CORROSION EVALUATION

DEP-HX-00001
Evaporator Concentrate/Feed LAW Effluent Cooler

Contents of this document are Dangerous Waste Permit affecting

Component Type – Plate and Frame Heat Exchanger

Materials Considered:

Material (UNS No.)	Acceptable Material
Carbon Steel-Painted	X (end covers only)
Type 304L (S30403)	X (shroud only)
Type 316L (S31603)	X
AL-6XN® 6% Mo (N08367)	X
Hastelloy® C-22® (N06022)	X

Recommended Material Types:
Plates –Type 316 (max 0.030% C; dual certified)
End covers – Painted carbon steel
Nozzles: Type 316 (max 0.030% C; dual certified)
Removable shroud – Type 304 (max 0.030% C; dual certified)

Minimum Corrosion Allowance:
Wetted surfaces (except heat transfer surfaces) – 0.04 inch
Heat transfer surfaces: 0.0 inch corrosion allowance

Inputs and References

- Operating Temperature (°F) (hot side inlet/outlet): 103/80* (24590-BOF-M4C-V11T-00006)
- Operating Temperature (°F) (cold side inlet/outlet): 84/120 (24590-BOF-MEC-PCW-00001)
- Design corrosion allowance (wetted surfaces) (inch): 0.04 (24590-WTP-M0C-50-00004)
- Design corrosion allowance (heat transfer surfaces): 0.0 inch (24590-WTP-GPG-M-047)
- General corrosion allowance (wetted surfaces) (inch): 0.024 (24590-WTP-M0E-50-00012)
- General erosion allowance (wetted surfaces) (inch): 0.004 (24590-WTP-M0C-50-00004)
- Location: Room E-0103 (24590-BOF-P1-25-00001)
- Operating conditions are as stated in the applicable section of *Direct Feed LAW Process Corrosion Data* (24590-BOF-RPT-PR-15-001)

* Hot side inlet temperature based on the higher of the DEP-VSL-00002 and DEP-VSL-00003A/B/C transfer temperature, Stream DEP02.

Assumptions and Justification (refer to Section 19—References)

- Source data presented on the Process Corrosion Datasheet (PCDS) is conservative with respect to corrosion.[7]
- Heat exchangers shall be designed to permit access for in-situ maintenance, repair, or inspection, as necessary.[1]
- DEP-HX-00001 is rarely expected to operate.[4]
- When requested, a batch transfer from DEP-VSL-00002 or DEP-VSL-00003A/B/C to Tank Farms will first pass through the heat exchanger, DEP-HX-00001, to ensure the temperature of the stream meets Tank Farm acceptance criteria.[3]
- The PCDS presents a temperature of 157 °F for the inlet stream to the heat exchanger based on the heat exchanger sizing calculation, 24590-BOF-MEC-DEP-00002. However, this is a worst-case temperature including margin and conservatisms as appropriate for sizing the heater exchanger; the temperature of the stream upon reaching the heat exchanger will never reach that maximum. Further, immediate cooling of the stream upon entering the heat exchanger will also ensure that the stream is within the temperature limits for Type 316L. A more reasonable temperature for the hot side inlet is 103 °F.[2]
- Sodium hydroxide is added and mixed with the eductors in the vessels, and sodium nitrite is added to the streams before passing through DEP-HX-00001 to meet the requirements for transfer in 24590-WTP-ICD-MG-01-031, *ICD 31 - Interface Control Document for DFLAW Effluent Returns to Double-Shell Tanks*.[3]

Operating Restrictions

- To protect against localized corrosion in the heat exchanger and transfer piping, develop procedures to bring the stream within the limits defined for Type 316L in 24590-WTP-RPT-M-11-002, *WTP Materials Localized Corrosion Design Limits*, in the event that sampling indicates that temperature, pH, or chloride concentration exceeds those limits.
- The purpose of DEP-HX-00001 is to cool waste to meet ICD-31 requirements; however, the frequency of this transfer is low. Therefore, procedures are required to control dry lay-up and storage; both before the start of plant operations and during idle periods after start-up.
- Procedures are to be reviewed and accepted by MET prior to use.

Concurrence Reviewed No Comments ☑ By: Maurice Bunker - mjbunker, Org Name: Plant Management, Placed: Nov 01, 2017
Plant Mgmt

REV	DATE	REASON FOR REVISION	ORIGINATE	CHECK	REVIEW	APPROVE
0	11/2/17	Initial Issue	Originator By: Debbie Adler - dladler, Org Name: MET, Placed: Oct 30, 2017	Checked By: A. Rangus - aprangus, Org Name: Bechtel, Placed: Oct 30, 2017 10:16 am	Approved By: Tom Erwin - terwin, Org Name: MET, Placed: Nov 02, 2017	~~T. Erwin~~ A. Kunkle 11/2/17

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Corrosion/Erosion Detailed Discussion

The Evap Concentrate/Feed LAW Effluent Cooler (DEP-HX-00001) is a heat exchanger that is used to cool the waste that will be returned to the Tank Farms during off-normal operating conditions. Waste can be returned to the tank farms from either DEP-VSL-00002 or DEP-VSL-00003A/B/C. Process condensate from DEP-VSL-00005A/B can be used to dilute these waste streams, as needed. Waste from DEP-VSL-00003A/B/C is routed through DEP-FILT-00003 to remove solids before passing through DEP-HX-00001.

Under an off-normal operating condition where a waste stream is transferred back to the Tank Farms, DEP-HX-00001 is used to cool the stream so that it is below the temperature limit for waste acceptance at the Tank Farms. A temperature limit of 95 °F is established for waste returned to the tank farms from the Effluent Management Facility according to ICD 31.

In the event that waste is returned to the Tank Farm, the waste must be chemically adjusted to meet waste acceptance criteria for corrosion mitigation. ICD 31 establishes the specific chemical requirements for corrosion mitigation. The DEP system will be designed to allow the addition of these corrosion mitigation chemicals, currently planned to be sodium hydroxide and sodium nitrite. Sodium hydroxide additions will occur in the vessel (DEP-VSL-00002 or DEP-VSL-00003A/B/C). Additions of sodium nitrite and process condensate from DEP-VSL-00005 or demineralized water will occur in-line prior to DEP-HX-00001.

1 General/Uniform Corrosion Analysis

a Background

General corrosion or uniform corrosion is corrosion that is distributed uniformly over the surface of a material without appreciable localization. This leads to relatively uniform thinning on sheet and plate materials and general thinning on one side or the other (or both) for pipe and tubing. It is recognized by a roughening of the surface and by the presence of corrosion products. The mechanism of the attack is an electrochemical process that takes place at the surface of the material. Differences in composition or orientation between small areas on the metal surface create anodes and cathodes that facilitate the corrosion process.

b Component-Specific Discussion

There are no normal operating modes identified for this component; therefore, expected off-normal conditions are utilized for this evaluation. Under these anticipated off-normal conditions, the heat exchanger will receive evaporator feed or evaporator concentrate and will cool the stream to 90 °F. The stream is adjusted to meet the acceptance criteria for receipt at Tank Farms. The adjusted conditions are under development; however, it can be expected that the stream adjusted to meet ICD-31 requirements, will be compatible with Type 316L. A 0.04 inch corrosion allowance is recommended, except for the heat transfer surfaces. Heat transfer surfaces can be designed with no corrosion allowance; the material is selected to minimize corrosion, and the heat exchangers are maintainable.

2 Pitting Corrosion Analysis

Pitting is localized corrosion of a metal surface that is confined to a point or small area and takes the form of cavities. According to Dillon (2000), in alkaline solutions, pH> 12, chlorides are likely to promote pitting only in tight crevices. Normally the heat exchanger is to operate at a nominal pH of 12.4 or higher. The heat exchanger is operated such that conditions do not promote pitting corrosion.

There are no normal chemistry and operating conditions developed for this component. However, prior to reaching DEP-HX-00001, the stream will be adjusted for compliance for transfer to the tank farms and is expected to be within the limits established for Type 316L stainless steel in Table 1-2 of *WTP Materials Localized Corrosion Design Limits* report, 24590-WTP-RPT-M-11-002.

3 Crevice Corrosion Analysis

Crevice corrosion is a form of localized corrosion of a metal or alloy surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of proximity of the metal or alloy to the surface of another material or an adjacent surface of the same metal or alloy. Crevice corrosion is similar to pitting in mechanism.

Crevices in this heat exchanger are limited by the design and fabrication practice. All welding uses butt welds and crevices are limited.

There are no normal chemistry and operating conditions developed for this component. However, prior to reaching DEP-HX-00001, the stream will be adjusted for compliance for transfer to the tank farms and is expected to be within the limits established for Type 316L stainless steel in Table 1-2 of WTP Materials Localized Corrosion Design Limits report, 24590-WTP-RPT-M-11-002.

4 Stress Corrosion Cracking Analysis

Stress corrosion cracking (SCC) is the cracking of a material produced by the combined action of corrosion and sustained tensile stress (residual or applied). 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; also, chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. With the expected conditions, Type 316L stainless steel is acceptable.

There are no normal chemistry and operating conditions developed for this component. However, prior to reaching DEP-HX-00001, the stream will be adjusted for compliance for transfer to the tank farms and is expected to be within the limits established for Type 316L stainless steel in Table 1-2 of WTP Materials Localized Corrosion Design Limits report, 24590-WTP-RPT-M-11-002.

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5 End Grain Corrosion Analysis

End grain corrosion is preferential corrosion which occurs along the cold working direction of wrought stainless steels exposed to highly oxidizing acidic conditions. The ends of the stainless steel plates are not exposed to fluids, and temperatures are lower than what would be necessary for accelerated end grain attack; therefore, end grain corrosion is not a concern.

6 Weld Corrosion Analysis

The welds used in the fabrication will follow the WTP specifications and standards for quality workmanship. The materials selected for this fabrication are compatible with the weld filler metals and ASME/AWS practice. Using the welding practices specified for the project, there should not be gross micro-segregation, precipitation of secondary phases, formation of unmixed zones, or volatilization of the alloying elements that could lead to localized corrosion of the weld. If correct weld procedures are followed, no preferential corrosion of weld beads or heat-affected zones occurs in the expected aqueous chemistry and ambient temperature.

A plate and frame heat exchanger has no welds exposed to the process or cooling stream other than those used to connect pipe.

7 Microbiologically Influenced Corrosion Analysis

Microbiologically influenced corrosion (MIC) refers to corrosion affected by the presence or activity, or both, of microorganisms. Microbes are likely in this system, and the proposed operating conditions are suitable for microbial growth. Therefore, chemical treatment of the cooling water will be required. The occurrence of MIC is more likely during long periods lay-up or when the heat exchanger is idle. Dry lay-up is recommended to prevent MIC. With proper control and trending of conditions that minimize growth, MIC is expected to be negligible.

8 Fatigue/Corrosion Fatigue Analysis

Fatigue is the process of progressive localized permanent structural change occurring in a material subjected to fluctuating stresses at less than the ultimate tensile strength of the material. Corrosion fatigue is the process wherein a metal fractures prematurely under conditions of simultaneous corrosion and repeated cyclic loading at lower stress levels or fewer cycles than would be required to cause fatigue of that metal in the absence of the corrosive environment. Corrosion fatigue is not an issue because the number of thermal and loading cycles for the operation window is limited and low (24590-BOF-MVC-M80T-00001, *DFLAW EMF Vessel Cyclic Datasheet Inputs And Fatigue Evaluation*).

9 Vapor Phase Corrosion Analysis

Conditions in the vapor phase and at the vapor/liquid interface can be significantly different than those present in the liquid phase. The vapor space corrosion rates are less than the immersed surfaces and the transport away from the surface will be less because of the no-flow conditions. As compared to the corrosion in the immersion section, the corrosion rates in the vapor space are much lower. Vapor phase corrosion is not a concern.

10 Erosion Analysis

Erosion is the progressive loss of material from a solid surface resulting from mechanical interaction between that surface and a fluid, a multi-component fluid, or solid particles carried with the fluid. Velocities within the heat exchanger are expected to be below 12 ft/s. The solids content is reported as 0 wt%. Erosion allowance of 0.004 inch for Type 316L stainless steel components with solids content less than 2 wt% at velocities below 12 ft/s is based on 24590-WTP-M0C-50-00004, *Wear Allowance for WTP Waste Slurry Systems*.

11 Galling of Moving Surfaces Analysis

Where two metals are moving in contact with each other without lubrication, there is a risk of damage to their surfaces. No moving unlubricated surfaces are present within these components; therefore, galling is not a concern.

12 Fretting/Wear Analysis

Fretting corrosion refers to corrosion damage caused by a slight oscillatory slip between two surfaces. It is similar to galling but at a much smaller movement, the corrosion products and metal debris break off and act as an abrasive between the surfaces, producing a classic three-body wear problem. This damage is induced under load and repeated relative surface motion. Conditions which lead to fretting are not present in these heat exchangers; therefore, fretting is not a concern.

13 Galvanic Corrosion Analysis

Galvanic corrosion is accelerated corrosion caused by the potential difference between the two dissimilar metals in an electrolyte. One material becomes the anode and the other the cathode. Corrosion occurs on the anode material at the interface where the potential gradient is the greatest. A potential difference of more than 200 mV is needed for a sufficient driving force to initiate galvanic corrosion. The potential difference for any combination of alloys used in this component in the presence of an electrolyte is not sufficient for galvanic currents to overcome the passive protective film. For such alloys, there is negligible potential difference so galvanic corrosion is not a concern.

14 Cavitation Analysis

Cavitation is the formation and rapid collapse of cavities or bubbles of vapor or gas within a liquid resulting from mechanical or hydrodynamic forces. Cavitation is typically associated with pumps and orifice plates and is not a concern.

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15 Creep Analysis

Creep is time-dependent strain occurring under stress and is described as plastic flow, yielding at stresses less than the yield strength. Creep is only experienced in plants operating at high temperatures. Temperatures much greater than one half the absolute melting temperature of the alloy are necessary for thermally activated creep to become a concern. In this case, the operating and design temperatures are too low to lead to creep; therefore, creep is not a concern.

16 Inadvertent Nitric Acid Addition

At this time, the design does not provide for the regular use of nitric acid reagent in this system. Addition of nitric acid into the system would require operator intervention to complete the routing. Nitric acid is a known inhibitor solution for austenitic stainless steels. The presence of nitric acid is not a concern for the stainless steel; especially at the operating temperatures listed.

17 Conclusion and Justification

The conclusion of this evaluation is that the plates for DEP-HX-00001 can be fabricated from a 300 series stainless steel. With maintenance and water chemistry control, the heat exchanger is capable of providing service for the design life of 40 years (excluding replaceable elements). Based on the expected operating conditions, a 300 series stainless steel is expected to be satisfactorily resistant to uniform and localized corrosion. The plates are designed with 0.0 inch corrosion allowance to enhance heat transfer. Should localized corrosion cause leakage, then the plate can be replaced. The margin in the erosion and corrosion allowances used above is contained in the referenced calculation.

The localized corrosion margin is based on comparison of the expected process conditions against the limits for Type 316L documented in 24590-WTP-RPT-M-11-002. The heat exchanger contents are within the applicable limits. No localized erosion allowance is necessary for these components.

18 Margin

The plate and frame heat exchanger is designed for heat transfer and, consequently, does not include an allowance for corrosion. The Type 316L stainless steel offers sufficient corrosion resistance. Providing the water chemistry is controlled and routine maintenance is performed, then the heat exchanger is expected to provide 40 years of service. Fouling by silt, corrosion products, and biofilms is the more common reason for disassembly and cleaning.

The maximum operating parameters for this component are bounded by the materials localized corrosion design limits documented in the WTP Materials Localized Corrosion Design Limits report. The difference between the design limits and the operating maximums is the localized corrosion design margin and, based on the operating conditions, is sufficient to expect a 40 year operating life. The Evaporator Concentrate/Feed LAW Effluent Cooler, DEP-HX-00001, is protected from localized corrosion (pitting, crevice, and stress corrosion) by operating within the acceptable range of the design limits. Operational and process restriction will be used to ensure the limits are maintained.

MATERIALS LOCALIZED CORROSION DESIGN LIMITS – Type 316L

	Temperature (°F)	pH	Chloride (molar)	Hydroxide (molar)	Cl^-/OH^- (molar)
DESIGN LIMIT	**150 max**	**≥ 10**			**≤ 2**
Effluent Transfer to Tank Farms (DEP13e)	95	12.76	0.11	0.058	1.8

	Temperature (°F)	pH	Chloride (molar)	Hydroxide (molar)	Cl^-/OH^- (molar)
DESIGN LIMIT	**150 max**	**≥ 10**			**≤ 2**
Combined Transfer (DEP13e)	157[1]	12.76[2]	0.11	0.058	1.8

Note 1: Temperature of 157 °F taken from the PCDS inlet stream is based on maximum temperature of upstream vessel. However, this is a worst-case temperature including margin and conservatisms intended to be used for sizing the heater exchanger and not intended for material selection purposes. The actual temperature of the stream upon reaching the heat exchanger will never reach that maximum. Further, immediate cooling of the stream upon entering the heat exchanger will also ensure that the stream is within the temperature limits for Type 316L. Per 24590-BOF-M4C-V11T-00006, the high temperature of the transfer from DEP-VSL-00002 is reported as 103 °F.

Note 2: The pH for the inlet stream is shown on the PCDS as TBD because chemical adjustments will be made in the upstream vessel or in the line as necessary to ensure compliance with the transfer waste acceptance criteria. However, as there is no modification to the pH between the entry and exit of the heat exchanger, it can be assumed that the pH provided for the effluent transfer to the tank farms can be used for the inlet stream as well.

Inlet vessels to DEP-HX-00001 based on 24590-BOF-RPT-PR-15-001, Section 4.9, and Figure 10.

References sources for this table:

1. Design limits - 24590-WTP-RPT-M-11-002, *WTP Materials Localized Corrosion Design Limits*
2. Inlet stream temperature - 24590-BOF-M4C-V11T-00006, *Calculation of Process Stream Properties for The Effluent Management Facility.*

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19 References:

1. 24590-BOF-3ZD-25-00001, *WTP Direct Feed Low Activity Waste (DFLAW) Facility and System Design Descriptions.*
2. 24590-BOF-M4C-V11T-00006, *Calculation of Process Stream Properties For The Effluent Management Facility.*
3. 24590-BOF-MEC-DEP-00002, *DFLAW EMF (DEP) Heat Exchanger DEP-HX-00001 Heat Duty.*
4. 24590-BOF-MEC-PCW-00001, *EMF Heat Exchanger PCW-HX-00025 Sizing.*
5. 24590-BOF-MVC-M80T-00001, *DFLAW EMF Vessel Cyclic Datasheet Inputs and Fatigue Evaluation.*
6. 24590-BOF-P1-25-00001, *Balance of Facilities LAW Effluent Process Bldg & LAW Effluent Drain Tank Bldg General Arrangement Plan at Elev 0 ft - 0 in.*
7. 24590-BOF-RPT-PR-15-001, *Direct Feed LAW Process Corrosion Data.*
8. 24590-WTP-GPG-M-047, *Preparation of Corrosion Evaluations.*
9. 24590-WTP-ICD-MG-01-031, *ICD 31 - Interface Control Document for DFLAW Effluent Returns to Double-Shell Tanks.*
10. 24590-WTP-M0C-50-00004, *Wear Allowance for WTP Waste Slurry Systems with ECCN 24590-WTP-M0E-50-00012.*
11. 24590-WTP-RPT-M-11-002, *WTP Vessel Localized Corrosion Limit Analysis Report.*
12. CCN 297811, email, SR Crow (WTP) to RB Davis and others (WTP), *Corrosion Evaluation Temperature for DEP-HX-00001.* 24 October 2017.
13. Dillon, CP (Nickel Development Institute), Personal Communication to J R Divine (ChemMet, Ltd., PC), 3 Feb 2000.

Additional Reading

- 24590-BOF-M6-DEP-00002006, *P&ID - BOF/EMF Direct Feed LAW EMF - Process System Evaporator Concentrate / Feed Vessels - LAW Effluent Cooler DEP-HX-00001.*
- 24590-BOF-MED-DEP-00001, *24590-BOF-ME-DEP-HX-00001 - Evaporator Concentrate/Feed LAW Effluent Cooler.*
- 24590-WTP-RPT-M-04-0008, *Evaluation of Stainless Steel and Nickel Alloy Wear Rates In WTP Waste Streams At Low Velocities.*
- Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158.
- Davis, JR (Ed), 1987, *Corrosion, Vol 13*, In "Metals Handbook", ASM International, Metals Park, OH 44073
- Davis, JR (Ed), 1994, *Stainless Steels*, In ASM Metals Handbook, ASM International, Metals Park, OH 44073.
- Hamner, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX 77218.
- Jones, RH (Ed.), 1992, *Stress-Corrosion Cracking*, ASM International, Metals Park, OH 44073.
- Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
- Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158
- Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084.

CORROSION EVALUATION

PROCESS CORROSION DATA SHEET (extract)

Component(s) (Name/ID #) **Evap Concentrate/Feed LAW Effluent Cooler (DEP-HX-00001)**

Facility **EMF**

In Black Cell? **NO**

Chemicals	Unit	Stream ID DEP13e AQUEOUS
Cations (ppm)		
Al^{+3} (Aluminum)	ppm	115
Fe^{+3} (Iron)	ppm	124
Hg^{+2} (Mercury)	ppm	0
Pb^{+2} (Lead)	ppm	6
Anions (ppm)		
Cl^- (Chloride)	ppm	3767
CO_3^{-2} (Carbonate)	ppm	1212
F^- (Fluoride)	ppm	6361
NO_2^- (Nitrite)	ppm	80732
NO_3^- (Nitrate)	ppm	170
PO_4^{-3} (Phosphate)	ppm	17
SO_4^{-2} (Sulfate)	ppm	707
$OH(aq)^-$	ppm	904
$OH(s)^-$	ppm	32
pH		12.76
Suspended Solids	wt%	TBD
Temperature	°F	95
Liquid Density*	lb/ft3	68.6

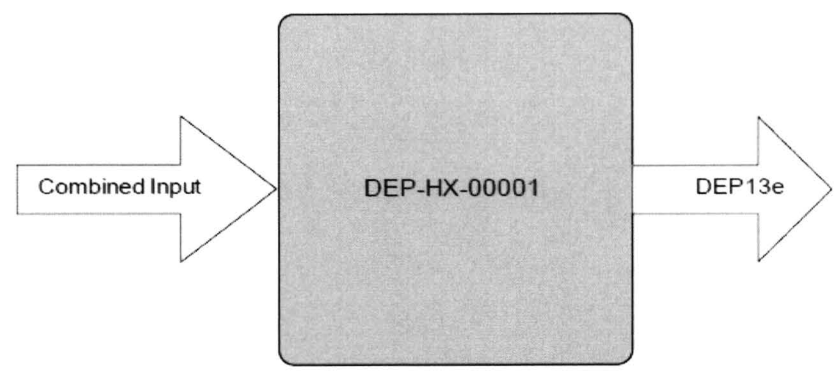
Values marked as "TBD" will be provided in later revision.

24590-BOF-RPT-PR-15-001, Rev 1
Direct Feed LAW Process Corrosion Data

Figure A-10 DEP-HX-00001 Aqueous PCDS

	Combined Input	DEP13e
Maximum Properties		
Suspended Solids [wt %]	TBD	TBD
Total Salts [wt %]	TBD	TBD
Sodium Molarity [M]	TBD	TBD
Relative Humidity [%]	n/a	n/a
pH	TBD	12.76 (4)
Anti-Foam Agent [ppm]	TBD	TBD
TOC [lbm/hr]	TBD	TBD
Pressure [psig]	TBD	TBD
Temperature [C]	69 (3)	35 (2)
Temperature [F]	157 (3)	95 (2)
Water Flow Rate [lbm/hr]	TBD	TBD
Total Aqueous Flow Rate [lbm/hr]	TBD	TBD
Total Flow Rate [lbm/hr]	TBD	TBD
UserNote	VIT LIQUID DFLAW waste returns to Tank Farms	VIT LIQUID DFLAW waste returns to Tank Farms

	Combined Input	DEP13e
	Aqueous concentration, ppm (mg/kg)	
Cations		
Ag+	0	0
Al+3	115	115
Am+3	0	0
As+5	0	0
B+3	399	399
Ba+2	0	0
Be+2	0	0
Bi+3	0	0
Ca+2	106	106
Cd+2	0	0
Ce+4	1	1
Co+2	0	0
Cr+3	13	13
Cr+6	54	54
Cs+	0	0
Cu+2	0	0
Eu+3	0	0
Fe+2	0	0
Fe+3	124	124
H+	0	0
Hg+2	0	0
K+	95	95
La+3	0	0
Li+	326	326
Mg+2	5	5
Mn+4	1	1
Mo+6	0	0
Na+	49833	49833
Nd+3	0	0
Ni+2	2	2
Pb+2	6	6
Pd+2	0	0
Pr+4	0	0
Pu+4	0	0
Ra+2	0	0
Rb+	0	0
Rh+3	0	0
Ru+4	0	0
Sb+3	0	0
Se+4	2	2
Si+4	203	203
Sr+2	0	0
Ta+5	0	0
Tc+4	0	0
Te+4	0	0
Th+4	0	0
Ti+4	44	44
Tl+5	1	1
U+4	0	0
V+3	0	0
W+6	0	0
Y+3	0	0
Zn+2	139	139
Zr+4	8	8
Anions		
B(OH)4-	31	31
C2O4-2	5	5
Cl-	3767	3767
CN-	0	0
CO3-2	1212	1212
F-	6361	6361
H2PO4-	59	59
H2SiO4-2	524	524
H3SiO4-	393	393
HCO3-	0	0
HPO4-2	10	10
HSO3-	176	176
HSO4-	589	589
I-	0	0
IO3-	0	0
NH4+	53	53
NO2-	80732	80732
NO3-	170	170
O-2	1568	1568
O2-2	0	0
OH(aq)-	904	904
OH(s)-	32	32
PO4-3	17	17
SO3-2	260	260
SO4-2	707	707
Organics		
AFA_DCMP	5	5
AFA_NVOC	0	0
NVOC	63	63
Sucrose	0	0
SVOC	68	68
VOC	1	1



Notes:
(1) Values marked as "TBD" will be provided in the revision to 24590-BOF-M4C-V11T-00004 (Ref. 5.1.4(2)) based on APPS model runs for corrosion.
(2) Maximum outlet temperature per 24590-WTP-ICD-MG-01-031 (Ref. 5.1.1(7),Table 4).
(3) Maximum inlet temperature per 24590-BOF-MEC-DEP-00002 (Ref. 5.1.4(13), Table 8-1).
(4) pH of governing stream calculated as described in Section 3.2.2 based on composite stream concentrations. The pH calculation use: stream data from the worksheet "DFLAW_High Cl-F - Leach" in "DEPHX1_PCDS_Support.xlsx" (Ref. 5.1.4(10)).

4.9 Evap Concentrate/Feed LAW Effluent Cooler (DEP-HX-00001)

4.9.1 Description of Equipment

The Evap Concentrate/Feed LAW Effluent Cooler (DEP-HX-00001) is a heat exchanger that is used to cool the waste that will be returned to the Tank Farms during off-normal operating conditions.

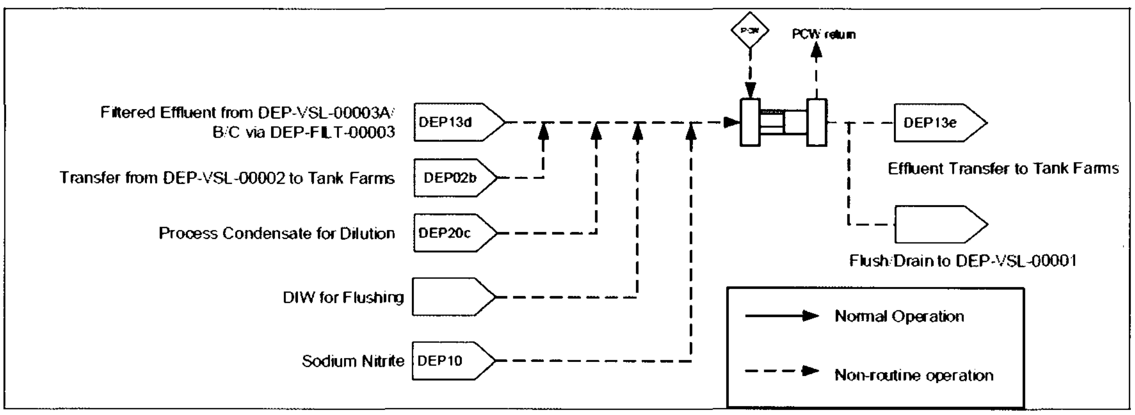
Waste can be returned to the tank farms from either DEP-VSL-00002 or DEP-VSL-00003A/B/C (Ref. 5.1.3(3)). Process condensate from DEP-VSL-00005A/B can be used to dilute these waste streams, as needed. Waste from DEP-VSL-00003A/B/C is routed through DEP-FILT-00003 to remove solids before passing through DEP-HX-00001.

Under an off-normal operating condition where a waste stream is transferred back to the Tank Farms, DEP-HX-00001 is used to cool the stream so that it is below the temperature limit for waste acceptance at the Tank Farms. A temperature limit of 95°F is established for waste returned to the tank farms from the EMF according to ICD 31 (Ref. 5.1.1(7), Table 4).

In the event that waste is returned to the tank farm, the waste must be chemically treated to meet waste acceptance criteria for corrosion mitigation. ICD 31 establishes the specific chemical treatment requirements for corrosion mitigation (Ref. 5.1.1(7), Table 4). The DEP system will be designed to allow the addition of these corrosion mitigation chemicals, currently planned to be sodium hydroxide and sodium nitrite. Sodium hydroxide additions will occur in the vessel (DEP-VSL-00002 or DEP-VSL-00003A/B/C). Additions of sodium nitrite and process condensate from DEP-VSL-00005 or DIW will occur in line prior to DEP-HX-00001.

Figure 10 is a sketch of the input and output arrangement of streams for DEP-HX-00001.

Figure 10 – DEP-HX-00001 Sketch



4.9.2 System Functions

The process functions of DEP-HX-00001 are as follows:

- Cool effluent return streams

The equipment performs additional system functions beyond the process functions, but these additional functions are beyond the scope of this document. These functions are not discussed any further in this document, however are listed below for completeness.

- Confine hazardous materials
- Sample return stream
- Report system conditions

4.9.3 Description of Process Functions

4.9.3.1 Cool Effluent Return Streams

The following streams taken from PFD 24590-BOF-M5-V17T-00013 (Ref. 5.1.3(3)) and P&IDs 24590-BOF-M6-DEP-00002005 (Ref. 5.1.3(11)) and 24590-BOF-M6-DEP-00002006 (Ref. 5.1.3(12)) are inputs/outputs to DEP-HX-00001.

Inputs
- DEP13d - Filtered Effluent from DEP-VSL-00003A/B/C via DEP-FILT-00003
- DEP02b - Transfer from DEP-VSL-00002 to Tank Farms
- DEP20c – Process Condensate for Dilution
- DEP10 – Sodium Nitrite
- DIW for Flushing
- Process Cooling Water Supply

Outputs
- DEP13e - Effluent Transfer to Tank Farms
- Drain to DEP-VSL-00001
- Process Cooling Water Return

4.9.3.1.1 Effluent Return Streams Entering DEP-HX-00001

Filtered effluent from DEP-VSL-00003A/B/C (DEP13d) and transfers from DEP-VSL-00002 (DEP02b) are passed through DEP-HX-00001 before returning to the Tank Farms. Sodium nitrite (DEP10) can be added prior to DEP-HX-00001 as described in Section 4.9.3.1.2. Process condensate (DEP20c) can be used to dilute these waste streams as needed. Also, DIW is used to flush the transfer line following a transfer (Ref. 5.1.1(7), Section 2.6.2).

4.9.3.1.2 DEP10 – Sodium Nitrite

Sodium nitrite can be added via inline mixing to the effluent return stream prior to DEP-HX-00001. 40wt% $NaNO_2$ is supplied from SNR-TK-00002. The sodium nitrite is added as a corrosion inhibitor in accordance with the chemical treatment requirements in ICD 31 (Ref. 5.1.1(7), Table 4).

4.9.3.1.3 Plant Cooling Water Supply from PCW System

Plant cooling water is supplied to DEP-HX-00001. PCW is a utility and will not be addressed in this report. See Section 2.3.2 for further details.

4.9.3.1.1 DEP13d - Effluent Transfer to Tank Farms

The stream leaving DEP-HX-00001 is transferred to the Tank Farms. The conditions for this stream are the same as the stream entering DEP-HX-00001 (Section 4.9.3.1.1) except with the maximum temperature limited to 95°F in accordance with ICD 31 (Ref. 5.1.1(7), Table 4).

4.9.3.1.2 Flush/Drain to DEP-VSL-00001

DEP-HX-00001 can be flushed and drained to DEP-VSL-00001.

This is a non-routine process that is not included in the APPS model and is not discussed further in this document.

4.9.3.1.3 Plant Cooling Water Return

Plant cooling water is returned from DEP-HX-00001. PCW is a utility and will not be addressed in this report. See Section 2.3.2 for further details.

4.9.4 Process Modes

4.9.4.1 Normal Operations

There are no normal operations for DEP-HX-00001.

4.9.4.2 Infrequent Operations

Based on the assessment of streams frequently transferred in and out of the DEP-HX-00001, the following infrequent processing modes are considered:

<u>Inputs</u>

- DEP13d - Filtered Effluent from DEP-VSL-00003A/B/C via DEP-FILT-00003
- DEP02b - Transfer from DEP-VSL-00002 to Tank Farms
- DEP20c - Process Condensate for Dilution
- DEP10 – Sodium Nitrite
- DIW for Flushing
- Process Cooling Water Supply

<u>Outputs</u>

- DEP13e - Effluent Transfer to Tank Farms
- Flush/Drain to DEP-VSL-00001
- Process Cooling Water Return

4.9.5 Summary of Processing Conditions for DEP-HX-00001

4.9.5.1 Normal Operations

There are no normal operations for DEP-HX-00001.

4.9.5.2 Infrequent Operations

Values of properties (Na molarity, Temperature, UDS%) normally provided in summary of process condition tables can be found in the PCDS for DEP-HX-00001 (Figure A-10, pg. A-13).