CORROSION EVALUATION

R10433846

UFP-VSL-00002A/B (PTF)
Ultrafiltration Feed Vessels

- Design Temperature (°F)(max/min): 225/40
- Design Pressure (psig) (max/min): 15/-12
- Location: incell
- PJM Discharge Velocity (mps) (max): 14.2
- Drive Cycle: 9 % (at 14.2 mps)

Off-spring items

UFP-PJM-00006- UFP-PJM-00017

ISSUED BY
RPP-WTP PDC

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

No maintenance will be performed on these vessels.

Operating Modes Considered:

- Normal operating conditions
- Vessel is heated to 194°F with about 3 M OH^- and permanganate
- The vessel will be cleaned using 2 N HNO_3 with residual chlorides and fluorides at normal operating temperatures; the condition of high temperature and acid is not examined
- The vessel is filled with process water without other chemicals

Materials Considered:

Material (UNS No.)	Relative Cost	Acceptable Material	Unacceptable Material
Carbon Steel	0.23		X
304L (S30403)	1.00	X	
316L (S31603)	1.18	X	
6% Mo (N08367/N08926)	7.64	X	
Alloy 22 (N06022)	11.4	X	
Ti-2 (R50400)	10.1		X

Recommended Material: 304 (max 0.030% C; dual certified)

Steam Ejector: high temp components located inside vessel shall be UNS N06022

Recommended Corrosion Allowance: 0.040 inch (includes 0.024 inch corrosion allowance and 0.016 inch erosion allowance; localized protection is required as discussed in section j)

Process & Operations Limitations:

- Develop rinsing/flushing procedure for acid and water
- Have waste present before adding 19 M NaOH; minimum waste level to be determined

Concurrence KW
Operations

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
5	3/29/06 ~~3/10/05~~ LG 3/29/06	Update wear allowance based on 24590-WTP-RPT-M-04-0008 Modify section j text	DLAdler	HMKrafft	NA	SWVail

 28 March 2006

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REVISION HISTORY

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
4	3/10/05	Update PJM and erosion info based on 24590-WTP-M0E-50-00003 Update wear allowance based on 24590-WTP-RPT-M-04-0008 Incorporate revised PCDS	DLAdler	JRDivine	NA	APRangus
3	5/17/04	Addition of information regarding inadvertent nitric acid addition Append updated PCDS	DLAdler	APRangus	NA	SWVail
2	5/12/04	Revised to incorporate new PCDS Correct duty cycle Revise erosion section	DLAdler	JRDivine	NA	APRangus
1	10/15/03	Update design temp/pressure and associated items Add PJM info Append updated MSDS Add DWP note	DLAdler	JRDivine	HMK	SWVail
0	3/19/02	Initial Issue	DLAdler	JRDivine	NA	BPosta

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Corrosion Considerations:

These vessels contain feed received from UFP-VSL-00001A/B that is then concentrated to 20 % solids by being pumped and recirculated through an ultrafiltration loop. Treatment of the feed may include solids washing to remove excess sodium and/or caustic leaching by addition of 19 M NaOH and heating the solution to between 176 °F and 194 °F by direct steam injection followed by cooling back to ambient temperature (77 °F). Further ultrafiltration follows cooling.

a General Corrosion
Hamner (1981) lists a corrosion rate for 304 (and 304L) in NaOH of less than 20 mpy (500 µm/y) at 77°F and over 20 mpy at 122°F. He shows 316 (and 316L) has a rate of less than 2 mpy up to 122°F and 50% NaOH. Dillon (2000) and Sedriks (1996) both state that the 300 series stainless steels are acceptable in up to 50% NaOH at temperatures up to about 122°F or slightly above. Divine's work (1986) with simulated-radwaste evaporators, six months at 140°F, showed 304L was slightly more resistant to corrosion (<0.2 mpy) than was 316L (<0.6 mpy); Ni 200, pure nickel, was much less resistant (≈7 mpy) probably due to the complexants. Zapp (1998) notes that the Savannah River evaporator vessels, operating at about 300°F, are made of 304L and have suffered no failures in about 30 years. The 304L heat transfer surfaces have failed, however, after about 10 years. Thus there needs to be nitrate or nitrite present if caustic solutions exceed about 140°F. The expected waste composition envelope is expected to contain sufficient nitrite and nitrate for protection.

Davis (1994) states the corrosion rate for 304L in pure NaOH will be less than about 0.1 mpy up to about 212°F though Sedriks (1996) states the data beyond about 122°F are incorrect (low) due to the presence of oxidizing agents. The waste contains large amounts of oxidizing agents and therefore the data may be valid. Danielson & Pitman (2000), based on short term studies, suggest a corrosion rate of about 0.5 mpy for 316L in simulated waste at boiling, >212°F.

Ohl & Carlos (1994) found in their review of the 242-A Evaporator that the corrosion of 304L in waste similar to that expected in WTP after about two years of operation at 140°F was less than the accepted variability of the plate. Therefore, no definitive corrosion rates were calculated.

In this system, the hydroxide concentrations and temperatures are such that 304L stainless steel will be acceptable. The amount of dilution of fluoride when acid is added is unknown but is expected to be small. Wilding and Paige (1976) have shown that in 5% nitric acid with 1000 ppm fluoride at 290°F, the corrosion rate of 304L can be kept as low as 5 mpy by the use of Al^{+++}. Additionally, Sedriks (1996) has noted with 10% (≈2N) nitric acid and 3,000 ppm fluoride at 158°F, the corrosion rate of 304L is over 4,000 mpy. Therefore, there is a concern about excessive corrosion rates during acid cleaning. Acid cleaning should be done at normal operating temperature in order to reduce the extent of attack by chloride (pitting and crevice corrosion) and, general corrosion due to fluoride. Acid cleaning should be preceded by thorough flushing.

The alternation between hot caustic and acid environments tends to increase the corrosion rate. The use of 304L, with its higher chromium content than 316L, may be more resistant to corrosion.

Conclusion:
At temperatures less than about 140°F, 304L is expected to be sufficiently resistant to the waste solution with a probable general corrosion rate of less than 1 mpy. Based on the Savannah River experience with Hanford-like waste at higher temperatures, 304L is expected to be satisfactory to 300°F.

b Pitting Corrosion
Chloride is known to cause pitting in acid and neutral solutions. Dillon (2000) is of the opinion that in alkaline solutions, pH>12, chlorides are likely to promote pitting only in tight crevices such as under deposits. Dillon and Koch (1995) are both of the opinion that fluoride will have little effect in an alkaline media. Further, Revie (2000) and Uhlig (1948) note nitrate inhibits chloride pitting.

Normally the vessel is to operate at 77°F with a maximum fluid temperature of 194°F. At these temperatures, based on the work of Zapp (1998) and others, 304L stainless steel would be acceptable in the proposed alkaline conditions. Acid cleaning should be performed only when vessel is at or near ambient temperature (77°F) and after flushing.

If the vessel were filled with process water and left stagnant, there would be a tendency to pit. The time to initiate would depend on the source of the water, being shorter for filtered river water and longer for DIW. Pitting has been observed in both cases, and is likely because residual chlorides are likely to remain.

Conclusion:
Localized corrosion, such as pitting, is common but can be mitigated by alloys with higher nickel and molybdenum contents. Based on the expected operating conditions, 304L is expected to be satisfactory..

c End Grain Corrosion
End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions; it is possible this might occur with high acid/permanganate concentrations. The temperature control should be exercised during acid cleaning.

Conclusion:
Not likely in this system.

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d Stress Corrosion Cracking
The exact amount of chloride required to cause stress corrosion cracking is unknown. In part this is because the amount varies with temperature, metal sensitization, and the environment. But it is also unknown because chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. Hence, even as little as 10 ppm can lead to cracking under some conditions. Generally, as seen in Sedriks (1996) and Davis (1987), chloride stress corrosion cracking does not usually occur below about 140°F. Caustic cracking is not expected below 210 °F. With the low temperature and alkaline conditions, 304L is expected to be satisfactory. However, if acid cleaning is to be used, it should only be performed at normal operating temperature.

Conclusion:
Because of the normal operating environment as well as that which can occur during off normal conditions, the minimum alloy recommended is a 304L stainless steel.

e Crevice Corrosion
See Pitting.

Conclusion:
See Pitting

f Corrosion at Welds
Corrosion at welds is not considered a problem in the proposed environment.

Conclusion:
Weld corrosion is not considered a problem for this system.

g Microbiologically Induced Corrosion (MIC)
The proposed operating conditions are not conducive to microbial growth – the temperature is approximately correct but the pH is too alkaline. Further, the system is downstream of the main entry points of microbes.

Conclusion:
MIC is not considered a problem.

h Fatigue/Corrosion Fatigue
Corrosion fatigue is a not expected to be a problem.

Conclusions
Not expected to be a concern.

i Vapor Phase Corrosion
The vapor phase portion of the vessel is expected to be contacted with particles of waste from splashing. The presence of wash rings within vessels will provide rinsing capability. 304L will be satisfactory.

Conclusion:
Not expected to be a concern.

j Erosion
Based on past experiments by Smith & Elmore (1992), the solids are soft and erosion is not expected to be a general concern for the vessel wall. A general erosion allowance of 0.016 inch is adequate for components for erosive wear from fluids with a maximum solids content of up to 27.3 wt% at velocities less than 4 mps, based on the analysis in 24590-WTP-RPT-M-04-0008. An additional erosive wear allowance of at least 0.517 inch 304L stainless steel should be provided as localized protection for the applicable portions of the bottom head to accommodate erosive wear due to PJM discharge velocities of up to 14.2 m/s with solids concentrations of 25 wt% for a usage of 100 % operation as documented in 24590-WTP-M0C-50-00004. The 25 wt% is considered to be conservative and is based on the WTP Prime Contract maximum. During normal operation, the solids content of UFP-VSL-00002A/B is expected to be well below the anticipated maximum.

The wear of the PJM nozzles can occur from flow during both the discharge and reflood cycles of operation. An additional erosive wear allowance of at least 0.380–inch of additional 304L stainless steel should be provided on the inner surface of the PJM nozzle to accommodate erosive wear due to discharge and suction velocities of fluids with normal solids concentrations of up to 25 wt% for usage of 100 % operation as documented in 24590-WTP-M0C-50-00004.

Conclusion:
The recommended general erosion wear allowance provides sufficient protection for erosion of the vessel wall. Additional localized protection for the bottom head will accommodate PJM discharge velocities and additional localized protection for the PJM nozzles will accommodate PJM discharge and reflood velocities.

k Galling of Moving Surfaces
Not applicable.

Conclusion:
Not applicable.

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l Fretting/Wear
No contacting surfaces expected.

Conclusion:
Not applicable.

m Galvanic Corrosion
No dissimilar metals are present.

Conclusion:
Not applicable.

n Cavitation
None expected.

Conclusion:
Not believed to be of concern.

o Creep
The temperatures are too low to be a concern.

Conclusion:
Not applicable.

p Inadvertent Nitric Acid Addition
Higher chloride contents and higher temperatures usually require higher alloy materials. Nitrate ions inhibit the pitting and crevice corrosion of stainless alloys. Furthermore, nitric acid passivates these alloys; therefore, lower pH values brought about by increases in the nitric acid content of process fluid will not cause higher corrosion rates for these alloys. The upset condition that was most likely to occur is lowering of the pH of the vessel content by inadvertent addition of 2 M nitric acid. Lowering of pH may make a chloride-containing solution more likely to cause pitting of stainless alloys. Increasing the nitric acid content of the process fluid adds more of the pitting-inhibiting nitrate ion to the process fluid. In addition, adding the nitric acid solution to the stream will dilute the chloride content of the process fluid.

Conclusion:
The recommended materials will be able to withstand a plausible inadvertent addition of 2 M nitric acid for a limited period.

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References:

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Bibliography:

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2. CCN 130171, Ohl, PC to PG Johnson, Internal Memo, Westinghouse Hanford Co, *Technical Bases for Cl- and pH Limits for Liquid Waste Tank Cars*, MA: PCO:90/01, January 16, 1990.
3. Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
4. Berhardsson, S, R Mellstrom, and J Oredsson, 1981, *Properties of Two Highly corrosion Resistant Duplex Stainless Steels*, Paper 124, presented at Corrosion 81, NACE International, Houston, TX 77218
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CORROSION EVALUATION

CCN #110849
Revised Process Corrosion Data Sheet For UFP-VSL-00002 A/B

PROCESS CORROSION DATA SHEET

Component(s) (Name/ID #) Ultrafiltration feed vessels (UFP-VSL-00002 A/B) Ultrafilter (UFP-FILT-00001,2,3 A/B), Ultrafiltration pulse pot (UFP-PP-00001,2,3,A/B) Ultrafiler Heat Exchangers (UFP-HX-00001A/B)

Facility PTF

In Black Cell? Yes (UFP-VSL-00002A/B only)

Chemicals	Unit[1]	Contract Maximum		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	3.61E+01	4.79E+01			
Chloride	g/l	1.20E+01	1.44E+01			
Fluoride	g/l	1.43E+01	1.72E+01			
Iron	g/l	1.69E+02	1.15E+02			
Nitrate	g/l	2.29E+02	2.63E+02			
Nitrite	g/l	6.66E+01	7.97E+01			
Phosphate	g/l	4.81E+01	5.63E+01			
Sulfate	g/l	2.56E+01	3.06E+01			
Mercury	g/l	1.18E+00	1.67E+00			
Carbonate	g/l	1.05E+02	1.06E+02			
Undissolved solids	wt%	25%	25%			
Other (NaMnO4, Pb,...)	g/l	1.00E-02				Note 4
Other	g/l					
pH	N/A					Note 3
Temperature	°F					Note 2

List of Organic Species:

References

System Description: 24590-PTF-3YD-UFP-00001, Rev 0
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: UFP04, UFP17, UFP39, UFP07
Off Normal Input Stream # (e.g., overflow from other vessels): N/A
P&ID: 24590-PTF-M6-UFP-00002,3, Rev 0
PFD: 24590-PTF-M5-V17T-00010, Rev 1
Technical Reports: N/A

Notes:

1. Concentrations less than 1x 10^{-4} g/l do not need to be reported; list values to two significant digits max.
2. T normal operation 77 °F to 194 °F (24590-PTF-MVC-UFP-00002, Rev 0)
3. Alkaline streams with pH range from approximately 12 to 14
4. NaMnO4 is added for oxidative leaching. The other chemicals should not be effected by oxidative leaching. Concentrations may be lowered, but for conservatism did not change in this datasheet

Assumptions:

Assume the NaMnO4 addition was 1.1 Mole per mole of Cr.

4.14.3 Ultrafiltration Feed Vessels (UFP-VSL-00002 A/B), Ultra Filters (UFP-FILT-00001,2,3 A/B), Ultrafiltration Pulse Pots (UFP-PP-00001A/B,2A/B,3A/B)

Routine Operations

These two vessels receive the feed from the ultrafiltration feed preparation vessels (UFP-VSL-00001A/B). The feed is then concentrated to 20 % solids by being pumped and recirculated through an ultrafiltration loop. The liquid fraction of the filtered feed is sent to the LAW vitrification facility. The feed containing the 20 % solids is sampled to determine the appropriate treatment steps. Treatment of the solids may include solids washing to remove excess sodium through dilution and ultrafiltration, and/or caustic leaching by adding 19 M NaOH until the solution reaches 3 M, allowing a period of 8 hours for digestion, during which the solution is heated to between 176 °F to 194 °F, and then cooled back to ambient temperature (77 °F). After cooling, the contents are reconcentrated to 20 % solids by ultrafiltration. Ultrafiltration pulse-pots (UFP-PP-00001A/B, UFP-PP-00002A/B, and UFP-PP-00003A/B) are used to perform back-pulsing on the ultrafilter tube units. Back-pulsing may involve adding cleaning chemicals (2 M HNO_3, 2 M NaOH, and process condensate).

Non-Routine Operations that Could Affect Corrosion/Erosion

There is the option to transfer the Sr/TRU solids directly to the HLW blending vessel (HLP-VSL-00028), if necessary.