USE OF A REVERSE OSMOSIS SYSTEM FOR

TREATING RADWASTE AT PALO VERDE

Thomas P. Hillmer
Arizona Nuclear Power Project
Phoenix, AZ 85072

Deborah P. Swindlehurst
Associated Technologies Incorporated
Charlotte, NC 28281

ABSTRACT

Nuclear power plants rely heavily on their radioactive waste disposal systems in order to maintain the plant in operation. When the radioactive waste evaporator at Palo Verde Nuclear Generating Station developed cracks, plant personnel arranged to have a portable demineralizer system process the low-level radwaste normally handled by the evaporator. In addition, a reverse osmosis system was positioned upstream of the demineralizers to remove a majority of the dissolved solids from the stream before it was sent to the demins. This paper discusses the developments at Palo Verde which lead it to using an RO/demin system and how the RO reduced the load on the demineralizers.

BACKGROUND

During June 1985, liquid leakage through wall cracks were discovered in Unit I's Liquid Radwaste Evaporator. By July 1985, leakage was significant enough to force the shutdown of the evaporator. After shutdown, the evaporator vapor body was opened to allow access for liquid penetrant testing. All visually identified cracking were associated with the sieve tray stiffeners or weir tray attachment welds to the vessel walls. Because the visual examination of the cracks indicated fatigue cracking and no evidence of corrosion was observed, it was decided to attach strain gauges and accelerometers to the internal trays and vessel wall to determine the nature of the fatigue cracks stresses. Additionally, a portion of the vessel wall where cracking occurred was removed and sent to an offsite metallurgical laboratory for analysis. The existing cracks were ground out and weld repaired and the test specimen (the portion of the vessel wall) was replaced.

The evaporator was restarted with all pertinent operational parameters being monitored. After 3 days of operation, cracks reappeared in the same locations. The evaporator was left in operation due to a backlog of liquid to be processed. The cracks were monitored twice a shift and were allowed to grow until they reached a predetermined length before the evaporator was shutdown again. The data taken during startup was analyzed and revealed that the cause of cracks was low stress - high cycle fatigue failure.

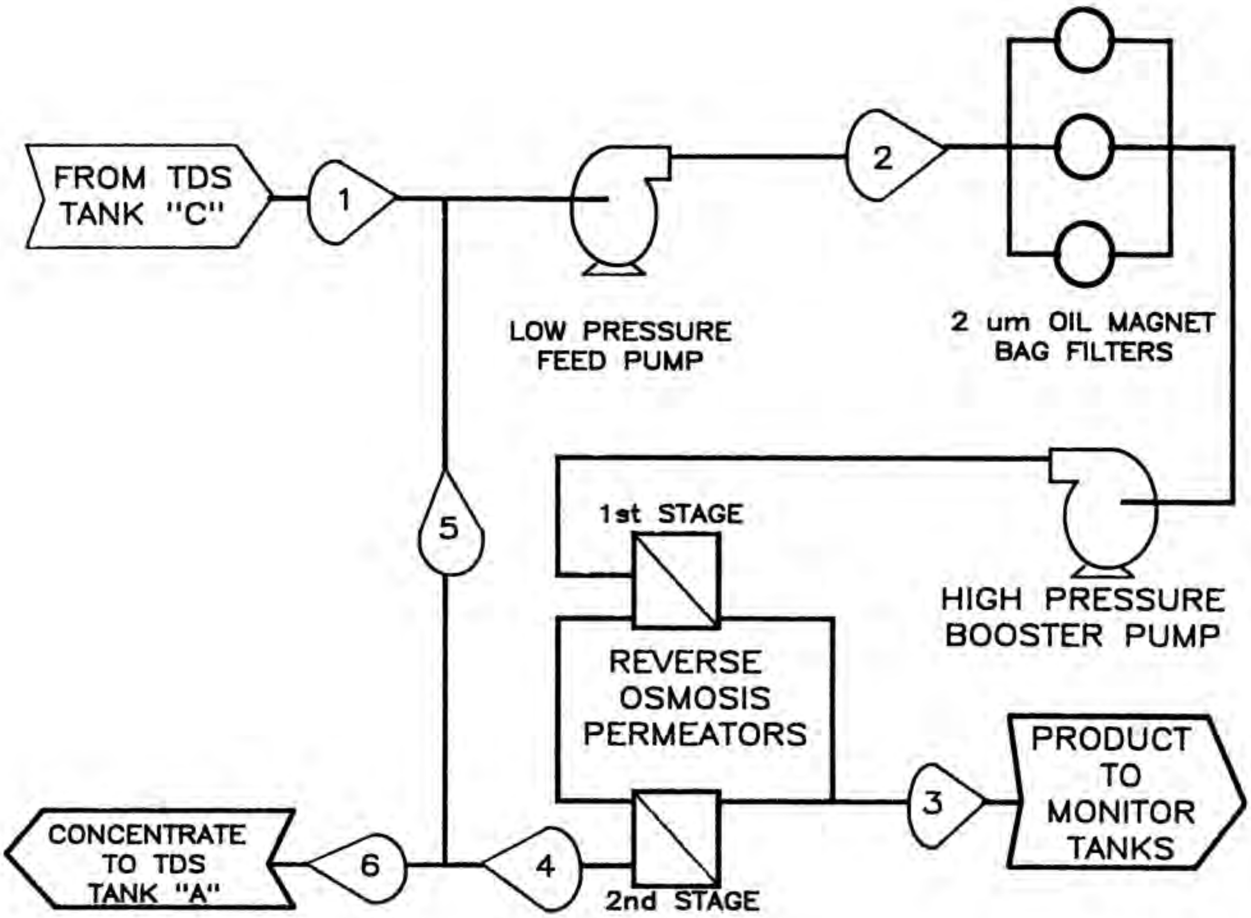
The results of the strain gauge, accelerometer and impact test determined that vibrational stresses on the sieve trays were being transferred to the tray stiffeners. The stiffeners were welded to the vapor body wall in only a few locations and the vibrating stresses were concentrated at these locations which cracked.

A computer model was developed which allowed the analysis of various repairs which would reduce the vibrational stresses or spread the load. A design was approved and an outage planned that would require about 4 to 6 weeks. During this time frame, radwaste liquid would be processed by portable/disposable demineralizers. Because the quality of the radwaste liquid was periodically unsuitable for demineralization, ATI was contracted to supply a portable reverse osmosis (RO) unit to be placed upstream of demins.

SYSTEM DESCRIPTION

The RO system's purpose in the processing of the plant's radwaste was to concentrate the waste volumes in the waste holding tanks, thereby providing additional storage capacity in the tanks while producing, with the aid of the demins, recyclable-quality water. The RO system used (Fig. 1) was an existing system which was available for lease from Associated Technologies Incorporated (ATI). It is a skid mounted system which consists of a low pressure feed pump, three oil-magnet bag filters, a high pressure booster pump and four reverse osmosis permeators consisting of hollow fiber membranes. The purpose of the bag filters was to protect the RO from fouling by removing oil and suspended solids larger than 2 microns.

Water from one of the three TDS tanks (Total Dissolved Solids Tanks) is supplied by the feed pump to the bag filters. The booster pump then increases the feed pressure to the level required to force the permeate through the membranes. The feed is supplied by a distributor core to the center of each RO housing. The cleaned product water permeates into the hollow fiber membranes leaving the concentrated "reject" water on the shell side. Valves on the discharge of the booster pump and on the concentrate header are throttled to achieve the desired product and concentrate flows.



Sample of Performance Data
13th Day of Operation

Line Number	1*	2	3	4	5	6
Flow rate, gpm	37.5	49.5	31	18.5	12	6.5
Boron, ppm	(1,055)	1,459	416	2,722	2,722	2,722
Chloride, ppm	(175)	208	31	310	310	310
Sulfate, ppm	(988)	1,100	69	1,450	1,450	1,450
TDS, ppm	(10,608)	14,000	1,620	24,600	24,600	24,600
TOC, ppm	(398)	622	17.4	1,322	1,322	1,322
Conductivity, umho/cm	(6,485)	8,200	480	13,560	13,560	13,560

(*calculated concentration)

Fig. 1. Performance Data: Reverse Osmosis System Flow Diagram

The system was modified to reduce its operating capacity from 227 l/min to 136 l/min by recycling both the RO permeate and the concentrate back to the inlet of the low pressure feed pump. During actual operation no permeate recycle was necessary; the high pressure drop of the permeate flowing through the demineralizers reduced the driving force across the membranes, thereby reducing the permeate production rate to the desired 114 l/min. Twenty-three liters per minute of concentrate were sent to the third TDS tank to be held there for reprocessing by the RO/demin system after its concentration had been partially diluted with new radwaste from the plant.

The permeate from the RO, after passing through the demineralizer system, was sent to one of the plant's two Recycle Monitor Tanks. There it was sampled and analyzed in order to determine where in the plant the water would be sent for reuse.

OPERATION

The system was operated for 43 days while welding to repair the evaporator was going on. The system's operating conditions (pressure and flow rates) were monitored hourly. The system was equipped with switches and interlocks which shut down the system on low booster pump suction pressure or high membrane feed pressure. When the oil bags were saturated with oil, their permeability by water sharply declined. The low pressure switch downstream of the oil bags shut the system down at 10 psig and closed an automatic valve on the feed line. This put the system in a safe condition until the operator, on his next tour of the equipment, could change out the bags and restart the unit.

Figure 1 gives typical operating data for the RO system. Overall, the system was retaining 95% of the waste's total dissolved solids, thereby extending the life of the demineralizers by 20 times the life of the beds without the use of the RO system.

Oil in the waste, up to 1000 ppm TOC, reduced the RO's removal of TDS by fouling the membranes. A partially expended charcoal bed was moved from upstream of the demineralizer system to upstream of the RO. However, its remaining removal capability was insufficient to effectively handle the high influent TOC concentrations. Future installations should place a fresh charcoal bed upstream of the RO system to protect both the RO's and the demins.

CONCLUSION

The use of the RO/Demineralization system enabled radwaste to continue to function and the plant to produce power. It would have been impossible from an operational perspective to process liquid waste only by demineralization based on chemistry of the waste.