CORROSION EVALUATION

R10664185

PWD-VSL-00043 (PTF)
HLW EFFLUENT TRANSFER VESSEL

- Design Temperature (°F)(max/min): 225/0
- Design Pressure (psig) (max/min): 15/FV
- Location: out cell
- PJM Discharge Velocity (fps): 40
- Drive Cycle: 17 % (at 40 fps)

ISSUED BY
RPP-WTP PDC

Offspring items

PWD-RFD-000141, PWD-RFD-000142
PWD-PJM-00041 – PWD-PJM-00048
PWD-VSL-00141, PWD-VSL-00142

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

Operating Modes Considered:

- The vessel is always at pH 7 at the normal operating temperature.

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 acid and water
- Develop lay-up strategy

Concurrence KW
Operations

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
5	1/12/06	Update PJM and erosion info based on 24590-WTP-M0C-50-00004 Update wear allowance based on 24590-WTP-RPT-M-04-0008	DL Adler	[signature]	NA	[signature]

8 December 2005

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REVISION HISTORY

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
4	10/13/04	Update design temperature	DLAdler	JRDivine	NA	APRangus
3	6/25/04	Incorporate new PCDS Correct PJM discharge velocity Modify Section j – Erosion Add Section p – Inadvertent Addition of Nitric Acid Reduce CA based on Wear Allowance Calculation	DLAdler	JRDivine	NA	APRangus
2	3/31/03	Editorial changes Correct vessel description Add PJM info Update design temp Modify references page	DLAdler	HMKrafft	NA	MHoffmann
1	9/23/02	Add DWP note Update Design Temp New Chemistry New Mat'l Recommendation Update format Remove Open Issues	DLAdler	JRDivine	SS	SMKirk
0	2/26/02	Initial Issue	JRDivine	DLAdler	NA	BPosta

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Corrosion Considerations:

RLD-VSL-00043 receives material from multiple sources including canister decontamination effluent from the HLW Vitrification facility, plant wash solution from the HLW plant wash and drains vessel and waste solution from the HLW acidic waste storage vessel. It can also receive overflow from PWD-VSL-00033 but this is considered an abnormal occurrence.

a General Corrosion
General corrosion is not expected to be a concern with an anticipated corrosion rate less than 1 mpy.

Conclusion:
For the stated neutral waste conditions, 304L or 316L is recommended. The corrosion rate is expected to be < 1 mpy.

b Pitting Corrosion
Chloride is known to cause pitting in acid and neutral solutions. Normally the vessel is to operate at approximately 115°F at a pH of 7. Berhardsson et al (1981) concluded based solely on concentrations that 316L will provide added protection against the concentration of chlorides during operation.

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 likely occurs because residual chlorides remain.

Conclusion:
Localized corrosion, such as pitting, is common but can be mitigated by alloys with higher molybdenum contents than the standard austenitic stainless steels. Based on the expected operating conditions, 316L will be acceptable.

c End Grain Corrosion
End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions.

Conclusion:
Not applicable 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 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. The continual use of the vessel is expected to allow use of 316L.

Conclusion:
For the normal operating environment, 316L or better is required.

e Crevice Corrosion
With the stated normal operating conditions, 316L would be the minimum acceptable. Also see Pitting.

Conclusion:
316L is acceptable.

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 conditions are correct but the fluids have been through several processes that make MIC contamination unlikely.

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.

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i Vapor Phase Corrosion
The vapor phase portion of the vessel is expected to be contacted with particles of waste from splashing that should keep that area sufficiently rinsed.

Conclusion:
Vapor phase corrosion is unlikely.

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 solids concentrations of 27 wt% for a usage of 28 % operation as documented in 24590-WTP-M0C-50-00004. PWD-VSL-00043 requires at least 0.123-inch additional protection. The 27 wt% is considered to be conservative and is based on the WTP Prime Contract maximum. During normal operation, the solids content of PWD-VSL-00043 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 0.078–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 27 wt% for usage of 28 % 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.

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.

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References:

1. 24590-WTP-M0C-50-00004, Rev. D, *Wear Allowance for WTP Waste Slurry Systems*
2. 24590-WTP-RPT-M-04-0008, Rev. 2, *Evaluation Of Stainless Steel Wear Rates In WTP Waste Streams At Low Velocities*
3. 24590-WTP-RPT-PR-04-0001, Rev. B, *WTP Process Corrosion Data*
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
5. Davis, JR (Ed), 1987, *Corrosion, Vol 13*, In "Metals Handbook", ASM International, Metals Park, OH 44073
6. Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
7. Smith, H. D. and M. R. Elmore, 1992, *Corrosion Studies of Carbon Steel under Impinging Jets of Simulated Slurries of Neutralized Current Acid Waste (NCAW) and Neutralized Cladding Removal Waste (NCRW)*, PNL-7816, Pacific Northwest Laboratory, Richland, Washington.

Bibliography:

1. CCN 130170, Blackburn, LD to PG Johnson, Internal Memo, Westinghouse Hanford Co, *Evaluation of 240-AR Chloride Limit*, August 15, 1991.
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. CCN 130172, Divine, JR, 1986, Letter to A.J. Diliberto, *Reports of Experimentation*, Battelle, Pacific Northwest Laboratories, Richland, WA 99352
4. CCN 130173, Dillon, CP (Nickel Development Institute), Personal Communication to J R Divine (ChemMet, Ltd., PC), 3 Feb 2000.
5. CCN 130178, Wilding, MW and BE Paige, 1976, *Survey on Corrosion of Metals and Alloys in Solutions Containing Nitric Acid*, ICP-1107, Idaho National Engineering Laboratory, Idaho Falls, ID
6. Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
7. Danielson, MJ & SG Pitman, 2000, *Corrosion Tests of 316L and Hastelloy C-22 in Simulated Tank Waste Solutions*, PNWD-3015 (BNFL-RPT-019, Rev 0), Pacific Northwest Laboratory, Richland WA.
8. Davis, JR (Ed), 1994, *Stainless Steels*, In ASM Metals Handbook, ASM International, Metals Park, OH 44073
9. Hamner, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX 77218
10. Jones, RH (Ed.), 1992, *Stress-Corrosion Cracking*, ASM International, Metals Park, OH 44073
11. Koch, GH, 1995, *Localized Corrosion in Halides Other Than Chlorides*, MTI Pub No. 41, Materials Technology Institute of the Chemical Process Industries, Inc, St Louis, MO 63141
12. Phull, BS, WL Mathay, & RW Ross, 2000, *Corrosion Resistance of Duplex and 4-6% Mo-Containing Stainless Steels in FGD Scrubber Absorber Slurry Environments*, Presented at Corrosion 2000, Orlando, FL, March 26-31, 2000, NACE International, Houston TX 77218.
13. Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158
14. Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084
15. Zapp, PE, 1998, *Preliminary Assessment of Evaporator Materials of Construction*, BNF—003-98-0029, Rev 0, Westinghouse Savannah River Co., Inc for BNFL Inc.

CORROSION EVALUATION

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

PROCESS CORROSION DATA SHEET

Component(s) (Name/ID #) HLW effluent transfer vessel (PWD-VSL-00043)

Facility PTF

In Black Cell? No

Chemicals	Unit[1]	Contract Maximum		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	3.3E-02	5.3E-02	9.79E+01	7.25E+01	
Chloride	g/l	1.2E-01	1.4E-01	4.24E+01	3.14E+01	
Fluoride	g/l	7.2E-02	9.5E-02	5.08E+01	3.76E+01	
Iron	g/l	3.2E-01	2.5E-01	1.88E+02	1.27E+02	
Nitrate	g/l	1.6E+01	1.5E+01	6.83E+02	5.80E+02	
Nitrite	g/l	6.9E-04		2.34E+02	1.73E+02	
Phosphate	g/l	1.9E-03	3.7E-03	1.67E+02	1.23E+02	
Sulfate	g/l	3.4E-04		9.00E+01	6.66E+01	
Mercury	g/l	4.0E-01	6.0E-01	1.31E+00	1.83E+00	
Carbonate	g/l	1.9E-03		2.57E+02	1.91E+02	
Undissolved solids	wt%			27%	26%	Note 4
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-PWD-00001, Rev 1
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: FRP11, PWD13, RLD62, RLD64
Off Normal Input Stream # (e.g., overflow from other vessels): PWD-VSL-00033
P&ID: 24590-PTF-M6-PWD-00002, Rev 1
PFD: 24590-PTF-M5-V17T-00022001, Rev 1
Technical Reports:

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 59 °F to 122 °F, T nominal 115 °F (24590-PTF-MVC-PWD-00030, Rev 0)
3. pH approximately 7
4. Overflow is diluted to Newtonian fluid with water as soon as normal operation is achieved. Expected minimum dilution ratio 1.5.

Assumptions:

4.9.12 HLW Effluent Transfer Vessel (PWD-VSL-00043)

Routine Operations

During normal operations, vessel PWD-VSL-00043 receeives material from the following sources. These sources enter the vessel through a diptube to allow for a ventilation seal between facilities:

- Canister decontamination effluent via breakpot (HLW)-RLD-BRKPT-00007 or 9 from HLW vitrification waste neutralization vessel (HLW)-HDH-VSL-00003
- Plant wash solution via breakpot (HLW)-RLD-BRKPT-00007 or 9 from HLW vitrification plant wash and drains vessel (HLW)-RLD-VSL-00008
- Waste solution (primarily SBS condensate stream) and plant wash via breakpot (HLW)-RLD-BRKPT-00007 or 9 from HLW vitrification acidic waste storage vessel (HLW)-RLD-VSL-00007
- Transfer line drain from HLW/PT interface
- Waste feed line drains
- An air in-bleed and forced purge air are provided to dilute hydrogen generated in vessel PWD-VSL-00043. Wash rings are used for vessel washing. RFDs transfer the effluent from vessel PWD-VSL-00043 to PWD-VSL-00044.
- Vessel PWD-VSL-00043 vents to the vessel vent caustic scrubber (PVP-SCB-00002) via the vessel vent header.

Non-Routine Operations that Could Affect Corrosion/Erosion

- Vessel PWD-VSL-00043 initially overflows to PWD-VSL-00033 and ultimately to PWD-SUMP-00040. Ejectors are used to transfer the sump contents back to vessel PWD-VSL-00043 or to PWD-VSL-00033.
- A vessel-emptying ejector is used for non-routine transfers to the plant wash vessel (PWD-VSL-00044) via PWD-BRKPT-00010. This ejector uses process condensate as a motive force instead of steam.
- During abnormal operations, vessel PWD-VSL-00043 receives material from the following sources:
  - Overflow from PWD-VSL-00033
  - Hot cell west berm floor drain (PWD-FD-00005)