CORROSION EVALUATION

R10667999

ISSUED BY
RPP-WTP PDC

FEP-COND-00003A/B (PTF)
Waste Feed Evaporator Aftercondensers

- Design Temperature (°F)(max/min): Shell side; 378/0: Tube side; 150/49
- Design Pressure (psig) (max/min): Shell side: 50/FV; Tube side; 100/FV
- Location: out cell

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

Operating Modes Considered:

- pH ≈ 7, temperature up to 250°F

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: Shell side; 0.040 inch (includes 0.024 inch corrosion allowance and 0.004 inch erosion allowance);
Tube side; 0.0 inch

Process & Operations Limitations:

- None

DOE Radioactive Materials Disclaimer: Please note that source, special nuclear, and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at the US Dept. of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts, that, pursuant to the AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.

Concurrence NA
Operations

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	MET	APPROVER
3	3/14/06	Update design temp Update wear allowance based on 24590-WTP-RPT-M-04-0008	DLAdler	HMKrafft	NA	SWVail
2	10/14/04	Incorporate new PCDS Add section p -- Inadvertent Addition of Nitric Acid	DLAdler	JRDivine	NA	APRangus
1	3/19/04	Update equipment description Update design temp/pressure Add DWPA note Remove reference to open issues Re-format reference Append updated MSDS	DLAdler	JRDivine	NA	SWVail
0	4/29/02	Initial Issue	DLAdler	JRDivine	SS	SMKirk

CORROSION EVALUATION

Corrosion Considerations:

a General Corrosion
In the proposed pH operating range, no information was found for the general/uniform corrosion of stainless steels or other material. Typically, the austenitic and higher alloy steels are expected to have corrosion rates of less than about 1 mpy. This lack of data is not critical because the alloys needed for the system typically fail by pitting, crevice corrosion, or cracking. On this basis, a corrosion allowance has little meaning though a nominal value is given.

Conclusion:
Little uniform corrosion is expected, even under accident conditions. A nominal corrosion allowance is given even though it has minimal significance.

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. Dillon and Koch (1995) are of the opinion that fluoride will have little effect. Jenkins (1998) has stated that localized corrosion can occur under the deposits on tubes, probably due to the chlorides. Further, Revie (2000) and Uhlig (1948) note that nitrates inhibit chloride pitting.

The condensers have no reportable concentrations of chloride and pH of 7 rather than above 12. At the stated conditions, 316L stainless steel is recommended.

Conclusion:
Based on the expected operating conditions the vessel should be 316L stainless steel.

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

Conclusion:
Not applicable to 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. Under the stated conditions, 316L is considered acceptable.

Given the environment and the lack of heat transfer into the process stream, caustic cracking is not anticipated to be a problem.

Conclusion:
Because of the normal operating environment, the minimum alloy recommended is a 316L 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 on the process side are acceptable for microbe growth. Because, however, the source of the stream is from the evaporation of a process fluid, no microbes are expected to be present.

Conclusion:
MIC is not considered a problem.

CORROSION EVALUATION

h Fatigue/Corrosion Fatigue
Corrosion fatigue should not be a problem.

Conclusions
Not expected to be a concern.

i Vapor Phase Corrosion
The vapor phase portion of the shell will be continually washed with condensing vapors.

Conclusion:
No vapor phase corrosion is anticipated.

j Erosion
Velocities within the condenser are expected to be low. Erosion allowance of 0.004 inch for components with low solids content (< 2 wt%) at low velocities is based on 24590-WTP-RPT-M-04-0008.

Conclusion:
Not a concern

k Galling of Moving Surfaces
Not applicable.

Conclusion:
Not applicable.

l Fretting/Wear
Not expected to be applicable.

Conclusion:
Not applicable.

m Galvanic Corrosion
For the environment and the proposed alloys, there is not believed to be a concern.

Conclusion:
Not believed to be of concern.

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.

CORROSION EVALUATION

References:

1. 24590-WTP-RPT-M-04-0008, Rev. 2, *Evaluation Of Stainless Steel Wear Rates In WTP Waste Streams At Low Velocities*
2. 24590-WTP-RPT-PR-04-0001, Rev. B, *WTP Process Corrosion Data*
3. CCN 130173, Dillon, CP (Nickel Development Institute), Personal Communication to J R Divine (ChemMet, Ltd., PC), 3 Feb 2000.
4. Jenkins, CF, 1998, *Performance of Evaporators in High Level Radioactive Chemical Waste Service*, Presented at Corrosion 98, NACE International, Houston TX 77084
5. 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
6. Revie, WW, 2000. Uhlig's Corrosion Handbook, 2nd Edition, Wiley-Interscience, New York, NY 10158
7. Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158

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. 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.
5. Davis, JR (Ed), 1987, *Corrosion, Vol 13*, In "Metals Handbook", ASM International, Metals Park, OH 44073
6. Davis, JR (Ed), 1994, *Stainless Steels*, In ASM Metals Handbook, ASM International, Metals Park, OH 44073
7. Hamner, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX
8. Jones, RH (Ed.), 1992, *Stress-Corrosion Cracking*, ASM International, Metals Park, OH 44073
9. Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
10. Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084

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 primary, inter-, and after-condensers (FEP-COND-00001A/B; FEP-COND-00002A/B; FEP-COND-00003A/B)

Facility PTF

In Black Cell? No

Chemicals	Unit[1]	Contract Max		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l					
Chloride	g/l					
Fluoride	g/l					
Iron	g/l					
Nitrate	g/l					
Nitrite	g/l					
Phosphate	g/l					
Sulfate	g/l					
Mercury	g/l					
Carbonate	g/l					
Undissolved solids	wt%					
Other (NaMnO4, Pb,...)	g/l					
Other	g/l					
pH	N/A					Assumption 1
Temperature	°F					Note 2
						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 #: FEP06
Off Normal Input Stream # (e.g., overflow from other vessels): N/A
P&ID: N/A
PFD: 24590-PTF-M5-V17T-00004002, 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. 111 °F to 122 °F (24590-PTF-MEC-FEP-00001, Rev B)
3. All chemical data below reporting level

Assumptions:
1. pH 7

CORROSION EVALUATION

4.4.1 Waste Feed Evaporator Primary Condenser (FEP-COND-00001A/B), Waste Feed Evaporator Inter-Condenser (FEP-COND-00002A/B), Waste Feed Evaporator After-Condenser (FEP-COND-00003A/B)

Routine Operations

The de-entrained water vapor and gases enter the feed evaporator condensers. The primary condensers (FEP-COND-00001A/B) are designed to provide condensation of process vapors generated by evaporation of waste. This minimizes vapor carry-over by noncondensable gases to the vacuum ejectors. Condensate is gravity-drained to the waste feed evaporator condensate vessel (FEP-VSL-00005). Cooling water is supplied to the condensers without restriction. The maximum inlet temperature of the cooling water is 83 °F (from the *Basis of Design*, 24590-WTP-DB-ENG-01-001).

Two ejectors (per evaporator train) generate the vacuum requirements that enable boiling at approximately 122 °F. The ejectors use high-pressure steam provided at a mean pressure and temperature of 109 psig and 343 °F from the *Basis of Design*. Control air for the vacuum system is drawn from the vessel vent system. The first ejector uses high-pressure steam to pull a vacuum off the primary condenser. The ejector discharges steam and noncondensable gases to the waste feed evaporator inter-condenser (FEP-COND-00002A/B) to condense steam from the ejector.

The condensate drains from the inter-condenser to the waste feed evaporator condensate vessel. The second ejector draws noncondensable gases from the inter-condenser. This ejector augments the function of the first. The ejector discharges steam and noncondensable gases to the waste feed evaporator after-condenser to condense the ejector steam. The condensate drains from the after-condenser (FEP-COND-00003A/B) to the condensate vessel. The vessel vent system draws noncondensable gases from the after-condenser through the waste feed evaporator demister. This vessel contains a demister pad to remove liquid entrained in the noncondensable gases. The liquid drains from the demister to the condensate vessel.

Non-Routine Operations that Could Affect Corrosion/Erosion

None identified.