Membrane Flux = 20 GPD/ft² (Experimental Data)
- Operating Pressure = 60 psig (Design)
= 75 psig (Maximum)
- Operating Temperature = 30°C (Design)
= 25 - 41°C (Range)

4.1.0.2 The UF unit shall be skid mounted with all the equipment, control, and accessories.

4.1.1 Self-Priming Well Pump

The Vendor shall furnish a self-priming well pump, instrumentation and controls to provide AFFF wastewater to UF feed tank.

4.1.1.1 The well pump shall rate at 25 GPM and 25 feet TDH. The effective static lift shall be 20 feet.

4.1.1.2 Materials of construction shall be of type 304 or 316 stainless steel.

4.1.1.3 Motor shall be 1750 R.P.M. non-overloaded type with TEFC enclosure.

4.1.1.4 Pump shall be equipped with foot valve, isolation valve, basket strainer and check valve.

4.1.1.5 Selector switch for well pump operating modes shall be Hand/Off/Auto with indicating light.

4.1.1.6 In the Auto mode, the well pump will be signalled to run and shut down by UF feed tank level control.

4.1.1.7 The level control located at the wet well shall protect the well pump from running dry.

4.1.2 UF Pretreatment

The Vendor shall furnish UF feed tank, UF feed pump, cartridge filter, instrumentation and controls for the UF pretreatment system.

4.1.2.1 UF feed tank shall be premium resin FRP tank with siphon drain type outlet; tank storage capacity shall be 500 gallons.

4.1.2.2 UF feed pump shall rate at 25 GPM and 50 ft TDH. Materials of construction shall be type 304 or 316 stainless steel; pump shall be equipped with isolation valve and check valve.

4.1.2.3 Motor shall be 3500 R.P.M. non-overloaded type with TEFC enclosure.

4.1.2.4.0 Cartridge filter housing shall be PVC construction.

4.1.2.4.1 Filter elements shall be 25 micron polypropylene type.

4.1.2.4.2 Filter housing shall contain six (6) filter elements.

4.1.2.4.3 Inlet and outlet pressure gauges shall be 0 - 30 psig range.

4.1.3.0 UF System

The Vendor shall furnish UF recirculation pump, membrane block, distribution piping system, instrumentation and controls for the UF system.

4.1.3.1 The system shall be able to operate either at batch or semi-batch operation.

4.1.3.2 The design parameters are as follows:

UF System Performance

--Permeate = 7 GPM

--Membrane Feed = 700 GPM

--Concentrate = 693 GPM

--Recovery = 1 %

Overall Performance

--Permeate = 7 GPM

--Reject Return = 7 GPM

--UF Feed = 14 GPM

- 4.1.3.3.0 Membrane shall be Abcor HFM-300 tubular ultrafiltration membrane or approved equal.
- 4.1.3.3.1 Membrane configuration shall be Abcor Ultra-Cor type containing five (5) 1/2" diameter tubes in a single PVC housing or approved equal alternative.
- 4.1.3.3.2 Membrane housing shall have 8 tubes in a series per bank and with a total of 22 banks.
- 4.1.3.3.3 Flow rate per bank shall be 25 GPM minimum and 35 GPM maximum.
- 4.1.3.3.4 Pressure drop per bank shall be approximately 30 psi; piping manifolds shall be equipped with automatic air relief valve.
- 4.1.3.3.5 Final design parameters shall base on individual membrane manufacturer recommendation and design guidelines.
- 4.1.3.4 Membrane feed pressure and concentrate (reject) flow throttling valves shall be either globe type or butterfly valve; Butterfly valve shall obtain engineer's approval with supporting design and technical data.
- 4.1.3.5 Pressure switch shall be furnished to protect membrane feed and permeate from being overpressurized, and recirculation pump low suction pressure.
- 4.1.3.6 Turbidity meter shall be located at UF permeate stream for UF performance indication.
- 4.1.3.7 The 3-way valve located at the permeate stream shall be signalled by RO level control to bypass UF permeate to UF feed tank when RO feed tank is full.
- 4.1.3.8 Recirculating pump shall rate at 700 GPM and 175 ft TDH. Material of construction shall be type 304 or 316 stainless steel; motor shall be 3500 R.P.M. non-overloaded type with TEFC enclosure.
- 4.1.3.9 Permeate flow meter shall be equipped with totalizer and recorder for the record of performance study and troubleshooting.

- 4.1.3.10 Operation modes selector switch shall be Auto/Cleaning with indicating light.
- 4.1.3.11 Power On/Off selector switch, run, stop, and emergency push buttons shall be included as a minimum.
- 4.1.4 Membrane Cleaning System

The design and piping layout of the UF unit shall be provided as self cleaning system without any additional required equipment.
- 4.1.4.1 The cleaning system shall be batch operation; permeate and reject shall be routed back to the feed tank.
- 4.1.4.2 Level control located at the feed tank shall have no interlock to the well pump and the UF feed pump.
- 4.1.4.3 Uf feed tank shall serve as cleaning recirculation tank.
- 4.1.4.4 The Vendor shall include membrane manufacturer recommended cleaning procedure and recommended cleaning agents for the subject membrane in the Operating and Maintenance manual.

- 4.2 REVERSE OSMOSIS UNIT--ALTERNATIVE No. 1
- 4.2.0.1 The RO system shall be operated per the following parameters:
- Permeate Flow = 10,000 GPD (Design)
 - Average Membrane Flux (Experimental Data) = 1,000 GPD per permeator (DuPont Model No. 6440)
 - Operating Pressure = 800 psig at 35°C
 - Operating Temperature = 35°C (Design)
- 4.2.0.2 The RO unit shall be skid mounted with all the equipment, controls, and accessories.
- 4.2.1 RO Pretreatment System
- The Vendor shall furnish RO feed tank, RO feed pump, heat exchanger, cartridge filter, instrumentation and controls for the RO pretreatment system.
- 4.2.1.1 RO feed tank shall be premium resin FRP tank with siphon drain type outlet; tank storage capacity shall be 500 gallons.
- 4.2.1.2.1 RO feed pump shall be rated at 28 GPM and 120 ft TDH. Material of construction shall be type 304 or 316 stainless steel.
- 4.2.1.2.2 Pump shall be equipped with isolation valve and check valve.
- 4.2.1.2.3 Motor shall be 3500 R.P.M. non-overloaded type with TEFC enclosure.
- 4.2.1.2.4 Selector switch for feed pump operating modes shall be Hand/Off/Auto with indicating light.
- 4.2.1.3 Detachable hose connection located at the RO feed pump discharge shall be used to collect RO concentrate for re-use.
- 4.2.1.4 Acid feed system shall be equipped with chemical metering pump, footvalve, injector acid tank and ph monitor.
- 4.2.1.5.0 Heat exchanger shall be used to maintain RO feed at 35°C or below.

- 4.2.1.5.1 Temperature indicators shall be located at the inlet and outlet of the heat exchanger.
- 4.2.1.5.2 Temperature switch shall be located at the outlet of the heat exchanger to signal the heat exchanger's motor-driven ball valve and high temperature protection of the RO membrane.
- 4.2.1.6.0 Dual cartridge filters shall be furnished.
- 4.2.1.6.1 Cartridge filter housing shall be PVC construction.
- 4.2.1.6.2 Filter elements shall be 5 and 1 micron polypropylene type.
- 4.2.1.6.3 Each filter housing shall contain eight (8) filter elements.
- 4.2.1.6.4 Inlet and outlet pressure gauges shall be 0 - 100 psig range
- 4.2.1.7 Station SDI kit and conductivity monitor shall be located at the outlet of cartridge filter for the RO feed quality monitoring.
- 4.2.2.0 RO System
The Vendor shall furnish RO high pressure pump (HPP), permeators, draw back tank, distribution piping system, instrumentation and controls for the RO system.
- 4.2.2.1 The system shall be at batch operation with constant feed pressure design concept.
- 4.2.2.2 The design parameters are as follows:
 - Permeate = 7 GPM
 - Membrane Feed = 28 GPM
 - Concentrate = 21 GPM
 - Conversion = 25%
- 4.2.2.3.0 Membrane shall be DuPont B-10 Permasep permeators, Model No. 6840, and the total quantity of three (3).
- 4.2.2.3.1 System design shall take into consideration of minimum brine rate, maximum brine rate, bundle pressure drop, and temperature and operating pressure guidelines.

- 4.2.2.3.2 Permeators shall be in a single stage design and shall be in a single stage cleaning operation.
- 4.2.2.3.3 The system conversion for the RO shall be controlled by an automatic reject throttling valve in the concentrate manifold, the materials of construction shall be type 316 stainless steel with a motor-driven actuator.
- 4.2.2.3.4 Flow balancing tubes shall be used to induce artificial pressure drop in the piping across each permeator to achieve concentrate flow equalization in a single stage parallel array.
- 4.2.2.3.5 A minimum pressure drop of 35 psig plus the permeator bundle pressure drop shall be used for design purpose or recommendation from membrane manufacturer.
- 4.2.2.4.0 The RO high pressure pump shall rate at 28 GPM and 300 psig; materials of construction shall be suitable for high brackish water application.
- 4.2.2.4.1 A pressure relief valve shall be furnished on the HPP discharge line for equipment protection and accumulator shall be on the pump inlet and discharge line to dampen pressure variations.
- 4.2.2.5.0 Operation modes selector switch shall be Auto/Cleaning with indication light.
- 4.2.2.5.1 Power On/Off selector switch, run, stop and emergency push buttons shall be included as a minimum.

4.2.3 Membrane Flush Water Supply

4.2.3.1 Membrane flush water supply shall be from city water.

4.2.3.2 Carbon filter shall be furnished to remove residual chlorine for the membrane flush water supply.

4.2.3.3 Sodium bisulfite chemical feed system shall be an acceptable alternative for chlorine removal

4.2.3.4 Membrane flush water supply shall be design per membrane manufacturer recommendation.

4.3.0 REVERSE OSMOSIS UNIT - ALTERNATIVE NO. 2

The design and requirements shall be the same as Reverse Osmosis Unit - Alternative No. 1 with the following exceptions:

- Du Pont B-15 spiral wound membrane in lieu of B-10 hollow fibers permeator
- B-15 Permasep cartridge model No. 3840
- Membrane staging 1:1:1, with initial product water capacity 25,800 GPD at standard test condition
- No heat exchanger in the RO pretreatment system
- Centrifugal high pressure pump in lieu of positive displacement type
- No draw back tank required

4.3.1 In case of conflicting requirements between this specification and membrane manufacturer recommendations, the Vendor shall call to the Purchaser's attention, and shall obtain a clarification in writing from the Purchaser before any work is done.

4.4 MEMBRANE CLEANING UNIT

4.4.0 The membrane cleaning unit for the RO unit shall include with the following:

- One (1) chemical cleaning tank
- One (1) mixer
- One (1) chemical cleaning pump
- One (1) cooling coil
- One (1) 5 micron cartridge filter
- One (1) set of instrumentation, control and required equipment to provide a complete workable unit

4.4.1 The tank shall be sized for at least three minute retention time.

4.4.2 A temperature indicator shall be provided for temperature indication.

4.4.3 The cleaning pump shall be centrifugal type with materials of construction compatible with the anticipated cleaning chemical.

4.4.4 The membrane cleaning unit shall conform to the membrane manufacturer recommendations.

5.0

CONSTRUCTION

All materials used in the fabrication of the specified equipment shall be new, and of first quality. Workmanship shall be neat, of professional caliber, and in accordance with best engineering practices.

5.1 STRUCTURE

- 5.1.1 The skid shall be a heavy duty "rigid frame" structural steel skid of welded construction, and to be completed with lifting lugs.
- 5.1.2 Structural steel shall conform with ASTM specifications for weldable carbon or carbon manganese steels. The Vendor shall have mill certificates available to verify that the steel meets ASTM requirements.
- 5.1.3 Lifting lugs shall be welded to the skid frame or members directly.
- 5.1.4 Plastic grating shall be fire retardant with non skid surface.
- 5.1.5 All grating clips, nuts, washers and bolts shall be 304 stainless steel.
- 5.1.6 All welds shall be seal welded, radiography is not required. The Purchaser has right to reject any poor workmanship.
- 5.1.7 Design calculations are the responsibility of the Vendor for the furnished equipment.

5.2 PIPING, VALVES and ACCESSORIES

- 5.2.0.1 The Vendor shall furnish all piping, valves, fittings, pipe supports, flanges, gaskets, nuts, bolts, etc., necessary for the complege UF unit, RO unit and cleaning unit.
- 5.2.0.2 Skids piping assemblies, cleaning, hydrostatic testing of the skid's piping shall be done by the Vendor.
- 5.2.0.3 Purchaser will provid field interconnecting piping, wiring, installation, and field hydrostatic testing.
- 5.2.0.4 The interskid piping systems shall provide for flushing, distribution, and drainage of each unit; all the interfaces piping between the Purchaser and the Vendor shall be piped to the skid edge and terminated with a flanged valve or a flanged-end connection.
- 5.2.1 Low Pressure Piping System
The low pressure piping systme shall include the entire UF unit, cleaning unit, RO permeate, and the suction side of the RO high pressure pump and the discharge side of the RO reject throttling valve. The pressure rating of the above piping system shall be 75 psig operating pressure; the hydrostatic and leakage test shall be 150% of the operating pressure.
- 5.2.1.1 The piping manifold shall be Schedule 80 polyvinyl chloride(PVC) pipe. PVC piping and fittings shall be PVC 1120 or 1220 conforming to ASTM specification D-1785.
- 5.2.1.2 Fittings shall be Schedule 80 socket-type conforming to ASTM D-2467.
- 5.2.1.3 Solvent cement shall conform to ASTM D-2564.
- 5.2.1.4 Butterfly valve, 3 inches or larger, shall be PVC butterfly wafer type valve with stainless steel shaft, lever operator, PVC body, and polypropylene disc. All valves shall be of full line size.

- 5.2.1.5 Ball valve, 3 inches or smaller except sample valve, shall be PVC true union ball type valve, full porting and with teflon seats. All valves shall be of full line size. Actuator shall be motor-driven type, if required.
- 5.2.1.6 Check valve shall be PVC swing check type valve. Disc shall be seated with 0.5 psig back pressure.
- 5.2.1.7 Globe valve shall be of PVC construction. Sizing shall take into consideration of Cv value, flow rate, system pressure, and allowable pressure drop.
- 5.2.1.8 Bolts, nuts and washers used for the flanges shall be type 304 stainless steel. Flat washers shall be used under all bolt heads and nuts.

5.2.2 High Pressure Piping System

The high pressure piping system shall include the feedwater piping from the discharge of the high pressure booster pump to the inlet piping manifold of the reject throttling valve.

- 5.2.2.1 All piping and piping manifolds shall be designed so that water shall flow greater than 5 feet per second during normal operation and stagnant areas shall be minimized. Maximun flow shall not exceed 12 feet per second.
- 5.2.2.2 High pressure pipe, manifold and fitting shall be of type 316L stainless steel, Schedule 40 or Schedule 80.
- 5.2.2.3 Butt welds shall be made with a gas welder, using compatible filler material and backing gas on the interior. Soctet welds shall not be used.
- 5.2.2.4 Ball balve shall be or type 316 stainless steel, 3-piece body ball valve. Operating pressure shall be rated at 800 psig. All valves shall be of full line size.
- 5.2.2.5 Automatic throttling valve shall be of globe type of approved equal. Sizing shall take into consideration of Cv value, flow rate, system pressure, and allowable pressure drop. Actuator shall be of motor-driven type.
- 5.2.2.6 Bolts, nuts and washers used for the flanges shall be of type 304 stainless steel. Flat washers shall be used under all bolt heads and nuts.
- 5.2.2.7 The pressure rating of the high pressure piping system shall be 800 psig operating pressure; the hydrostatic and leakage test shall be 150% of the operating pressure.

5.3 ELECTRICAL

5.3.1 Skid Wiring

All skid wiring and necessary control wiring for all motor controls shall be furnished as part of the package.

5.3.2 Internal Wiring

Internal wiring in the electrical enclosures, terminal and junction boxes shall be done in an orderly practice. All wiring shall be tied in bundles and placed in wiring troughs with tags.

5.3.3 Control Panel

Control panel shall be weather proof NEMA 4 type with proper opening for external field installation of cables in conduits entries.

5.3.4 Motor

Motor of 10 hp and above shall have motor space heaters; heating element shall not exceed 93°C maximum operating surface temperature.

5.3.4.1 All motors shall have totally enclosed fan cooled (TEFC) enclosures as a minimum.

5.3.4.2 All starters for three phase motors shall be provided with unitized block - type thermal overload trip relays

5.3.5 Conduit Installations

Conduit shall be sized and provided in conventional (English) units in accordance with the National Electrical Code (USA).

5.3.5.1 The minimum size conduit shall be 3/4 inches.

5.3.5.2 Conduit shall not be supported from process piping lines.

5.3.5.3 Conduit entry in electrical enclosures shall be either at the bottom or at the side entry.

5.4 INSTRUMENTATION

5.4.1 General Requirements

- 5.4.1.1 All instrumentation and controls are to be in accordance with the best industrial practice and consistent with sound engineering and safety requirements. Instruments and controls shall be selected to provide a high degree of dependability with a minimum of maintenance for plant operation, shall be accessible for testing, calibration and servicing, and must be readily removable for maintenance procedures.
- 5.4.1.2 The ultrafiltration and the reverse osmosis units shall be furnished completely with an individual locally mounted control panel on each skid with all the instrumentation and controls.
- 5.4.1.3 The ultrafiltration and the reverse osmosis units shall be either capable to operate independently or as a joined complete system.
- 5.4.1.4 Electronic instruments shall be selected for 4-20ma in/output range, if required.
- 5.4.1.5 Component devices shall be furnished to provide electrical contacts for all required interlocks, tripping circuits, etc.
- 5.4.1.6 All instruments shall be tagged with an identification number.

5.4.2 Factory Installed Electrical Systems

- 5.4.2.1 The control panel shall be skid mounted, assembled, tested and functions as a complete system to minimize any field assembly.
- 5.4.2.2 Control power shall be of 115AC/60Hz. The Vendor shall furnish a 480V-110V control power transformer and disconnect hand switch for the control panel.
- 5.4.2.3 Shutdown and alarm wiring shall run via terminal blocks with quick-disconnect terminals.

- 5.4.2.4 Control and alarm circuits shall be designed to fail-safe; the failure of an instrument shall not cause equipment to start up. Single-pole double-throw potential free contacts shall be provided for alarm and trip systems.
- 5.4.2.5 Purchaser will supply one 480 Volt, 3-Phase, 60 Hertz feeder to a skid or multi-skid packaged system to serve motor loads and all other loads.
- 5.4.2.6 Push buttons, pilot lights and switches shall be oil-tight heavy duty type. Long life type derated lamps shall be used. The color of the push buttons or lights shall be green for "on" and red for "off" positions.
- 5.4.2.7 Test facility shall be provided for all indicating lights with a common test push button for each panel section.
- 5.4.2.8 Limit switches shall be used for motor-driven valve to indicate valve position.
- 5.4.2.9 Light shall be provided for each motor and elapsed timers for each high pressure pump.

5.4.3 Monitoring Instruments

The Vendor shall provide, as a minimum, all required instrumentation to perform the functions listed below:

5.4.3.1 UF System

<u>Function</u>	<u>Local Instrument</u>	<u>Panel Mounted Instrument</u>	<u>Alarm Set Point</u>
Recirculation Pump Suction Pressure	1	--	5 psig Decreasing
Membrane Feed Pressure	1	--	75 psig Increasing
Permeate Feed Pressure	1	--	5 psig Increasing
Permeate Feed Turbidity	--	1	NTU Increasing
Concentrate Temperature	1	--	45°C Increasing
Permeate Flow	--	1	--
Concentrate Flow	1	--	--
Reject Flow	1	--	--

5.4.3.2 RO System

<u>Function</u>	<u>Local Instrument</u>	<u>Panel Mounted Instrument</u>	<u>Alarm Set Point</u>
Feed Ph	--	1	Ph 4 Decreasing Ph 6 Increasing
Feed Temperature	1	--	35°C Increasing
HPP Suction Pressure	1	--	5 psig Decreasing
Membrane Feed Pressure	1	--	810 psig Increasing
Feed Conductivity	--	1	--
Permeate Conductivity	--	1	--
Concentrate Flow	1	--	--
Permeate Flow	--	1	--

5.4.2.3 Pressure Indicators

The following is the minimum required pressure indicators to be provided:

<u>UF System</u>	<u>RO System</u>	<u>Clearing System</u>
Feed Pump Discharge	Cartridge Filter Inlet	Feed Flow
Recirculating Pump Suction	HPP Suction	Reject Flow
Membrane Feed	Membrane Feed	
Permeate	Concentrate	
Concentrate		

Temperature Indicators

The following is the minimum required temperature indicators to be provided:

<u>UF System</u>	<u>RO System</u>	<u>Clearing System</u>
Concentrate	Heat Exchanger Inlet	Feed Flow
	Heat Exchanger Outlet	

5.4.3.4 Level Control

<u>Location</u>	<u>Level Description</u>	<u>Function</u>
Wet Well	Low	Sump Pump Off
UF Feed Tank	Low Low	Sump Pump On
	Low	UF Shut Down
	High	UF Run
	High High	Sump Pump Off
RO Feed Tank	Low Low	UF Permeate Feed
	Low	RO Shut Down
	High	RO Run
	High High	UF Permeate Bypass

5.5

TOOLS

The Vendor shall supply one set of special tools for field erection and maintenance of the units, but not limited to the following:

- Slide-hammer for permeator "O"-ring replacement
- Special wrench for high pressure pump packing replacement
- SDI kit with 500 filter papers
- Portable conductivity/ph meter
- Buffer solution for conductivity, turbidity and ph meter calibrations.

5.6 PAINTING

- 5.6.1 All painted and external coated surfaces shall be prepared in accordance with paint manufacturer's recommendations.
- 5.6.2 The Vendor shall provide paint specification for approval, if any.
- 5.6.3 All sharp surface protrusions and all welded splatter shall be removed prior to sand blasting.
- 5.6.4 Non-ferrous metals and alloy steels do not require painting.
- 5.6.5 The dry film thickness of the paint shall not less than 3 mils on surfaces.
- 5.6.6 The following coats shall be applied as a minimum or approved equal:
- One (1) coat of zine chromate primer
 - One (1) under coat of high quality weather resistant paint
 - One (1) finishing coat of high quality weather resistant enamel
- 5.6.7 A one quart can of finishing paint of the same batch shall be included with the units for field touch-up.

6.0 INSPECTION and TESTING

The Vendor shall notify the Purchaser 15 days prior to a witness acceptance test being performed.

6.0.1 The Vendor shall check all electrical equipment for proper voltage, phase, and frequency.

6.0.2 A functional test of the instrumentation and control systems shall be performed in addition to the continuity check.

6.0.3 Rotating equipment shall be checked for proper alignment.

6.0.4 All components and piping systems except for permeators and UF membrane shall be hydrostatically tested at 150% of the maximum working pressure of the individual unit.

6.0.5 For testing, the Vendor shall supply all electrical power supplies, chemical, testing equipment, utility and testing facility as required to calibrate and simulate all instrument functions.

6.0.6 Visual checks shall be made for general appearance and workmanship.

6.0.7 A 4-hour continuous un-interrupted equipment performance acceptance test shall be performed for each unit.

6.0.8 A witness acceptance test shall be passed and accepted by the Purchaser representative before shipment authorization.

7.0 PREPARATION for SHIPMENT

- 7.0.1 All skids and ship loose materials shall be packed for containerized shipment. A ship loose bill of material shall be provided.
- 7.0.2 Each skid shall be drained and dried.
- 7.0.3 Membrane shall be shipped per membrane manufacturer shipping instruction with insulation (if required) and shall be chemically treated against biological attack and freezing.
- 7.0.4 Exposed flange connections shall be covered with plastic or wooden cover. Other connection shall be plugged.
- 7.0.5 Special shipping and handling instructions, if any, shall be provided with the shipment together.
- 7.0.6 Each ship loose instrumentation shall be tagged with appropriate mark number or identification.
- 7.0.7 Each gauge, electrical control cabinet, and instrumentation shall be protected against damage during shipment.

8.0 OPERATING and MAINTENANCE MANUALS

The Vendor shall furnish 6 sets of bounded Operating and Maintenance Manuals and complete set of reproducible drawings to the Purchaser prior shipment. The O & M manuals must be received before final payment is made. This manual shall include a brief process description, maintenance instruction and schedule, catalog cuts, electrical schematic diagram, P & I diagram, etc. The manual shall consist of the following, as a minimum:

- 8.0.1 General description shall consist of a description of all the equipment installed on each skid and their function, a control sequence describing startup, different operation modes and plant shutdown procedures.
- 8.0.2 Installation instructions shall highlight special precautions and conditions, mechanical and electrical interfaces between the Purchaser and Vendor, and site requirements.
- 8.0.3 Membrane storage and shipping guidelines shall be provided with detailed instructions for membrane sterilization and freeze protection.
- 8.0.4 Operating instruction shall consist of preparation procedure for the initial startup, normal process operation in Auto and Manual modes, a normal shutdown, an emergency shutdown and long term plant shutdown, and equipment/instrumentation and membrane performance trouble-shooting.
- 8.0.5 Maintenance instruction shall consist of preventative maintenance procedure, a schedule for data taking, sampling, and equipment calibration and servicing.
- 8.0.6 Membrane cleaning procedure and the required cleaning chemical shall be presented in detail.
- 8.0.7 All required chemical safety data sheets shall be included.
- 8.0.8 Equipment literature shall consist of O & M manual for pump, motor, membrane, instrumentation, etc., catalog cuts, bulletins and parts list.
- 8.0.9 A complete set of the Vendor drawings and spare parts list shall be included.

9.0 SPARE PARTS

9.0.1 The Vendor shall provide a recommend spare parts list for maintenance of the equipment indicated in this specification. Based on equipment manufacturer and the Vendor's recommendations, the two (2) years recommended spare parts list and a startup spare parts list shall be furnished along with the Operating and Maintenance Manual prior shipment.

9.0.2 The spare parts description shall include the following as a minimum:

- Equipment Name
- Full Description
- Size, Operating Range, Rating and Set Point
- Material of Construction
- Model
- Manufacturer Name
- Part Number
- Quantity Require
- Lead Times

000107

GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia

Cost Estimates for
Ultrafiltration and Reverse
Osmosis Systems

Prepared for
U. S. Navy Civil Engineering Laboratory
Port Hueneme, California

PREPARED BY _____

APPROVED BY _____

DATE APPROVED _____

Cost Estimates for 10,000 GPD AFFF Membrane Recovery System

UF System

<u>Description</u>	<u>Qty.</u>	<u>Unit Price</u>	<u>Total</u>
-Abcor Ultra-Cor Tube	176	200	\$35,200
-Tank, FRP, 500 gals	1	900	900
-Well Pump w/motor	1	2,800	2,800
-Feed Pump w/motor	1	1,600	1,600
-Recirculation Pump w/motor	1	6,500	6,500
-Cartridge Filter	1	150	150
-Pressure Gauge	4	30	120
-Temperature Gauge	1	45	45
-Florometer-w/totalizer & recorder	1	1,000	1,000
-Rotometer	2	100	200
-Valve, 3-way, electrical	1	350	350
-Valving	1 set	500	500
-PVC Piping	1 set	1,000	1,000
-Pressure Switch	3	175	525
-Turbidity Meter	1	1,200	1,200
-Level Control	2	400	400
-Control Panel w/components	1	3,000	3,000
-Skid 7½ x 25	187.5 ft ²	10/ft ²	1,875
-Sand Blast & Paint	1	1,000	1,000
-Labor & Overhead (include wiring, cut, welding, pre-assembly, final assembly, trouble shooting and testing, and acceptance test)	332	30/hr	9,960
-Contingency 5% (include crating)			<u>3,500</u>
		Subtotal	71,825
-1.5 Mark Up (include engineering)			107,738
Total Estimated Costs			\$110,000 ± 10%

Cost Estimate for a 10,000 GPD RO System

Alternative No. 1

<u>Description</u>	<u>Qty.</u>	<u>Unit Price</u>	<u>Total</u>
-B-10 6840	3	5,500	16,500
-Tank, FRP, 500 gals	1	900	900
-Feed Pump w/motor	1	1,600	1,600
-Heat Exchanger	1	1,500	1,500
-Cartridge Filter	2	200	400
-Temperature Gauge	2	45	90
-Pressure Gauge	4	30	120
-Temperature Switch	1	200	200
-Pressure Switch	2	175	350
-HPP w/motor	1	3,800	3,800
-Sheaves, Belts, etc.	1 set	750	750
-Drawback Tank	1	450	450
-Safety Relief Valve	2	250	250
-Accumulator	2	550	1,100
-Acid Feed	1	650	650
-Tools	1	1,000	1,000
-Conductivity Meter	2	400	800
-pH Meter	1	650	650
-Piping, SS	1 set	600	600
-Piping, PVC	1 set	500	500
-Valve, Automatic Throttling	1	1,500	1,500
-Valving, PVC	1 set	300	300
-Valve, 3-way, electrical	1	350	350
-Rotometer	1	100	100
-Florometer-w/totalizer & Recorder	1	1,000	1,000
-Level Control	1	200	200
-Control Panel and Wiring	1	2,000	2,000
-Skid 7½ x 15	112.5 ft	10/ft	1,125
-Sand Blas and Paint	1	700	700
-Labor and Overhead	250	30/hr	7,500
-Contingency 5% (include crating)			<u>2,500</u>
		Subtotal	49,485

Cost Estimate for a 10,000 GPD RO System (continued)

<u>Description</u>	<u>Qty.</u>	<u>Unit Price</u>	<u>Total</u>
-1.5 Markup (include engineering)			74,228
Total Estimated Costs			\$75,000 ± 10%

Grand Total	UF	\$110,000
	RO	75,000
	Clening Units	<u>15,000</u>
		\$200,000 ± 10%