

**PLANT ITEM MATERIAL SELECTION DATA SHEET**

**TLP-SEP-00001 (PTF)**

**Treated LAW Evaporator Separator Vessel**

- Design Temperature (°F)(max/min): 175/49
- Design Pressure (psig) (internal/external): 50/14.7
- Location: incell



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RPP-WTP PDG

**Contents of this document are Dangerous Waste Permit affecting**

**Operating conditions are as stated on attached Process Corrosion Data Sheet**

**Options Considered:**

- Normal operating conditions
- The vessel will be cleaned using 2 N HNO<sub>3</sub> with residual chlorides and fluorides at reduced temperatures

**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)**

**Recommended Corrosion Allowance: 0.040 inch (includes 0.024 inch corrosion allowance and 0.004 inch general erosion allowance)**

**Process & Operations Limitations:**

- Develop rinsing/flushing procedure for acid and water



**EXPIRES: 12/07/07**

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This bound document contains a total of 7 sheets.

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## PLANT ITEM MATERIAL SELECTION DATA SHEET

### Corrosion Considerations:

#### a General Corrosion

The vessel has a normal operating temperature of 122°F. According to Hamner (1981), 304 (and 304L) has a corrosion rate of less than 20 mpy (500  $\mu\text{m}/\text{y}$ ) at 77°F and over 20 mpy in NaOH at 122°F. He shows 316 (and 316L) has a rate of less than 2 mpy up to 122°F and 50% NaOH. These data are qualified by Dillon (2000) and Sedriks (1996) who both state that the 300 series are acceptable in up to 50% NaOH at temperatures up to about 122°F. Davis (1994) states the corrosion rate for 304L will be less than about 0.1 mpy at these temperatures. Based on short term studies, Danielson & Pitman (2000), suggest a corrosion rate of about 0.5 mpy for 316L in simulated waste at 122°F. Zapp's report (1998) notes the successful use of 304L as the shell of the Savannah River evaporators.

Uhlig (1948) has shown that pure nickel is more resistant to corrosion by NaOH than stainless steel. However, as Divine pointed out (1986), the presence of complexing agents [part of the total organic carbon (TOC) measured] may reverse the trend. Agarwal (2000) states that the higher nickel alloys are highly corrosion resistant though specific mention of alkaline media is not made. Their high nickel content is a positive feature. The general literature mainly discusses cracking problems (see below) rather than uniform corrosion.

Ohl & Carlos (1994), in their review of the 242-A Evaporator, found that after about 2 years of operation in waste similar to LAW, the corrosion of 304L was less than the accepted variability of the plate. Thus, the NDE data are sufficiently uncertain to prevent definite conclusions from being drawn.

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  $\text{Al}^{+++}$ . Additionally, Sedriks (1996) has noted with 10% ( $\approx 2\text{N}$ ) 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 unless the fluoride is well inhibited. The use of acid cleaning while operating at higher temperatures would require the use of a 6% Mo alloy. Keeping the vessel as cool as possible would reduce the extent of attack by chloride (pitting and crevice corrosion) and, with the addition of  $\text{Al}^{+++}$ , general corrosion due to fluoride. 304L will be suitable if properly protected by temperature and fluoride complexants such as  $\text{Al}^{+++}$ .

#### Conclusion:

At temperatures less than 140°F, 304L or 316L are expected to be sufficiently resistant to the waste solution with a probable general corrosion rate of less than 1 mpy. The Savannah River work suggests they will be acceptable to higher temperatures in waste.

#### b Pitting Corrosion

Chloride is notorious for causing pitting in acid and neutral solutions. Dillon (2000) is of the opinion that in alkaline solutions,  $\text{pH} > 12$ , chlorides are likely to promote pitting only in tight crevices. Dillon and Koch (1995) is of the opinion that fluoride will have little effect.

Revie (2000) and Uhlig (1948) both note nitrate inhibits chloride corrosion. Therefore the high nitrate concentrations in the LAW are expected to be beneficial. The 18,000 – 20,000 ppm chloride concentration will mean residual chloride is present during acid cleaning.

The apparent lack of pitting in the 242-A Evaporator suggests 304L is acceptable at the design conditions -  $\leq 140^\circ\text{F}$ . Zapp (1998) confirms the good behavior of 304L in the shell. The 304L shell of the evaporator at Savannah River has performed successfully for approximately 30 years.

#### Conclusion:

Localized corrosion, such as pitting, is common but probably can be mitigated by alloys with higher nickel and molybdenum contents even under heat transfer conditions or where deposits can form. Based on Savannah River data, the vessel is expected to be free of significant corrosion and can be constructed of 304L. Rinsing/flushing procedure will be developed to eliminate concern during acid cleaning.

#### 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 stress corrosion crack stainless steel is unknown. In part this is because the amount varies with temperature, metal sensitization, and the environment and 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 is 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 and stress corrosion can occur.

Caustic cracking tends not to occur below 140°F (Sedriks 1996; Dillon 2000) or below 212°F (Zapp 1998). Because the maximum operating temperature is 122°F, all sources suggest caustic cracking should be minimal. Zapp's data from the Savannah River Site evaporators is auspicious for the use of 304L for the vessel.

#### Conclusion:

The use of 304L is expected to be acceptable for the vessel during operation. During rinsing and flushing, the temperature should be kept as low as possible. A rinsing/flushing procedure is needed to define temperature/time limits.

**PLANT ITEM MATERIAL SELECTION DATA SHEET****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 too extreme for MIC with high temperatures and pH. Additionally, MIC is not normally observed in operating systems except for those exposed to process water.

*Conclusion:*

MIC is not considered a problem.

**h Fatigue/Corrosion Fatigue**

Corrosion fatigue is a not expected to be a concern.

*Conclusions*

Not applicable.

**i Vapor Phase Corrosion**

Due to flashing liquid, the surface is expected to be continually sprayed with liquid and be kept relatively clean.

*Conclusion:*

No vapor phase corrosion is expected.

**j Erosion**

Velocities within the vessel 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**

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.

**PLANT ITEM MATERIAL SELECTION DATA SHEET****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.

## PLANT ITEM MATERIAL SELECTION DATA SHEET

### 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 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. Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
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### 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. Jones, RH (Ed.), 1992, *Stress-Corrosion Cracking*, ASM International, Metals Park, OH 44073
4. 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
5. Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084

**PLANT ITEM MATERIAL SELECTION DATA SHEET**

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

**PROCESS CORROSION DATA SHEET**

Component(s) (Name/ID #) Waste feed evaporator separator (TLP-SEP-00001)  
Treated LAW evaporator reboiler (TLP-RBLR-00001)

Facility PTF

In Black Cell? Yes (TLP-SEP-00001 only)

Chemicals	Unit <sup>1</sup>	Contract Maximum		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	3.85E+01	3.52E+01			
Chloride	g/l	1.83E+01	2.00E+01			
Fluoride	g/l	1.84E+01	2.01E+01			
Iron	g/l	2.83E+00	2.89E+00			
Nitrate	g/l	2.72E+02	2.88E+02			
Nitrite	g/l	8.19E+01	8.89E+01			
Phosphate	g/l	5.91E+01	6.28E+01			
Sulfate	g/l	3.15E+01	3.42E+01			
Mercury	g/l	8.96E-01	3.14E-02			
Carbonate	g/l	1.27E+02	1.10E+02			
Undissolved solids	wt%					
Other	g/l					
Other	g/l					
pH	N/A					Note 3
Temperature	°F					Note 2

List of Organic Species:

**References**

System Description: 24590-PTF-3YD-TLP-00001, Rev 0  
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A  
Normal Input Stream #: TLP13, TLP02, CXP23  
Off Normal Input Stream # (e.g., overflow from other vessels): FRP03, UFP08  
P&ID: 24590-PTF-M6-TLP-P0003, Rev 0  
PFD: 24590-PTF-M5-V17T-P0005, Rev 0  
Technical Reports:

**Notes:**

1. Concentrations less than  $1 \times 10^{-4}$  g/l do not need to be reported; list values to two significant digits max.
2. T normal operation 122 °F (24590-PTF-MVC-TLP-00002, Rev B)
3. pH approximately 12 to 14

**Assumptions:**

**PLANT ITEM MATERIAL SELECTION DATA SHEET**24590-WTP-RPT-PR-04-0001, Rev. B  
WTP Process Corrosion Data**4.13.3 Treated LAW Evaporator Separator Vessel (TLP-SEP-00001)****Routine Operations**

When the recirculating liquor reaches the separator vessel, flash evaporation occurs due to reduced pressure in the vessel. The liquid continues to flash, separating the vapor and liquid streams. The liquid stream recirculates in this closed loop while the vapor stream enters the evaporator overheads. The maximum designed boil-off rate for the TLP evaporator system will be 30 gpm of vapor condensate.

The pressure in the separator vessel is maintained at about 1 psia by a controlled in-bleed of air to the suction side of the primary vacuum ejector. This reduced pressure lowers the boiling point of the liquor to about 122 °F. If the pressure in the separator vessel rises, the air in-bleed is reduced to allow a higher rate of vapor to be withdrawn from the separator vessel, thereby reducing the pressure.

The overhead vapor produced in the separator vessel is superheated by about 24 °F due to the boiling point elevation of the concentrate. The overhead vapor is passed through a set of demister pads for de-entrainment purposes. The demister pads are sprayed with recycled condensate from the treated LAW evaporator condensate vessel, or in the event that evaporator condensate is unavailable, the process condensate tanks (RLD-TK-00006A/B). This spray ensures that the demister pads are always wetted completely to mitigate solids formation and plugging. This also diminishes solids formation on the walls of the separator above the liquid level in the vessel.

The nature of the evaporator feed, coupled with the boiling action, creates the potential for foaming in the separator vessel (TLP-SEP-00001). The separator vessel design includes an antifoam agent feed line from the antifoam vessel. The need for, and magnitude of, the antifoam addition will be determined by development and commissioning work. This addition is expected to be part of normal operations.

The treated LAW evaporator will concentrate the waste to between 8 and 10 M sodium or a maximum specific gravity of approximately 1.44. Concentrate is removed continuously from the treated LAW evaporator at the lowest point on the suction side of the recirculation pump using the variable-speed evaporator concentrate pumps (TLP-PMP-00011A/B).

While in operation, the evaporator train provides sufficient vapor space dilution to prevent the build-up of hydrogen.

For purposes of decontamination, the separator vessel is equipped with wash rings.

**Non-Routine Operations that Could Affect Corrosion/Erosion**

None identified.