ANL/APS/TB-39

DESIGN MANUAL FOR
APS POLISHING, DEAERATION AND
MAKEUP SYSTEM IN BUILDING 450

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1.0 INTRODUCTION

1.1 Purpose

The purpose of the polishing and deaeration systems for the APS Process DI (deionized) Water (PW) system is to maintain the quality of water supplied to technical components of the APS facility within the following limits:

- Resistivity above 4.0 Mohm-cm (polishing system)
- Dissolved oxygen (DO) content below 10 ppb (deaeration system)

The deaeration system also provides for filtration of process water to levels of 0.05 micron, and the polishing system provides for treatment by ultraviolet (UV) lamps to inhibit biological growth.

The makeup system maintains a continuously available supply of approximately 6000 gallons of DI water that is transferred to the PW system upon demand. The DI makeup water is produced by a reverse osmosis (RO) system that uses domestic lab water as its feed.

The polishing, deaeration and makeup systems are also referenced in this manual as the "treatment system."

1.2 References

ANL-E ES&H Manual, Chapter 7, Section 7.1: Control of Hazardous Energy and Lockout/Tagout

Procedures for Operation of Process (DI) Water Treatment System in Building 450, Procedure #750303-00025

Emergency Shutdown and Lock-out/Tag-out Procedures for Process (DI) Water Treatment System in Building 450, Procedure #750303-00026

Drawing #J0450-0348-E-P001: DI Water System, Utility Building 450, DI Makeup Water System

Drawing #J0450-1295-EE-P001: D.I. Water Makeup and Polishing System Components

1.3 Major Subsystems and Components

Drawing #J0450-0348-E-P001 is a detailed piping and instrument diagram (P&ID) for the overall treatment system that is made up of the three major subsystems (polishing, deaeration, and makeup systems). The polishing and deaeration subsystems operate as "slipstreams"; that is, water from the primary PW supply line is diverted from the main flow of water on its way to the APS facility, treated in two parallel streams, and returned to the primary return line. Makeup water is delivered to either the polishing stream or deaeration stream as selected by the operator.

1.3.1 Polishing System

This system comprises two 100% capacity pumps (tags WPW-P-801 and -802) to circulate up to 150 gpm through two parallel trains of 30-ft^3 tanks. Each train comprises an oxygen scavenger resin tank to remove DO in series with at least one mixed bed resin tank containing both anion and cation resins to remove ions from (i.e., "polish") the water stream. Each parallel train has a nominal flow rate of 75 gpm.

After water is polished by the resins, the 75-gpm parallel streams are recombined and then pass through a 0.5-micron (nominal) filter, a UV treatment lamp, and another 0.5-micron (nominal) filter.

1.3.2 Deaeration System

This system comprises a 4-ft-diameter × 35-ft-high vacuum deaerator (also termed "degassifier") vessel (tag VAC-001), three 50% capacity pumps (tags WPW-P-806, -807 and -808), a 0.5-micron (nominal, 2.0 micron absolute) pre-filter (tag WPW-F-002), and a 0.05-micron (absolute) fine filter (tag WPW-F-002).

The deaerator (degassifier) is designed to remove dissolved oxygen from the PW stream at a high rate (flow rates up to 500 gpm) to quality levels as low as 5 ppb or less depending on the DO level in the bulk PW inlet.

Extremely fine filtration is provided in the event the PW becomes contaminated with copper oxide particles (CuO and/or CuO_2). These particles have been known to foul small passages in water system components. The particles are believed to start out very small in size and readily agglomerate to form larger particles.

1.3.3 Makeup System

The makeup system comprises a reverse osmosis system to produce high quality deionized water at a rate on the order of 2000 gallons per day (gpd). This water is stored in a 6000-gallon capacity fiberglass storage tank (WPW-ST-801). The tank is supplied with two 100% capacity pumps (WPW-P-804 and –805) to transfer the makeup water from the storage tank to the PW system when system pressure falls below a minimum set point.

Makeup water is deaerated prior to flowing to the PW system itself. The makeup pumps transfer the water from the storage tank to either the polishing system (where deaeration is performed by the scavenger resin) or to the degassifier (where deaeration is performed by the vacuum process). The choice of which deaeration method to use for makeup water is made by selecting the position of a three-way valve (CV-201) in the discharge line of the makeup transfer pumps.

In the event of a significant requirement for makeup water in excess of the rate produced by the RO system, "quick disconnect" type fittings are installed so that DI makeup water can be produced by the temporary installation of "jumbo" (30-ft^3) tanks (cation, anion, and/or mixed bed resin). Tanks of this type are typically available from local sources within 24 hours or less and can produce up to 50-60,000 gallons per set of four "jumbos."

1.4 Need

The need for these systems is, from the point of view of accelerator operations, essential and critical:

Electromagnets and high-power rf (radio frequency) technical components require non-conductive water for cooling and temperature stability conditioning. This requirement is maintained by components of the polishing system.

Levels of DO in the PW stream in excess of 20 ppb for extended periods has been found to cause significant fouling of small flow passages in the system. Plugging of flow passages in accelerator technical components such as magnets and absorbers has been observed. Fouling also occurs in flow regulating devices such as regulators and orifices. This plugging is caused by oxides of copper due to the corrosion process when DO is present in the PW stream.

Removal of oxygen and ultrafine oxide particles is performed in the deaerator system. Oxygen is removed in the polishing loop as well, however, the treatment rate is about one-third that of the deaerator. Although the treatment rate is lower, DO in the polishing effluent is lower than 1 ppb (better performance than the deaerator). This additional capacity is provided as an alternative means of oxygen removal in the event the deaerator is not functioning and serves to keep bulk system DO lower than if the deaerator only were used.

The need for makeup water is obvious. Using RO to produce makeup water reduces the need for resin exchanges that, when required, must be done without delay and usually occur with little or no prior notice. The RO system can be maintained on a regular schedule and delivers makeup water with virtually no interruptions.

1.5 Configuration and Performance

1.5.1 Polishing System

Design flow rate:	150 gpm total; 75 gpm each circuit (max flow through one 30-ft^3 resin tank is 75 gpm)*
System configuration:	two parallel circuits; each circuit having one 30-ft^3 oxygen scavenger resin tank in series with one 30-ft^3 mixed bed resin tank; total flow filtered to 0.5 micron (nom), 2 micron (abs), and UV treated

Pumps:	two × 100% capacity
Other:	ability to remove DO from makeup
Effluent quality:	12-18 Mohm-cm; <1 ppb DO
	* installed pumps capable of delivering only 135 gpm as of 9-30-99

1.5.2 Deaeration System

Design flow rate:	450 gpm
Effluent quality:	<5 ppb DO (ultimate)
Pumps:	Three ×50% capacity
Pre-filter:	0.5 micron (nom)
Ultra-fine filter:	0.05 micron (abs)
Vacuum vessel:	Design pressure: full vacuum to 150 psig; 48 in. diam. × 17 ft T.L.; ASME stamped
Vacuum pumps:	Two × 50%
Vacuum blower:	One × 100%

1.5.3 Makeup System

Capacity:	2000 gpd (min) at 35°F supply temp. (capacity increases with increasing temperature)
Treatment:	Softener (30 ft^3) Cation polisher (3 ft^3) Carbon bed (3 ft^3) RO membrane Final polish to 18 Mohm-cm (2 × 6-packs containing 3.5-ft^3 cation, anion, mixed bed resin)
Storage tank:	6000 gal capacity, not blanketed; quality maintained by circulation through resin tanks in RO system
Makeup rate:	2 × 50% pumps, 50 gpm each

Makeup quality:	>4 Mohm-cm
Discharge point:	Deaeration system or polishing system

1.6 Location

Components of all three systems are located in the southwest corner of building 450 as indicated on drawing J0450-1295-E-M001.

Connection of the three systems to the main PW system is made through one pair of 6"-diameter pipes (supply and return). Flow for all three systems passes through these lines. These 6" lines tie into the 24" PW main lines at the southeast corner of the building just before the main lines leave/enter the building.

2.0 SYSTEM DESCRIPTION

2.1 Flow Diagram, Piping and Instrumentation Diagram, Layout and Isolation

A detailed piping and instrumentation diagram is indicated on drawing J0450-0348-EE-P001. Major equipment items are located per drawing J0450-1295-E-M001.

The entire group of three subsystems covered by this manual, including the corresponding 6"-diameter supply and return lines for the systems, can be isolated from the PW main lines (line 24"-PWS-001 and 24"-PWR-001) with valves V-392 and V-280. These valves are relatively difficult to access (located above exchanger HX-804), and it is recommended that they be used only if work is required on the 6"-diameter supply and return lines themselves.

If all three systems must be isolated, the most convenient valves to use are valves V-208 (treatment supply line 6"-200) and V-389 (treatment return line 6"-303). Both of these valves are located near the deaerator vessel.

2.2 Polishing System

2.2.1 Flow Path

Water from the PW supply (line 24"-PWS-001) flows overhead through the 6"-diameter treatment supply line 6"-200 to the southwest corner of building 450. From this line, water flows to the suction side of pumps WPW-P-801 and -802 through line 4"-100. One pump is operated and the other is standby. The operating pump delivers water to two parallel polishing streams (lines 2"-102 and 2"-103).

Each polishing stream has a McCrometer V-cone flow element (FE-101 and -102) and dedicated differential pressure (DP) transmitter (DPT-101 and -102). These transmitters have local indicators that shows the flow in gpm and provide an analog current signal to the control system (FI-101 and -102). The desired flow rate is 75 gpm through each stream. These streams are provided with Griswold self-actuated flow control regulators (V-105 and -127).

Each stream then passes through a plastic-lined steel tank (WPW-DO-001 and -002) with a volume of 30 ft^3 that contains oxygen scavenger resin. Each resin tank has a sample port intended for sampling of DO in the water (DOE-101 and -102). The sample port, mounted in a blind flange in the shell (side wall) of the tank about one foot above the floor, provides an indication of the need to regenerate the corresponding resin. The location of the port corresponds to the place at which the flow has resided in the tank about 80-90% of its overall residence time. Thus, if the DO at this sample point is similar to the value at the inlet, then the tank is or will soon be in need of regeneration. The sample point inlet is designed with an inlet screen to prevent the ingress of resin fines.

After passing through the scavenger, each stream passes through another 30-ft^3 resin tank (WPW-MB-001 and -002) containing mixed bed resin (type II anion). A third 30-ft^3 resin tank (WPW-DO-003) containing mixed bed resin (type I anion) is provided and is installed in one of the two 75-gpm polishing streams. Fittings on these tanks are identical to those of the oxygen scavenger except that a sample port is not provided.

After passing through the mixed beds, each 75-gpm stream is sampled for resistivity (KI-100 and -101). After the two 75-gpm streams recombine, the total stream is again sampled for DO (DOE-103).

The fully polished stream then passes through a filter housing (WPW-F-003) containing 30" long double-open-end filters, nominal rating 0.45 micron (2 micron absolute). After passing through the filter WPW-F-003, the stream passes through a UV treatment lamp (WPW-UV-802).

Finally, the 150-gpm polishing stream passes through another filter (WPW-F-004) containing the same 30" long double-open-end filters, nominal rating 0.45 micron (2 micron absolute). A bypass line with valve (V-161) is provided around the two filter housings and UV lamp to permit maintenance without interruption of flow. The polishing stream then flows through line 4"-105, which takes it back to the treatment return (line 6"-303).

2.2.2 Isolation of Polishing System

Use valves V-205 and V-385 to isolate the polishing system from the other systems. Valves V-100 and V-123 can be used instead of V-205; valves DI.W-129 and V-161 can be used instead of V-385 (both pairs of valves are more readily accessible from ground level). Valves V-200 or -201 must also be closed to isolate the polishing system from the makeup pumps.

When the polishing system is isolated, pumps WPW-P-801 and P-802 are off.

2.2.3 Equipment

Two pumps are provided, each with 100% capacity (WPW-P-801 and -802). The pumps are end suction type mounted on a baseplate common with the electric motor. The pumps are Ingersoll-Rand GRP (fiberglass) type with 7.5-hp motors operating at 3600 rpm.

At the time this manual is written, the pumps deliver only about 130-gpm total flow. The existing 5.188"-diameter impeller can be increased to a maximum diameter of 6.25". An impeller with a diameter of approximately 6.0" is anticipated in order to deliver the 150-gpm design flow. It is further anticipated that the installed 7.5-hp motor is adequately sized for this increased flow condition (150 gpm with the 6" impeller). However, this should be confirmed after modification, if it is ever undertaken. If an impeller larger than 6" diameter is required, a 10-hp motor will be a necessity.

Each polishing stream is provided with a 3"-diameter Griswold self-regulating flow controller (V-105 and -127) to maintain the flow at approximately 75 gpm. The components are model 4924F, rated 76.1 gpm, 6-50 psid spring range.

Each polishing stream is provided with a 2"-diameter McCrometer V-cone flow element (FE-101 and -102) comprising a specially engineered obstruction in the pipe that produces a differential pressure proportional to the square root of the flow rate. The model number of these components is VP02QE44N. Each V-cone is provided with a Yokagawa differential pressure transmitter with digital display to indicate the actual flow rate through the stream.

A total of five resin tanks are provided for oxygen scavenger (two tanks: WPW-DO-001 and -002) and mixed bed resin (three tanks: WPW-MB-001, -002, -003). Oxygen scavenger resin is strong base anion in the sulfite form. One tank contains type I anion; the other tank contains type II. Mixed bed resin tanks contain a mixture of cation and type II anion.

Resin tanks are plastic lined and provided with 2"-diameter process inlet and outlet fittings with butterfly valves, 2"-diameter resin fill fitting, and 1"-diameter resin outlet fitting. The process inlet is the upper fitting on the vessel shell and the process outlet is the lower fitting on the vessel shell. The resin fill is located on the vessel top head and the resin outlet is located in the bottom head. The resin fill fittings are provided with special ¼" nominal fittings that may be used to vent the tanks when necessary. All fittings of the resin tanks are the so-called "CAM-LOCK" quick-disconnect type. Matching fittings for hose ends can be ordered as Dixon PT type couplings or equal.

The oxygen sensors are Orbisphere model 3660. Important features of this instrument are:

** ability to measure DO to within +/-1% or +/-1 ppb, whichever is greater

** ability to record up to 500 data points in memory

** programmable with a notebook personal computer (PC)

Resistivity monitoring is performed with Foxboro model 887 instruments commonly used in many locations in the PW system.

Two filter housings are installed in the polishing stream. These housings are manufactured by Pall and require double open-ended cartridges, 30" long. Cartridges with a rating of 0.5 microns nominal, 2 microns absolute are recommended.

Details on all the equipment summarized in this section are listed in section 4.1.

2.2.4 Available Configurations

The operator can configure the polishing system to use either of the two 100% capacity pumps. Except for unique operational circumstances not foreseen by this document, one of the pumps should be operated at all times. If both pumps are employed simultaneously, the installed Griswold flow regulators will maintain a flow of 75 gpm through each stream anyway. Therefore, there is no advantage to operating both pumps simultaneously.

At commissioning, the resin tanks were configured such that each 75-gpm stream passed first through an oxygen scavenger tank and then a mixed bed (type II anion) resin tank. For one of the streams only, the flow then passes through an additional mixed bed (type I anion).

The type I anion mixed bed resin was purchased in 1998 in order to provide standby capacity for the type II anion resins that have been in service since initial commissioning of the APS system. These original resins are known at this time to be significantly reduced in capacity and mechanically damaged. However, they are still quite capable of producing 12-15 Mohm-cm water and are expected to remain viable for years to come due to the light loading of the APS Process Water system.

It is recommended that both filter housings have elements in place at all times. The first (upstream) housing is intended to remove fine particles sloughed from the resin tanks. This filter will be the more heavily loaded of the two housings and will require cartridge changes on a regular (approximately 3-6 month interval, depending on operating experience) basis. The second housing provides secondary filtration and will require replacement no more than annually.

2.3 Deaeration System

2.3.1 Flow Path

Water from the PW supply (line 24”-PWS-001) flows overhead through the 6”-diameter treatment supply line 6”-200 to the southwest corner of building 450. From this line, water flows through line 4”-312, through level control valve LCV-300, and into the top of the deaerator vessel, which is maintained at a pressure of approximately 23-24 torr absolute.

When entering the vessel, water is sprayed through a specially designed nozzle that produces a conical pattern of droplets that is distributed over the vessel’s entire diameter.

Occupying the middle portion of the vessel is approximately 140 ft^3 of high efficiency, polypropylene tower packing. As the spray droplets make their way through the packing by gravity action, the surface of the droplets is exposed to the very low concentration of oxygen in the vessel’s atmosphere. During this period, oxygen dissolved in the droplets (existing at a level higher than the equilibrium value) makes its way across the liquid-vapor interface to the vapor space. The installed vacuum pumps remove vapors generated in the vessel including oxygen, nitrogen, other airborne gases and water vapor (since the water in the tank is at the boiling point).

Droplets falling from the bottom of the packing layer collect in a pool at the bottom of the vessel. Pumps WPW-P-806, -807, -808 are employed to transfer the water from the bottom of the deaerator vessel through line 6”-303, through filter housing WPW-F-002 (0.5 micron, nom), and through filter housing WPW-F-001 (0.05 micron, abs).

A flow control valve, CV-300, is installed in line 6”-303 to regulate the flow through the degassifier system. A bypass line with valve (V-391) is provided around the two filter housings to permit replacement of the elements without interruption of flow. The deaerator stream then flows back to the PW system through the 6”-diameter overhead return line 6”-303 where it connects to line 24”-PWR-001 (PW return).

A line that bypasses the entire degassifier system is provided using lines 6”-311 and 4”-310 with valve CV-316 closed. The degassifier vessel (only) may be bypassed by using line 6”-311 with valves V-301 and CV-316 open and valve V-302 closed.

When the degassifer is used, vacuum pumps WPW-P-809 and -810 must be operated to remove water vapor and gaseous contaminants (e.g., oxygen) from the top of the deaerator vessel VAC-001. This is done through the 6”-diameter line that draws vapor from the top of the tank down to the vacuum system. The vacuum pumps discharge to atmosphere through penetrations in the roof of building 450. A vacuum blower, WPW-P-811, is also provided. This machine is of greatest benefit when used when DO levels are high (e.g., >30 ppb in the bulk process water).

When vacuum pumps only are employed, the blower is bypassed through V-309. In this situation, ejectors E-28 and E-29 must be open to the atmosphere through valves V-312 and V-326. When the blower is used, valves V-309, V-313, and V-325 are closed and valves V-310, CV-314, and CV-315 are opened.

2.3.2 Isolation of Deaeration System

Use valves V-300 and V-383 to isolate the deaeration system from the other systems. Valve V-301 and valve V-302 must also be closed if bypassing of the deaeration system is not desired.

Except when there is a need to isolate individual water pumps (WPW-P-806, -807, and -808) or isolate filter housings (WPW-F-801 and -802) while on bypass, the degassifier system should be isolated using the valves listed in the preceding paragraph so as not to risk accidental filling of the deaerator vessel. When the deaeration system is isolated, pumps WPW-P-806, -807, and -808 must be off.

2.3.3 Equipment

Major equipment in the deaerator stream includes the deaerator vessel (VAC-001), the level control system for the vessel (LT/LCV-300), three water pumps (WPW-P-806, -807, -808), a flow meter (FI-300), flow control valve (CV-300), and the two filter housings (WPW-F-001 and -002). Adjunct to the vacuum vessel are the vacuum pumps (WPW-P-809 and -810) and vacuum blower (WPW-P-811).

The vacuum pumps are Siemens liquid ring type pumps that use a squirrel cage rotor in a cylindrical housing as the pumping mechanism. A small clearance exists between the squirrel cage and the housing, which is sealed by a film of water. Thus, there is a need for an external water supply for sealing and cooling the pump. It is important to understand that the use of water limits the ultimate pressure of the pump to the vapor pressure of water at its delivery temperature (on the order of 22 torr). Furthermore, when the pressure in the deaerator approaches this value, the liquid ring pump will exhibit cavitation (manifested externally by loud machine noise). Cavitation is prevented by using ejectors (one per pump) when the vacuum blower is not operating and by using manual air bleed valves when the vacuum blower is in operation.

The vacuum blower is a Kinney Vacuum mechanical blower of the type often referred to as a “Roots” blower. Suitable for the wet environment, it is oil lubricated and water cooled. When operating, it is used as a booster in series with the liquid ring pumps. The blower should not be operated above 100 torr inlet pressure.

The deaerator vessel is an ASME stamped pressure vessel rated from full vacuum to a maximum 150 psig. It is 4 ft in diameter with a 17’-0” tangent length. Including the skirt and top head, the overall height is approximately 26 ft. The vessel is made of stainless steel and has internal parts.

The deaerator vessel was modified in 1998 to include an additional penetration of the support skirt. The pressure boundary of the vessel was not altered in any way. The outlet nozzle itself was not modified (it remains 6" diameter), however, the line from the outlet nozzle to the pumps (WPW-P-806, -807, -808) was increased to 8" diameter (line 8"-300). The additional skirt penetration was installed to facilitate the new 8" line. Vessel skirt modifications were performed in accordance with ASME requirements and are documented in APS documents 750303-00002 through -00009 which include all original vendor vessel documents as well as documentation related to the 1998 modifications. Since only the vessel skirt was modified in 1998, the vessel was not rehydrotested.

The spray nozzle and related internal distribution pipe at the top of the vessel are both bolted in place and can be modified if needed. The original 2"-diameter spray nozzle was replaced with one with 4" diameter in 1998 (Spraying Systems 4-RR-SS-95-250).

The vessel contains approximately 135-145 ft^3 of tower packing. The packing is supported by a perforated stainless steel plate near the lower quarter point of the vessel. The location of the plate can be determined by the telltale burn marks on the outside of the vessel due to the internal weld that holds the plate in place. The vessel packing was replaced in 1998 with special high efficiency packing (Maspac FN-1000).

The level control system consists of a level transmitter (LT-300), level control valve (LCV-300), and two level switches (LSH-300 and LSL-300). The level transmitter and control valve system is completely pneumatic and operates in a proportional only mode to open the inlet control valve open in order to maintain a constant water level in the storage tank. The original control valve (Cashco 2") was replaced with a larger model (Cashco 4") in 1998. The level switches are located above and below the normal tank operating level and are used to notify of abnormal level condition. A visual indicator for tank liquid level is also provided (LI-300).

Three pumps are provided, each with 50% capacity (WPW-P-806, -807, -808). The pumps are end suction type mounted on a baseplate common with the electric motor. The pumps are Ingersoll-Rand GRP (fiberglass) type with 25 hp motors operating at 1750 rpm.

The pumps are designed to deliver 225 gpm each. The original 12.5"-diameter impellers have been replaced with 13.25" impellers (largest available). Normally, two pumps will be used and one maintained as a backup.

The flow from the pumps is measured by a 4"-diameter McCrometer V-cone flow element (tag FE-300, McCrometer part number VP04QE44N). The differential pressure across the V-cone is measured with a Yokagawa differential pressure transmitter. The transmitted signal is displayed by a Honeywell standalone controller (FI-300) with digital display to indicate the actual flow rate through the stream.

Flow from the pumps is controlled by the electrically actuated V-ball control valve purchased from Worcester Controls (CV-300). The valve model number is

WC4CPT466PT151/30A75Z-4. The position of the valve is controlled by the local indicating controller (Honeywell) mounted adjacent to the pumps.

The two filter housings are intended to remove extremely fine copper oxide particles that are formed when dissolved oxygen in the PW system combines chemically with copper components in the APS facility. The upstream filter housing (WPW-F-002) is considered a "pre-filter" to remove particles down to the level of around 0.5 microns (90% removal; 100% at 2.0 microns). The downstream filter housing (WPW-F-001) is for removal of extremely fine particles and is rated at 0.05 microns absolute. Clean pressure drops across these filters are 2 psid for the prefilter and 3 psid for the fine filter at 450 gpm. Differentials of 10 psid for either filter indicate a filter change is needed. If differentials become higher, there is no risk of failure of the elements. However, it will be necessary to open CV-300 more and more to maintain a constant flow rate through the degassifier until, eventually, the valve is wide open. If the differential pressure across the housings increases further after the valve is 100% open, the flow through the housings will be reduced. When DO levels are low (<10 ppb), the indicated pressure drop across the filters will remain at or near clean values for extended periods (months). When DO is high (~500-2000ppb), the fine filter (WPW-F-002) can exhibit a loss of up to 40 psid within 24 hours or less.

2.3.4 Available Configurations

When DO rises above normal operating levels (>5 ppb), there is little or no opportunity to begin operation of the deaerator system. Increased levels of DO usually occur unexpectedly, and it is important to reduce these upsets as quickly as possible.

Start up of the deaerator system takes from 2 to 6 hours depending on the level of residual DO in the water in the deaerator tower prior to startup. Furthermore, startup of the deaerator requires that the valves in the system are opened and closed. Opening and closing valves in the deaerator can result in pressure fluctuations in the PW system that can be great enough to cause trips of APS technical components. This is not acceptable and, therefore, the deaerator is normally operated continuously at a high throughput to handle unexpected upsets. As an additional benefit, operating the system at a high throughput provides continuous filtering of extremely fine particles.

Because DO levels in the PW system can increase rapidly without warning and because it takes hours for the deaerator to reach equilibrium DO levels after it is started, it is strongly recommended that the deaerator be operated at its design flow rate during most periods of time. This would include APS operations during so-called "run" periods (beam time for APS users). Operating the deaerator at design capacity (450 gpm using two of the 50% pumps) provides a high, on-line rate of oxygen removal in the event DO rises significantly. In this configuration, effluent from the deaerator is normally between 3.5 and 4.5 ppb without use of the vacuum blower.

The deaerator can be operated at flow rates as high as 550-600 gpm using all three installed pumps. Operation at this rate results in effluents from the deaerator being on the order of 6 ppb. Operation in this manner may be desirable during periods when DO levels are expected to rise (e.g., during APS maintenance periods when significant volumes of PW piping have been drained and require refilling) and would return DO levels below 10 ppb as quickly as possible.

Under all circumstances, both vacuum pumps should be operated. When DO levels are below 5 ppb, operation of the vacuum blower is of no benefit. When DO levels rise to higher levels, it becomes beneficial to use the blower. It is suggested that the blower be used when the DO level rises above 50 ppb.

There are other configurations of the deaerator that can be employed; however, these configurations would be used only under special circumstances. It is anticipated that these circumstances will occur only occasionally or (for some configurations) very rarely. These other configurations include:

<u>Startup of the deaerator:</u> This configuration is employed to remove residual DO from the water remaining in the vessel prior to startup of the system. In this configuration, the 4" flow control valve (CV-300) is closed, valve V-307 is open, and valve V-304 is opened partially. This permits flow from deaerator pumps -806, -807, and/or -808 to be recirculated back to the vessel inlet through line 3"-312 so that the DO level in the vessel eventually is reduced to a level below that of the PW system.

<u>Bypass of the deaerator vessel:</u> This configuration is employed if filtration is desired without deaeration. Valves V-301 and CV-316 in line 6"-311 are open, valve V-302 is shut, and control valve CV-317 is shut.

<u>Bypass of deaerator vessel, pumps, and filters:</u> This configuration is used to circulate water through the 6"-diameter supply and return lines (6"-200 and 6"-303) from and to the PW system without using any pumps.

<u>Recirculation of pump flow (not through vessel):</u> CV-317 open; CV-300 open or closed; V-307 open; V-304 closed; CV-316 closed. This configuration can be used to operate pumps on a recirculation loop without disturbing the vessel. This may be useful for pump checkout or for transition from one configuration to another.

2.4 Makeup System

The installed reverse osmosis (RO) system consists of a 30-ft^3 softening tank, 14" (3.5 ft^3) diameter carbon purifier and additional 14" (3.5 ft^3) diameter cation polisher, a membrane system, and two final polishing system 6-packs. The RO system was installed in June of 1999 and started operation in July of 1999. It can produce approximately 100 gallons per hour of high-quality DI water for the makeup tank.

Components of the RO system are owned by Culligan Industrial Systems of Glenwood, Illinois. APS leases the system on a monthly basis on P.O. 064043. The P.O. was placed on April 7, 1999 but installation was not complete until July 20, 1999. The P.O. is valid until July 20, 2004. The vendor is responsible for all preventative maintenance for his system.

For purposes of billing, the leasing charges for the RO system are at a fixed rate of $1285 per month. This includes offsite regeneration of the 30-ft^3 type J-36 softening tank in the very southwest corner of the area where the system is installed. The fixed-rate charge also includes 15,385 gallons of product per month. If more than that quantity of water is produced by the system, the charge is an additional 6.5 cents per gallon. Prices are applicable until July 20, 2004.

Although the agreement with Culligan is in effect until July, 2004, the budget authorization must be renewed by the requestor on a yearly basis prior to July 20.

2.4.1 Flow Path

Water from the ANL domestic water supply is the feed source for the RO system that produces makeup water for the deionized PW system. First, the feed water flows through a turbine meter (owned by ANL; tag FE-210) to measure the gross amount of feed water used by the RO system. After the meter, the feed water passes through a back flow preventer (V-263 and V-264).

The feed water is first presoftened in the 30-ft^3 softening tank (tag J-36). The softening tank is supplied with a panel (known as the J-36 panel) consisting of a pump (P-203) and filter (F-209) that continually keep flow moving through the 30-ft^3 tank even when there is no makeup demand.

The water then flows through the fiberglass carbon tank and final softening tank prior to being pumped through the membranes (MEMB-1,-2,-3,-4) by the pump mounted on the "RO panel." A solenoid valve mounted on the RO panel (CV-208) opens when the system receives a low storage tank level indication. The pump simultaneously operates to force water through the membranes. Some water does not pass through the membranes and is considered waste. A portion of this waste is sent to drain and the balance is recirculated back to pump inlet to improve yield.

Product out of the RO panel (with a resistivity on the order of 105 megohm-cm) flows to the RCS panel where it is distributed to the on-line bank of six 3.5-ft^3 resin polishing tanks (cation, anion, mixed bed). Here the water is polished to the final resistivity of 15-18 megohm-cm. From this location, the product flows to the storage tank after passing through filtration (0.5 micron nominal, 2.0 micron absolute) and UV treatment. A standby bank of six 3.5-ft^3 resin polishing tanks is provided in the event the on-line bank is exhausted prior to normal replacement.

The quality of water in the storage tank is maintained by a flow circulated from the bottom of the storage tank by pump WPW-P-803. This pump directs the flow from the bottom of the tank to a point in the RO system downstream of the membrane in the RCS panel. The storage tank stream and the RO product stream (discussed in the preceding paragraph) are mixed at this point. The flow is then directed through the on-line bank of resin polishing tanks, filtration, and UV treatment as discussed above. When there is no product flow, the storage tank (re)circulation stream is not interrupted.

Upon demand for makeup water in the PW system, pump WPW-P-804 or -805 will start automatically and pump water from the storage tank to the PW system. The water passes through a totalizing meter (FE-FQI-205) with nonsettable mechanical readout, then a 3-way valve (CV-201). The 3-way valve can be set to direct makeup flow through the resin bed polishing system or through the deaerator. This ensures that dissolved oxygen is removed from the makeup stream before it enters the PW system.

2.4.2 Isolation

The ANL raw water makeup supply can be isolated from the makeup production system with valve V-256.

The RO product water stream can be isolated with any of the following valves: DI.W-113, DI.W-114, V-231, or V-233.

The recirculation pump WPW-P-803 can be isolated with valve DI.W-112 and V-270.

The storage tank can be isolated with valves: DI.W-110, DI.W-112, and DI.W-113.

The makeup pumps can be isolated from the treatment system (degassifier and polishing loops) with valves V-212 and V-220.

2.4.3 Equipment

The turbine meter (FE-210) and back flow preventer (V-263/V-264) in the ANL raw water supply are owned by APS.

The boundary of the RO system at the inlet side is the point at which the lines change from copper (owned by APS) to CPVC (owned by Culligan). The actual location of the boundary is the downstream end of valve V-256. This location is on the south wall of the building near the motor end of pump WPW-P-801.

The boundary of the RO system at the product outlet side is at the upstream side of valve V-231 (product delivery point) and downstream side of valve V-270 (supply flow from pump WPW-P-803). This location is again characterized by the transition of piping from CPVC to stainless steel.

Pretreatment for the RO system is carried out by the gray steel 30-ft^3 J-36 softener, the 3.5-ft^3 fiberglass carbon purifier, and 3.5-ft^3 fiberglass cation polisher. The pretreatment panel (known as the J-36 panel) is located in the very southwestern corner of the building for the purpose of circulating about 3 gpm of water continuously through the J-36 softener tank even while there is no demand for water from the RO system. This flow is intended to keep the contents of the tank from packing. The panel is provided with a very small pump and is powered by 120 VAC.

The 30-ft^3 J-36 softener, the 3.5-ft^3 carbon purifier, and cation polisher must be exchanged from time to time. This is performed by the vendor on a regular basis.

The RO membrane panel houses the membranes; pump; solenoid valve; call-in modem; product, waste, and recirculation flows; quality meter (sampling product as it exits the membrane); and sample valve.

The third panel is known as the RCS panel and contains a pump that is not used in this application. The referenced pump is a standard part on this panel and is installed for resin tank recirculation purposes as on the J-36 panel. However, water is constantly recirculated through the resin tanks by pump WPW-P-803. Therefore, the resin tank recirc pump on the RCS panel is redundant and does not need to be operated. If it is operated, no harm will ensue. The panel is manifolded to mix RO product with the recirculation supply from pump WPW-P-803 and deliver this mixed stream (back) to the storage tank. Before delivery to the storage tank, the mixed stream is polished to 15-18 megohm-cm by one of the two resin bed 6-packs. Valves are provided (V-236, V-237, V-238, V-239) to be able to select the use of either of the two resin bed 6-packs for polishing (one on-line and one standby).

Also provided are three 2”-diameter male PT coupling connections at valves V-269, V-230, and V-257. These are installed in the event it is necessary to produce makeup water on an emergency basis, e.g., the RO system is out of order or does not have sufficient capacity to keep up with demand. In such an event, the PT couplings at the referenced locations would be connected to jumbo 30-ft^3 tanks containing resin (anion, cation, and/or mixed bed).

2.4.4 Available Configurations

Configuration options include only:

- The choice of makeup pump that can be used to fill the PW system (WPW-P-804 or -805);
- Use of male PT fittings at valves V-269, V-230, and V-257 in the event it is desired to produce makeup water from resin tanks rather than by means of the RO system;
- The choice of directing makeup water to the deaerator system or polishing system by selecting the position of valve CV-201.
- The choice of whether, when pumps WPW-P-804 or -805 are configured to deliver makeup through the resin polishing tanks instead of the deaerator, makeup flow is supplied to the suction side or the discharge side of pumps WPW-P-801 and -802. This choice is made by connecting the 3”-diameter hose in the makeup line (line

3”-200) to either the pump suction side at valve V-200 or discharge side at valve V-103. Normally, the hose is connected to the suction side at valve V-200 as pumps -804 and -805 do not have sufficient head to pump water to the discharge side of pumps WPW-P-801 and -802 if the latter are operating.

2.5 Flushing of “dead-ends”

It has been observed that branch lines with no water flow (a so-called “dead-end” or “dead leg”) can be a “source” of dissolved oxygen contamination for the main line from which the branch stems. This type of contamination can occur when:

- a line is filled with water after having been empty;
- DO-laden water flows through the line;
- flow in the line is stopped and the line is exposed to air.

When any one of these occurs, part or all of the branch line will contain DO. When normal flow through the main line is once again established at low levels of DO, the branch line will still have relatively high DO levels. The dissolved oxygen in the branch line “leaks” back to the water flowing through the main line because of the concentration gradient existing between the two regions. If a DO sensor were placed in the main line just upstream of the branch and another sensor just downstream, the downstream sensor would indicate a higher level of DO due to the “leakage” from the branch line. It can be compared to a so-called “virtual” leak.

The impact of piping dead-ends is a significant consideration in operating the deaerator system. During system commissioning, it was observed that contamination of dead-ends (e.g., discharge lines from pumps WPW-P-806, -807, -808) contributed DO to the deaerator effluent by as much as 20 to 100 ppb or more.

A network of small-diameter flushing lines has been installed to ensure that water in possible dead-end branches in the deaerator system can be continually flushed with water from the deaerator itself. The water for flushing has the very lowest levels of DO possible. Flushing the possible dead-ends in this manner removes “sources” of DO contamination. The flushing lines discussed here are lines containing the flushing valves V-305, V-341, V-342, V-338, V-340, V-355, and V-356. The flushing flow all goes through V-356 to the suction side of the pumps operating at vacuum.

During operation of the deaerator, the flushing valves should be opened 20-30% to permit a nominal throughput. The exact flow rate through each valve is not important since the pumps have ample capacity to supply this additional flow.

2.6 Practical Guidelines to Configuration Selection

2.6.1 Polishing System

The choice of which pump to employ (WPW-P-801 or -802) is left strictly to the operator. The choice of resin bed configuration should normally be as described in section 2.2.4: two parallel streams of 75 gpm each passing through oxygen scavenger resin then mixed bed polishing resin. One stream will have the additional (third) mixed bed resin in series with the first mixed bed. This is important in keeping the third mixed bed fresh.

The 30-ft^3 oxygen scavenger tanks are provided with sample ports at a location in the tank where water has passed through about 85-90% of the bed. If DO in this sample begins to rise above 1 ppb, regeneration of the scavenger resin is indicated. Only one scavenger should be regenerated at a time. If both beds begin to rise toward 1 ppb simultaneously, it is recommended that only one bed be regenerated. This should be a viable option since the beds should each have at least 10% of its capacity remaining.

The mixed bed resins are all provided with a resistivity sensor downstream of the resin bed. If the resistivity indicated downstream of any resin bed falls below 12 Mohm-cm, regeneration is indicated. Again, this should be done one bed at a time (always leaving at least two beds on line). If necessary, the third mixed bed resin tank can be installed in the other polishing stream in the event the single resin bed in the other stream needs to be regenerated.

It should be noted that the effectiveness of mixed bed resins improves as flow increases through the resin. Oxygen scavenger resin, however, exhibits improved effectiveness when the flow through the resin is decreased. The maximum effective rate of water flow through oxygen scavenger resin, depending on the manufacturer, will vary from 2 gpm/ft^3 up to as high as 3-4 gpm/ft^3 depending on how the resin has been processed. This figure can be increased if the water is continually recirculated through the resin in a closed loop system. The resin in place at APS in 1999 is manufactured by both Resintech and US Filter (but installed in separate 30-ft^3 tanks). US Filter recommends a maximum rate of flow through one tank of 75 gpm. This is slightly higher than the 2 gpm/ft^3 figure. Resintech also recommends the 2 gpm/ft^3 figure for water saturated with oxygen. Since the APS system is a closed loop, the 75-gpm maximum originally recommended by US Filter is an appropriate figure (2.5 gpm/ft^3) and should be respected as the maximum rate of flow through the resin tanks.

2.6.2 Deaeration System

It is recommended that the deaeration system be operated at its design throughput capacity (450 gpm using two of the three installed pumps) during all periods of APS user beam time (also known as "run periods"). During APS maintenance periods (shutdowns), it is recommended that the system be operated at the design capacity for early portions of the shutdown when DO loads remain relatively low. Near the end of shutdown periods, when DO levels rise due to filling of system piping, the deaerator flow rate can be increased to 550-600 gpm to treat as much water as possible if DO upsets are expected. See section 2.3.4.

Although operation of the PW system with the resin polishing system only (deaerator idle) would result in the lowest possible system DO value, this is not recommended. Operation of the system with scavenger resin only (no deaerator) would result in system DO levels of less than 1 ppb during steady state. Operation of the system with the deaerator results in a system DO level around 4-8 ppb. Such a difference is considered negligible and is offset by the system's ability to recoup low DO levels much faster when the deaerator is operating at the design flow rate of 450 gpm.

Routine maintenance of deaerator pumps WPW-P-806, -807, and -808 can be done at the design point while the deaerator is in operation. Filter elements in housings WPW-F-002 (0.05 micron) and WPW-F-001 (0.5 micron) can also be performed during deaerator operation. A bypass valve around the housings is provided just for this purpose.

Keeping the deaerator in operation whenever possible is also desirable from the point of view of convenience and contamination. Start-up of the deaerator requires several hours in order to strip DO contamination from the heel left in the vacuum vessel when it is shut down. Improper stripping of DO remaining in the heel can lead to contamination of the entire PW system.

If the deaerator must be shut down, it is imperative to use the procedure for starting the deaerator that is found in this manual so that excess contamination of the entire PW system does not occur.

Although the deaerator is provided with a bypass such that the pumps and filters can be operated while the vacuum vessel is idle, this is not recommended. If work on the vessel will not require a prolonged period of time, it is recommended that the deaerator system be stopped. The vessel or related work can then be executed and the system restarted. This is preferred because operation of the bypass valve results in propagation of water hammers in the system.

2.6.3 Makeup System

It is recommended that, as a general rule, makeup water be treated in the deaerator rather than the resin beds prior to introduction to the PW system (i.e., selection of position for valve CV-201). This will result in longer periods between required regeneration of resins. However, other circumstances and operating experience may indicate a need for change in this strategy in the future. The final decision should be made when sufficient operating experience is obtained.

If makeup water is directed for treatment to the resin polishing system, however, the makeup water connection must be made depending on whether or not the polishing system pumps are in operation (WPW-P-801 and -802). If the pumps are operating, the hose connection for this purpose (adjacent to the pumps) must be connected to pump -801/802 inlet at valve V-200 because the makeup pumps WPW-P-804 and -805 do not have sufficient head to overcome system resistance. If pumps -801 and -802 are not operating, the hose connection for this purpose must be connected to pump -801/802 outlet at valve V-103 because the idle pumps will offer too much resistance for the makeup pump and makeup flow will be reduced.

The GN_2 blanketing system provided with the makeup storage tank is not used. It is more convenient to maintain storage tank quality with resin tanks provided with the RO system than to continually maintain a supply of nitrogen gas. Furthermore, weight-operated relief valves as installed on the storage tank typically leak; resulting in high gas consumption if blanketing is used.

3.0 SYSTEM OPERATION

All three subsystems of the treatment system discussed in this manual are installed in the southwest corner of building 450. The 24”-diameter PW main lines (24-PWS-001 and 24-PWR-001) carrying the water requiring treatment are in the north and northwest corners of building 450. Two 6”-diameter lines, 6”-200 and 6”-303 respectively, carry water from the PW supply main to the treatment system and back again to the PW return main. Before any equipment in the systems covered by this manual are operated, these 6”-diameter lines (each in excess of 100 feet long) must be filled and opened to the 24”-diameter PW mains.

For purposes of this document, it will be assumed that lines 6“-200 and 6”-303 are filled with water, that valves V-392 (PWS line) and V-280 (PWR line) near the 6” branch connections in the PW mains are open, and that the bladder tanks WPW-WCT-801 and -802 are “on-line.”

It is further assumed here that the reverse osmosis system to produce makeup water is functioning as described in section 3.3 and that the control system for makeup pumps WPW-P-805 and -806 is active. Also, makeup water must be supplied to the PW system in either the conventional manner (section 3.3 of this document) or in an unconventional manner (e.g., makeup supplied directly to the PW mains through an unforeseen system upgrade or temporary modification). In the case of a temporary modification, this would require a special procedure approved by the building manager. Such a special procedure is outside the scope of this document.

3.1 Polishing System

3.1.1 Filling an Empty System

The steps in this section can not be followed unless the 3-way control valve CV-201 is configured such that flow from makeup pump WPW-P-804 or -805 is directed to the deaerator loop through line 3"-200. See section 3.3 for implementation.

Alternatively, a special procedure could be put in place to have makeup water delivered to the PW system in a specially designed manner that does not include the polishing system or deaerator system. For instance, a temporary hose could be installed from valve V-219 on the discharge of pump WPW-P-805 to some point in the PW system. This might be required in the event of a system upgrade or some special maintenance requirement. In this case, a special procedure for such installation and use would have to be developed separate from this document.

The first portion of the system to be filled is the pumps (WPW-P-801 and -802):

Ensure that makeup water is being diverted to the deaerator system. Control valve CV-201 should be rotated such that its directional indicator (mounted atop the yellow actuator housing) points toward line 3"-200 (away from valve V-201). If the polishing system is empty, this condition probably exists already.

All of the following valves should be closed at the beginning of this procedure: V-201, V-200, V-205, V-100, V-123, V-102, V-103, V-125, V-104, V-126, V-DO-001A and -001B, V-DO-002A and -002B, V-MB-001A and -001B, V-MB-002A and -002B, and V-MB-003A and -003B, V-122, V-140, V-150, DI.W-127, DI.W-129, V-161, V-384, and V-385.

All vents and drains of the 30-ft^3 resin tanks (WPW-DO-001, -002, and WPW-MB-001, -002, -003) should be closed. Vent valves V-156 and V-159 (filter housings WPW-F-803 and -804) should also be closed.

The following instrumentation valves should be open: V-107 and V-108 (on FE-101); V-129 and V-130 (on FE-102); V-111 (on DOE-101) and V-133 (on DOE-102); V-151, V-153 and V-154 (on DOE-103); V-155 and V-157 (on DPI-103); V-158 and V-160 (on DPI-102),

To begin filling the system, follow these steps in order:

- Crack open 3" vent valve V-103.
- Open fully 3" line valves V-100, V-123, V-102, V-125, V-200, and V-201.

- Crack open 4” line valve V-205. Line 4”-100 is now being filled. The flow of air should be noticeable from vent valve V-103. When water flows freely from the vent, close the vent valve and cap it.

- Open line valve V-205 fully.

The next portion of the system to be filled is the resin tanks. Note the resin tanks are configured in two parallel trains. The procedural steps are listed in two separate sets of instructions below. However, these trains may be filled simultaneously such that the two separate lists can be executed at the same time.

In general, resin tanks are filled from the top with water entering the 2”-diameter normal process inlet fitting near the top of the tank shell. While filling, air is vented from the highest vent connection in the top tank head. All vents on the gray 30-ft^3 resin tanks are Whitey BV series bleed valves with a 7/16” hex head. Loosening the hex head slightly will open the bleed vent.

FILLING RESIN TANK TRAIN 1 (tanks WPW-DO-001, WPW-MB-001, and WPW-MB-003):

Open the 2”-diameter inlet valve V-DO-001A on resin tank WPW-DO-001. Open the vent valve on the same tank. Slowly open 3” line valve V-104 20% or less. The flow of air should be noticeable from the tank vent. Allow the tank to fill until water streams from the bleed vent, indicating tank is full. When full, close the bleed vent. Leave 3” line valve V-104 open 20% or less.

Open the 2”-diameter inlet valve V-MB-001A on resin tank WPW-MB-001. Open the vent valve on the same tank. Slowly open the 2” outlet valve V-DO-001B on tank WPW-DO-001 that was filled as described in the previous paragraph. The flow of air should be noticeable from the tank vent. Allow the tank to fill until water streams from the bleed vent indicating tank is full. When full, close the bleed vent. Leave 3” line valve V-104 open 20% or less.

Open the 2”-diameter inlet valve V- MB-003A on resin tank WPW-MB-003. Open the vent valve on the same tank. Slowly open the 2” outlet valve V- MB-002B on tank WPW-MB-001 that was filled as described in the previous paragraph. The flow of air should be noticeable from the tank vent. Allow the tank to fill until water streams from the bleed vent indicating tank is full. When full, close the bleed vent. Open 3” line valve V-104 fully.

FILLING RESIN TANK TRAIN 2 (tanks WPW-DO-002 and WPW-MB-002):

Open the 2”-diameter inlet valve V-DO-002A on resin tank WPW-DO-002. Open the vent valve on the same tank. Slowly open 3” line valve V-126 20% or less. The flow of air should be noticeable from the tank vent. Allow the tank to fill until water streams from the bleed vent, indicating tank is full. When full, close the bleed vent. Leave 3" line valve V-126 open 20% or less.

Open the 2"-diameter inlet valve V-MB-002A on resin tank WPW-MB-002. Open the vent valve on the same tank. Slowly open the 2" outlet valve V-DO-002B on tank WPW-DO-002 that was filled as described in the previous paragraph. The flow of air should be noticeable from the tank vent. Allow the tank to fill until water streams from the bleed vent indicating tank is full. When full, close the bleed vent. Leave 3" line valve V-126 open 20% or less.

Fill filter housings WPW-F-003 and -004 as follows:

- Open 4" line valve DI.W-127. Crack vent valves on the top of the two filter housings (V-156 and V-159). Slowly crack open 4" line valve V-150. Slowly crack open valves V-122 and V-140. The flow of air should be noticeable from the filter vents. Close the respective vents when water flows from them without air. Open valves V-122, V-140, and V-150 fully.

Fill line 4"-105 as follows:

- Open 3" vent valve V-384 a small amount. Crack open 4" line valves V-DI.W-129 and V-161 until water flows from valve V-384. When full, close the vent and cap it. Open valve V-DI.W-129 and close V-161.

- Open valves V-104 and V-126 fully.

3.1.2 Normal Operation of the Polishing System

Refer to ASD Procedure #750303-00025 for routine operating procedures for this system.

3.1.3 Emergency Shutdown and Lockout/Tagout of the Polishing System

Refer to ASD Procedure #750303-00026 for emergency shutdown and lockout/tagout procedures for this system.

3.2 Deaeration System

3.2.1 Filling an Empty System

The steps in this section can not be followed unless the 3-way control valve CV-201 is configured such that flow from makeup pump WPW-P-804 or -805 is directed to the polishing loop through line 3"-200. See section 3.3 for implementation.

Alternatively, a special procedure could be put in place to have makeup water delivered to the PW system in a specially designed way that does not include the polishing system or deaerator system. For instance, a temporary hose could be installed from valve V-219 on the discharge of pump WPW-P-805 to some point in the PW system. This might be required in the event of a system upgrade or some special maintenance requirement. In this case, a special procedure for such installation and use would have to be developed separate from this document.

All of the following valves should be closed at the beginning of this procedure: V-210, V-203, V-204, V-300, V-301, V-302, CV-316, CV-317, CV-318, V-333, V-337, V-345, V-349, V-350, V-354, CV-300, V-342, V-304, V-305, V-306, V-343, V-338, V-340, V-355, V-356, V-357, V-358, V-359, V-360, V-361, V-332, V-330, V-331, V-327, V-341, V-339, V-307, V-366, V-367, V-373, V-374, V-372, V-379, V-380, V-381, V-383, V-391, V-368, V-375, V-371, and V-378.

The following instrumentation valves should be open: V-328, V-329, V-334, V-335, V-346, V-347, V-351, V-3552, V-362, V-363, V-364, V-365, V-369, V-370, V-376, and V-377.

Control valve LCV-300 should be active such that it responds to the liquid level in the deaerator vessel (VAC-001). If the liquid level is near or above the highest level indicated by LI-300, then LCV-300 will be closed. If the liquid level is near or lower than the lowest level indicated by LI-300, then LCV-300 will be wide open. The position of the valve will be somewhere between closed and wide open to a degree proportional with the level indicated.

The position of valves in the vacuum system is not listed in this section because water in liquid form does not enter the vacuum system. Positioning of the vacuum system valves is discussed in section 3.2.2.

To begin filling the system, follow these steps in order:

- Crack open valve V-203 or V-204.
- Open valves V-333, V-345, and V-350 on the inlet side of pumps WPW-P-806, -807, and -808.
- Open CV-316.
- Crack open V-301.
- Crack open V-210; lines 6”-311 and 8”-300 are being filled. Pumps WPW-P-806, -807, and -808 are also being filled. Close and cap V-203 and V-204 when water appears. Open V-210, V-300, and V-301 fully.
- Open the following valves: V-305, V-341, V-342, V-304, V-307, V-339, V-338, V-340, V-355, V-356, and V-343.

- Crack open V-337. Lines 6”-303, 3”-312 and the associated network of ¾” flush lines are being filled. When water appears at V-343, close and cap it. Open V-337, V-349, and V-354 fully.

- Open the following valves: V-366, V-373, V-379, and V-391. Open vent valves V-368 and V-375 on filter housings WPW-F-001 and -002.

- Crack open CV-300 to approximately 20-25%. When water flows freely from vent valves V-368 and V-375 on filter housings WPW-F-001 and -002, close them one at a time.

- Close CV-300.

- Close V-391.

- Open V-383.

- Ensure V-300 is closed.

- Open CV-318 to begin filling the vacuum vessel. Open vent valve V-327 on the level indicator upper nozzle. Fill the vessel until the level indicator is about halfway to the top of the sight gauge. Then close CV-318.

- Close V-327.

- Close CV-316.

- Open CV-318.

3.2.2 Normal Operation of the Deaeration System

Refer to ASD Procedure #750303-00025 for routine operating procedures for this system.

3.2.3 Emergency Shutdown and Lockout/Tagout of the Deaeration System

Refer to ASD Procedure #750303-00026 for emergency shutdown and lockout/tagout procedures for this system.

3.3 Makeup System

3.3.1 Normal Operation of the Makeup System

Refer to ASD Procedure #750303-00025 for routine operating procedures for this system.

3.3.2 Emergency Shutdown and Lockout/Tagout of Makeup System

Refer to ASD Procedure #750303-00026 for emergency shutdown and lockout/tagout procedures for this system.

4.0 EQUIPMENT SPECIFICATIONS

4.1 Polishing System

Pumps:	WPW-P-801/802	Ingersoll-Rand 150 gpm @ 92 ft TDH Size 3 × 1.5 × 6 GRP impeller 5.188” diameter 3600 rpm bhp = 6.25 motor = 7.5 hp Serial nos: 0692/7015 and 892672
Flow elements:	FE-101/102	McCrometer V-cone Model VP02QE44N 2” diameter Victaulic ends Serial nos: 98-1975 (train A) 98-1972 (train B)
DP transmitters:	DPT-101/102	Yokagawa Model EJA-110A
Mixed bed resins:		Strong base anion, type I and type II Cation component: -CG8 by Resintech (or equivalent) Anion component: -SBG1P by Resintech (or equivalent)
Oxygen scavenging resins:		Strong base anion (type I and II) in the sulfite form Resintech part SP-98-75 (or equivalent)
Resin tanks:	WPW-DO-001/002	30 ft^3 Polyethylene lined
Filter housings:	WPW-F-003/004	PALL Model P15-3-L-G49H13 215 psig; -20/250°F Serial 5HS-F8324-1 15 × 30” long elements

UV treatment:	WPW-UV-802	Aquafine Model CSL-12R Serial LS92040 118V; 60Hz; 6.5A
Flow regulators:	V-105/127	Griswold P/N 4924F 76.1 gpm @ 6-50 psid

4.2 Deaerator System

Level control valve:	LCV-300	Cashco flangeless (wafer style) Ranger QCT Rotary 3”, stainless steel body Model RB3-70A7-1A10E000B Linear characteristic Air to open; fail closed 9000R positioner, direct acting, 3-15 psig input C_v = 170 full open ST1 trim Handwheel operator
Level transmitter:	LT-300	Magnetrol Model P66-2C5B-PAA 1-1/2” connections 32” level range 275 psig, 100°F
Level indicator:	LI-300	Inferno Mfg. Co. Reflex type Model RA-36CABDABPAA Back connections ¾” FNPT End connections ½” FNPT Body 304SS Glass tempered borosilicate 250 psig, 400°F
Vacuum vessel:	VAC-001	Permutit – specification and design dwg #156-19738 Whiting Metals –manufacturer (dwg F-6023) 4’-0” diameter × 17’-0” tangent length support skirt 8’-0” 150 psig and full vacuum at 150°F manufactured 1992 Nat’l board S/N 1148

modified 1998
Following dwgs filed in APS Document Control Center:

750303-00002-00	Vessel Design dwg
750303-00003-00	SOW for vessel modifications
750303-00004-00	Mfr U-1 data sheet
750303-00005-00	Original design calculations
750303-00006-00	COC covering modifications
750303-00007-00	CTR covering mat'ls for modifications
750303-00008-00	Calculations for mods
750303-00009-00	Dwg covering mods
Inlet spray nozzle:	Spraying Systems 4-RR-SS-95-250
Internal packing:	Maspac FN-1000 (1" poly-pro)

Pumps:	WPW-P-806/807/808	Ingersoll-Rand 225 gpm @ 170 ft TDH Size 3 × 1.5 × 13 GRP impeller 13.25" diameter 1800 rpm bhp = 18 motor = 25 hp Serial nos: 0692/7016 0692/7017 1291/7056
Flow element:	FE-300	McCrometer V-cone Model VP04QE44N 4" diameter Victaulic ends Serial no: Q8050400
DP transmitter:	DPT-300	Yokagawa Model EJA-110A
Flow indicator:	FIC-300	Honeywell Progeny CTX

Flow control valve:	FCV-300	Worcester 4" WC4CPT466PT151 30A75Z-4 Actuator DFB17-4 Data-flow positioner
Prefilter:	WPW-F-002	US Filter Filtration (Memtec) 108MSO3-304-6FD-C150U-IP 150 psig, 200°F 36 × 30" long elements Use PFT0.45-30UE elements
Fine filter:	WPW-F-001	US Filter Filtration (Memtec) 144MSO4-304-6FD-C150U 150 psig, 200°F 36 × 40" long elements Use AXVR050-40M3S elements
Dissolved O_2 sensor:	DOE/DOI-300	Orbisphere Model 3660
Vacuum pumps:	WPW-P-809/810	Siemens Model 2BE1102-OBY4 1750 rpm 160 cfm (nominal) 80 cfm (est.) net w/ ejector 15 hp
Ejectors:	E-28 and E-29	Supplied by Kinney Vacuum P/N 077702-0000 Mfd. By Penberthy Model L4H-120-50 P/N 58969-000 Pressure: ATM Nozzle: STS; Body: 1RN; Del Jet: Stl
Vacuum blower:	WPW-P-811	Kinney Vacuum KMBD-720C 3000 rpm max. for application 600 cfm (nominal) 450 cfm (actual) w/ 2 backing pumps Baldor 7.5 hp VFD motor and panel Baldor Spec no. PN0015A21 Baldor Serial no. H9806100001

4.3 Makeup System

Circulation Pump:	WPW-P-803	Ingersoll-Rand 25 gpm @ 23 ft TDH Size 1.5 × 1 × 6 GRP impeller 5.0" diameter 1800 rpm bhp = 0.4 motor = 1.5 hp Serial nos: 0692/7020 and 0692/7021
Filter housings:	WPW-F-005/006	PALL Model P04-4-L-G33H13 215 psig; -20/250^{o}F Serial 5HG-F8296-2 4 × 40" long elements
UV treatment:	WPW-UV-802	Aquafine Model CSL-4R Serial IS92023 118V; 60Hz; 2.2A
Makeup Pumps:	WPW-P-804/805	Ingersoll-Rand 50 gpm @ 90 ft TDH Size 1.5 × 1 × 6 GRP impeller 4.94" diameter 3600 rpm bhp = 4 motor = 5 hp Serial nos: 0692/7020 and 0692/7021