CORROSION EVALUATION

HLP-VSL-00027A&B (PTF)
HLW Lag Storage Vessel

- Design Temperature (°F)(max/min): 237/40
- Design Pressure (psig) (max/min): 15/-8
- Location: incell
- PJM Discharge Velocity (fps): 40
- Drive Cycle: 14 % (at 40 fps)

Off spring items

HLP-PJM-00060 – HLP-PJM-00075

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

Operating Modes Considered:

- Normal operating conditions
- The vessel is alkaline at the maximum design temperature
- The vessel will be cleaned using 2 N HNO_3 at normal operating temperatures with residual chlorides and fluorides present; the condition of high temperature and acid is not examined

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: 316 (max 0.030% C; dual certified)

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

Process & Operations Limitations:

- Develop rinsing/flushing procedure for water and acid

Concurrence KW
Operations

6	1/5/06	Update PJM and erosion info based on 24590-WTP-M0C-50-00004 Update wear allowance based on 24590-WTP-RPT-M-04-0008	DLAdler	[signature]	NA	[signature]
REV	**DATE**	**REASON FOR REVISION**	**PREPARER**	**CHECKER**	**MET**	**APPROVER**

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REVISION HISTORY

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
5	5/17/04	Addition of information regarding inadvertent nitric acid addition Append updated PCDS	DLAdler	APRangus	NA	SWVail
4	5/11/04	Correct drive cycle Incorporate new PCDS	DLAdler	JRDivine	NA	APRangus
3	12/24/03	Update design temperature	DLAdler	JRDivine	NA	APRangus
2	9/25/03	Add PJM info Delete reference to steam ejector Update assoc. items DCA#24590-PTF-DCA-M-02-006 REV. 0 Modify reference page Editorial changes	DLAdler	JRDivine	NA	A.P. Rangus
1	11/21/02	Update design temp/pressure Update format Append updated MSDS Add DWP note Minor editorial changes	DLAdler	JRDivine	NA	SWVail
0	3/19/02	Initial Issue	DLAdler	JRDivine	SS	BPosta

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Corrosion Considerations:

Vessels are equipped with cooling jackets to maintain the temperature below 113°F.

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 states 316 (and 316L) has a rate of less than 2 mpy in 50% NaOH at temperatures up to 122°F. Dillon (2000) and Sedriks (1996) both state that the 300 series are acceptable in up to 50% NaOH at temperatures of about 122°F. Davis (1994) states the corrosion rate for 304L in pure NaOH will be less than about 1 mpy up to about 212°F though Sedriks states the data beyond about 122°F are incorrect. 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. Divine (1986) showed that in simulated waste at 140°F, 304L, with a corrosion rate < 1 mpy, performed slightly better than 316L – possibly due to the presence of nitrate. In this system, the hydroxide concentrations and temperatures are such that 304L stainless steel will be acceptable. If the alkaline waste reaches boiling, Zapp's work (1998) suggests 304L would be acceptable, probably due to the presence of nitrate.

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. There is no Al^{+++} present. Therefore, there is a concern about excessive corrosion rates during acid cleaning unless the fluoride is well diluted. Acid cleaning should not be performed at elevated temperatures in order to reduce the extent of attack by chloride (pitting and crevice corrosion). 304L will be suitable if properly protected by temperature and fluoride complexants such as Al^{+++}.

Conclusion:
At the normal operating temperature, 304L is expected to be sufficiently resistant to the waste solution with a probable general corrosion rate of less than 1 mpy. Operation at the design temperature under alkaline conditions is also acceptable. At acid or neutral pH, such as during acid cleaning, the temperature should be kept below about 122 °F.

b Pitting Corrosion
Chloride is known to cause pitting of stainless steel and related alloys 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. Dillon and Koch (1995) are both of the opinion that fluoride will have little effect in an alkaline media. Jenkins (2000) has stated that localized corrosion can occur under the waste deposits on heat transfer surfaces, probably due to the chlorides. Further, Revie (2000) and Uhlig (1948) note nitrate inhibits chloride pitting.

Normally the vessel is to operate between 50 and 113°F. At the normal temperature, based on the work of Zapp (1998) and others, 304L stainless steel would be acceptable in the proposed alkaline conditions at the upper pH values. Under acidic or neutral pH conditions, a more pitting resistant alloy, such as 316L, will be needed. If the duration of exposure to acidic conditions and lowered pH can be controlled, 316L will be acceptable.

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, which tends to be dirtier, and longer for DIW. Pitting has been observed in both cases, and is likely because residual chlorides are likely to remain and to concentrate.

Conclusion:
Based on the expected operating conditions, 316L 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.

Conclusion:
Not believed likely in this system.

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 also 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), stress corrosion cracking does not usually occur below about 140°F. With the stated low operating temperature and alkaline conditions, 304L is expected to be satisfactory. If acid cleaning is performed, 316L is recommended for additional protection. Even with 316L, acid cleaning at the design temperature is not recommended without a thorough water flush prior to acid addition.

Conclusion:
Because of the operating environment that can occur during cleaning, the minimum alloy recommended is a 316L stainless steel.

e Crevice Corrosion
See Pitting.

Conclusion:
See Pitting

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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 generally too alkaline.

Conclusion:
MIC is not considered a problem if the chemistry of the process water is controlled.

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

Conclusions
Not a concern.

i Vapor Phase Corrosion
The vapor phase portion of the vessel is expected to be contacted with particles of waste from splashing. It is unknown whether the vessel, and particularly the lid, will be sufficiently washed or whether residual acids or solids will be present. If solids or acids and solids are present, a 316L or better is preferred.

Conclusion:
Vapor phase corrosion is not a concern.

j Erosion
Based on past experiments by Smith & Elmore (1992), the solids in the waste are soft and erosion is not expected to be a concern for the vessel wall. Based on 24590-WTP-RPT-M-04-0008, a general erosion allowance of 0.016 inch is adequate for components with maximum solids content up to 27.3 wt%. Additional 316L stainless steel should be provided as localized protection for the applicable portions of the bottom head to accommodate PJM discharge velocities of up to 12 m/s with solids concentrations of 26.7 wt% for a usage of 100 % operation as documented in 24590-WTP-M0C-50-00004. Vessels HLP-VSL-00027A/B require at least 0.436-inch additional protection. The 26.7 wt% is considered to be conservative and is based on the WTP Prime Contract maximum. During normal operation, the solids content of HLP-VSL-00027A/B is expected to be well below the anticipated maximum.

The wear of the PJM nozzles can occur from flow for both the discharge and reflood cycles of operation. At least 0.291–inch of additional 316L stainless steel should be provided on the inner surface of the PJM nozzle to accommodate wear due to PJM discharge and suction velocities with solids concentrations of 26.7 wt% for usage of 100 % operation as documented in 24590-WTP-M0C-50-00004.

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

k Galling of Moving Surfaces
Not applicable.

Conclusion:
Not applicable.

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.

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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 0.5 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 0.5 M nitric acid for a limited period.

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References:

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CORROSION EVALUATION

24590-WTP-RPT-PR-04-0001, Rev. B
WTP Process Corrosion Data

PROCESS CORROSION DATA

Component(s) (Name/ID #) HLW lag storage vessel (HLP-VSL-00027A/B,-00028)

Facility PTF

In Black Cell? Yes

Chemicals	Unit[1]	Contract Max		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	1.71E+01	5.30E+01			
Chloride	g/l	4.51E+00	5.02E+00			
Fluoride	g/l	5.36E+00	5.98E+00			
Iron	g/l	1.88E+02	1.27E+02			
Nitrate	g/l	4.93E+02	4.94E+02			
Nitrite	g/l	2.49E+01	2.77E+01			
Phosphate	g/l	1.80E+01	1.96E+01			
Sulfate	g/l	9.58E+00	1.06E+01			
Mercury	g/l	1.31E+00	1.83E+00			
Carbonate	g/l	3.36E+01	3.43E+01			
Undissolved solids	wt%	26.7%	26.3%			
Other (NaMnO4, Pb,...)	g/l					
Other	g/l					
pH	N/A					Note 3
Temperature	°F					Note 2

List of Organic Species:

References

System Description: 24590-PTF-3YD-HLP-00001, Rev 0
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: CNP12, UFP07, HLP09
Off Normal Input Stream # (e.g., overflow from other vessels): N/A
P&ID: N/A
PFD: 24590-PTF-M5-V17T-00008, 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 operation HLP-VSL-00027A/B: 50 °F to 113 °F (24590-PTF-MVC-HLP-00002, Rev 0);
   T operation HLP-VSL-00028: 50 °F to 122 °F (24590-PTF-MVC-HLP-00009, Rev 0)
3. pH can range from approximately 12 to 14

Assumptions:

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4.6.3 HLW Lag Storage Vessel (HLP-VSL-00027A/B)

Routine Operations

The ultrafiltration process system (UFP) concentrates solid slurries to generate intermediate products, such as Sr/TRU precipitate (Envelope C) or treated solids (Envelopes A/D and B/D). These intermediate products are received, segregated, and staged separately in either HLW lag storage vessel HLP-VSL-00027A or B. The HLW lag storage vessels are equipped with cooling jackets to maintain the temperature below 113 °F. Sampling is done once the vessels are filled and locked out, to confirm the composition of the vessel for blending purposes. During this staging period and while a sufficient level is achieved in the vessel, PJMs and a recirculation pump will be operated to promote mixing and maintain a flooded suction line.

Once required, the HLW intermediate products are transferred to the HLW feed blend vessel, HLP-VSL-00028, prior to immobilization in the HLW vitrification facility. There is the option to return solids back to the Tank Farms via the waste feed return pump, FRP-PMP-00001. The return of solids is considered an infrequent event and is determined prior to processing by characterization of HLW feed with WTP contract Specification 3 (DOE 2000). For operational flexibility, there is the option to use HLP-VSL-00027B for HLW feed blending prior to transfer to the HLW vitrification facility.

Non-Routine Operations that Could Affect Corrosion/Erosion

Transfer lines from system CNP, and future Cs/Sr capsule treatment facilities, are also available on vessel HLP-VSL-00027B in order to achieve this blending function. However, this optional blending function is considered an infrequent event.