CORROSION EVALUATION

R10667301

FEP-VSL-00017A/B (PTF)

Waste Feed Evaporator Feed Vessels

- Design Temperature (°F)(max/min): 237/40
- Design Pressure (psig) (max/min): 15/-10
- Location: incell
- PJM Discharge Velocity (fps): 40
- Drive Cycle: 17 % (at 40 fps)

ISSUED BY
RPP-WTP PDC

Off spring items

FEP-VSL-00017A
FEP-PJM-00001 – FEP-PJM-00007,
FEP-PJM-00017
FEP-VSL-00017B
FEP-PJM-00008 – FEP-PJM-00015

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

Assumptions: No steam ejectors, no acid additions without prior water flush.

Operating Modes Considered:

- Normal operations

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 required and discussed in section j)

Process & Operations Limitations:

- Develop rinsing/flushing procedure for water and acid

Concurrence KW
Operations

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
6	3/8/06	Update wear allowance based on 24590-WTP-RPT-M-04-0008	DLAdler	HMKrafft	NA	SWVail

 30 January 2006

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Revision History

5	1/25/05	Update PJM and erosion info based on 24590-WTP-M0E-50-00003	DLAdler	JRDivine	NA	APRangus
4	5/17/04	Addition of information regarding inadvertent nitric acid addition Append updated PCDS	DLAdler	APRangus	NA	SWVail
3	5/7/04	Incorporate new PCDS	DLAdler	JRDivine	NA	APRangus
2	3/19/04	Update vessel descr/assoc. items Update design temp/pressure Re-format references	DLAdler	JRDivine	NA	SWVail for APRangus
1	9/25/02	Update format Remove ref. to open issues Add DWP note	DLAdler	JRDivine	SS	SMKirk
0	3/19/02	Initial Issue	DLAdler	JRDivine	NA	B. Posta
REV	**DATE**	**REASON FOR REVISION**	**PREPARER**	**CHECKER**	**MET**	**APPROVER**

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Corrosion Considerations:

Vessels receive waste feed from FRP-VSL-00002A/B/C/D and recycles routed from PWD-VSL-00044, PWD-VSL-00015/16, RDP-VSL-00002A/B/C and UFP-VSL-00001A/B. Vessels are equipped with emptying ejectors to remove vessel heel. Emptying ejectors are located external to vessel.

a General Corrosion
Based on Hamner's data (1981), 304 (and 304L) has a corrosion rate of less than 20 mpy (500 µm/y) in NaOH at 77°F and over 20 mpy at 122°F. He shows 316 (and 316L) has a rate of less than 2 mpy in 50% NaOH at up to 122°F. Dillon (2000) and Sedriks (1996) both state that the 300 series are acceptable in up to 50% NaOH at temperatures up to about 122°F.

Danielson & Pitman (2000), based on short-term studies, suggest a corrosion rate of about 0.5 mpy for 316L. This corroborates Dillon and Sedriks.

Work by Divine (1986) showed that 304L corroded less than 316L in simulated complexant waste with fluorides and chlorides at 140°F. The corrosion rate of 304L after six months of testing was less than 0.2 mpy and that of 316L about 0.6 mpy.

Ohl & Carlos (1994), in their review of the 242-A Evaporator, found that in waste similar to that expected in WTP, the corrosion of 304L after about 2 years of operation was less than the accepted variability of the plate. The uncertainties in the starting thickness made the exact calculation of a corrosion rate uncertain though for 304L it appeared to be less than about 10 mpy. However, no cracking or pitting was noted.

Conclusion:
At temperatures less than 122°F, 304L, or higher alloys, is expected to be sufficiently resistant to the waste solution with a probable general corrosion rate of less than 1 mpy.

b Pitting Corrosion
Dillon (2000) is of the opinion that in alkaline solutions, pH>12, chlorides are likely to promote pitting only in tight crevices. It is his opinion that 304L would probably be acceptable, but the use of 316L would provide a benefit because of their resistance to pitting by chlorides. Davis (1994) recommends the use of 316L over 304L. Dillon and Koch (1995) are of the opinion that fluoride will have little effect. Divine's work (1986) showed no hint of pitting after six months at 140°F with heat transfer in simulated evaporator waste.

Revie (2000) notes that nitrate inhibits chloride corrosion. Therefore, the high nitrate concentrations in the waste are expected to be beneficial.

Conclusion:
316L is recommended to offer greater protection against pitting.

c End Grain Corrosion
End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions. This system is generally alkaline. If nitric acid is used for cleaning, cleaning should not be performed at higher than 122°F.

Conclusion:
Not applicable to this system.

d Stress Corrosion Cracking
The exact amount of chloride required to stress corrosion crack stainless steel 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), stress corrosion cracking does not usually occur below about 140°F. Further, the use of "L" grade stainless reduces the opportunity for sensitization. From the above references, it also observed that alkaline conditions reduce the probability of the initiation of stress corrosion cracking to essentially zero. However, should a pit or crevice, including a deposit, be present where the environment can become acid, then the alkaline environment will no longer have an effect.

Conclusion:
316L is recommended to offer greater protection against pitting and therefore reduce the likelihood of cracking.

e Crevice Corrosion
Essentially the same comments and conclusions obtained for pitting are valid here.

Conclusion:
Same as for 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.

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g Microbiologically Induced Corrosion (MIC)
MIC typically is not prevalent in high pH solutions. Borenstein (1988) states most microbes prefer a pH below 7 though some have been grown at above 9.5. Further, microbial growth is normally not a concern in tanks.

Conclusion:
MIC is not a concern in the vessels.

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

Conclusions
Not expected to be a concern.

i Vapor Phase Corrosion
Because of the highly alkaline conditions, no free HF or HCl is expected to be present in the vapor phase and no uniform/general corrosion is expected. However, because of the air operated ejectors and agitators, it is likely aerosols will be formed that will deposit on the roof of the tank. If there is condensation, these might be washed off.

Conclusion:
Vapor phase corrosion will not be a concern. 316L is recommended.

j Erosion
Based on past experiments by Smith & Elmore (1992), the solids 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 normal maximum solids concentrations of 4 wt% and maximum solids concentrations of 5 wt% with a usage of 46 % operation as documented in 24590-WTP-M0C-50-00004. Vessels FEP-VSL-00017A/B require at least 0.094-inch additional protection. The 5 wt% is considered to be conservative. The fraction of time the solids concentration is expected to be at maximum is 10 %. During normal operation, 90 % of the time, the solids content of FEP-VSL-00017A/B is expected to be 4 %.

The wear of the PJM nozzles can occur from flow for both the discharge and reflood cycles of operation. At least 0.060–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 normal solids concentrations of 4 wt% and a maximum solids concentration of 5 wt% for usage of 46 % 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
There are no moving surfaces within the vessels. Connections are welded and not bolted.

Conclusion:
Galling is of no concern in these vessels.

l Fretting/Wear
There are no contacting surfaces that are part of the vessel.

Conclusion:
Fretting and wear are not of concern.

m Galvanic Corrosion
The vessel contains no dissimilar metals.

Conclusion:
Galvanic corrosion is not a concern.

n Cavitation
None expected.

Conclusion:
Not believed to be of concern.

o Creep
Creep is a high temperature phenomenon, occurring at greater than about 932°F. This system operates at approximately 75 °F.

Conclusion:
Creep is not a concern.

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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 SHEET

Component(s) (Name/ID #) Waste feed evaporator feed vessel (FEP-VSL-00017A/B)

Facility PTF

In Black Cell? Yes

Chemicals	Unit[1]	Contract Max		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	9.79E+01	7.25E+01			
Chloride	g/l	4.24E+01	3.14E+01			
Fluoride	g/l	5.08E+01	3.76E+01			
Iron	g/l	2.34E+01	1.74E+01			
Nitrate	g/l	6.83E+02	5.06E+02			
Nitrite	g/l	2.34E+02	1.73E+02			
Phosphate	g/l	1.67E+02	1.23E+02			
Sulfate	g/l	9.00E+01	6.66E+01			
Mercury	g/l	9.26E-02	6.86E-02			
Carbonate	g/l	2.57E+02	1.91E+02			
Undissolved solids	wt%	4.6%	3.9%			
Other (NaMnO4, Pb,...)	g/l					
Other	g/l					
pH	N/A					Note 2
Temperature	°F					Note 3

List of Organic Species:

References

System Description: 24590-PTF-3YD-FEP-00001, Rev 0
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: FRP02, PWD02, PWD01,RDP09, FEP01, FEP15, HLP11
Off Normal Input Stream # (e.g., overflow from other vessels): N/A
P&ID: N/A
PFD: 24590-PTF-M5-V17T-00004001, 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. Receives resin flush solution(RDP09) pH approx 1.0 with reportable Cl & F, and neutralized high active effluent from PWD-VSL-00015/16 pH approx 14. RDP09 volume is small relative to the other streams but administrative controls and precautions should be taken not to transfer RDP09 to the vessel without sufficient alkaline heel present.
3. T operation 59 °F to 122 °F (24590-MEC-FEP-00001, Rev B)

Assumptions:

4.4.4 Waste Feed Evaporator Feed Vessel (FEP-VSL-00017A/B)

Routine Operations

Two waste feed evaporator feed vessels (FEP-VSL-00017 A/B) receive waste feed and recycles. Waste feed is transferred from the waste feed receipt vessels (FRP-VSL-00002 A/B/C/D). Recycles are routed from the plant wash and disposal vessel (PWD-VSL-00044), acidic/alkaline effluent vessels (PWD-VSL-00015 and PWD-VSL-00016), spent resin collection and dewatering process vessels (RDP-VSL-00002 A/B/C), and ultrafiltration feed preparation vessels (UFP-VSL-00001 A/B). Each feed vessel is equipped with remote sampling capability.

The feed vessels (FEP-VSL-00017 A/B) can operate by both filling and discharging at the same time or by alternating one vessel filling and the other discharging. The design basis for normal operations is to have the feed vessels alternating on 12-hour cycles (i.e., 12 hours filling, 12 hours discharging). This cycle time is based on WTP contract conditions for LAW glass production of 80 t/day (DOE 2000). Operations can vary this cycle time according to equipment availability; operator preferences for recycle management, and throughput requirements. The discharge is accomplished with a waste feed evaporator feed pump (FEP-PMP-00007 A or B) normally dedicated to one feed vessel, but with the ability to receive from either feed vessel (FEP-VSL-00017 A or B).

Each vessel is equipped with PJMs that blend and maintain solids suspension in the waste. The vessel vent system draws air into the vapor space of each vessel while removing gases to maintain the hydrogen concentration to below the lower flammability limit. Forced purge air is also supplied to the vessels. The two vessels are connected by a bi-directional overflow line that overflows to the ultimate overflow vessel (PWD-VSL-00033). For purposes of decontamination, each vessel is equipped with wash rings.

Non-Routine Operations that Could Affect Corrosion/Erosion

None identified.