# CORROSION EVALUATION

**DVP-EXHR-00001A/B**  
Process Ventilation Exhauster

Contents of this document are Dangerous Waste Permit affecting

## Results

**Materials Considered:**

<table>
<thead>
<tr>
<th>Material (UNS No.)</th>
<th>Acceptable Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 304L (S30403)</td>
<td></td>
</tr>
<tr>
<td>Type 316L (S31603)</td>
<td></td>
</tr>
<tr>
<td>Al-6XN® 6% Mo (N08367)</td>
<td>X</td>
</tr>
<tr>
<td>Hastelloy® C-22® (N06022)</td>
<td></td>
</tr>
</tbody>
</table>

**Recommended Material Types:**  
- Housing - Type 316 (max 0.030% C; dual certified)
- Shaft - Type 316 (max 0.030% C; dual certified)

**Minimum Corrosion Allowance:** 0.0 inch

## Inputs and References

- Inlet temperature (°F) (norm/max): 124/180 (24590-BOF-M6C-DEP-00009)
- Discharge temperature (°F) (norm/max): 124/180 (24590-BOF-M6C-DEP-00009)
- Corrosion allowance: 0.0 inch (24590-WTP-GPG-M-047)
- Location: Room E-0102, (24590-BOF-P1-25-00001)
  - Operating conditions are as stated in the applicable section of (24590-BOF-RPT-PR-15-001)

## Assumptions and Justification

- Operating conditions presented on the Process Corrosion Datasheet (PCDS) are conservative with respect to corrosion.
- Cyclic data is not provided in 24590-BOF-MVC-M80T-00001, *DFLAW EMF Vessel Cyclic Datasheet Inputs and Fatigue Evaluation*, calculation. Based on the system configuration, the values for DVP-HEPA-00004A/B are considered representative of the exhausters.

## Operating Restrictions

- Develop a procedure for periodic, routine condition inspection assessments of the exhauster (both fan and motor assembly) for corrosion degradation from condensation, corrosion products, or debris as part of the Reliability Centered Maintenance program.
- Develop procedure to control lay-up and storage; preventing condensation during commissioning, startup and during inactive periods when the plant is operational.
- Procedures are to be reviewed and accepted by MET prior to use.

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*Some information on all pages may appear to be illegible, however, the information necessary for assuring adequate design is legible.*

<table>
<thead>
<tr>
<th>1</th>
<th>3/29/18</th>
<th>Revised sect 17 to discuss DFLAW PIBOD properties</th>
<th>DLAdler</th>
<th>SWVail</th>
<th>RBDavis</th>
<th>Terwin</th>
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<tr>
<td>0</td>
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<td>Initial Issue</td>
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<td>APRangus</td>
<td>RBDavis</td>
<td>Terwin</td>
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<td>DATE</td>
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<td>ORIGINATE</td>
<td>CHECK</td>
<td>REVIEW</td>
<td>APPROVE</td>
</tr>
</tbody>
</table>

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Please note that source, special nuclear and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at the U.S. Department 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.
The DFLAW EMF Vessel Vent Process System (DVP) receives the vessel vent streams from each of the EMF process vessels. The vessel vent streams are combined in a vent header and then sent through the ventilation system. The ventilation system consists of two identical train, with one in service and one as backup. Each train has a preheater (DVP-HTR-00001A/B), two-stage high efficiency particulate air (HEPA) filters (DVP-HEPA-00003A/B and -00004A/B), and a fan (DVP-EXHR-00001A/B). The ventilation stream is then exhausted to the atmosphere via a stack.

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 typically 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

Standard exhauster/blowers can be fabricated with a manufactured (cut and welded) housing or cast housing. The materials as allowed by design code can be either carbon steel or stainless steel; although corrosion and erosion resistant alloys are required unless there is sufficient bulk to the carbon steel material to ensure integrity while corroding at a high rate. The required corrosion allowance should be adjusted depending on the material selected; carbon steel or corrosion resistant steel.

Carbon steel or low alloy steel does not have sufficient corrosion resistance in reported environment. Depending on how the attachments are made, the inlet and outlet material should match either the piping or the housing where the weld is made. The reported operating conditions suggest that Type 316L is acceptable for the housing.

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. Pitting corrosion will only be a concern if moisture is present during normal operation. Shut-down and heat-up thermal transients will likely condense vapors on the cold surfaces. Measures should be taken to prevent the potential formation of condensation in the exhauster while offline. Locations at crevices, at dead-legs, at low points, and under deposits will host conditions that support corrosion. The constituents in the vapor phase can be aggressive in oxidizing environments, when mixed with aqueous condensate, towards carbon steel and Type 304L stainless steel. Therefore, a material with a higher pitting corrosion resistance than Type 304L is necessary. Type 316L stainless steel, or better, is recommended for this application.

At the stated operating conditions, localized corrosion is not a major concern; corrosion will not proceed without sufficient electrolyte present. Type 316L is recommended.

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 close 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. Crevice corrosion will only be a concern if sufficient moisture is present. The ventilation stream humidity is controlled by the preheater upstream so condensation is controlled.

At the stated operating conditions, localized corrosion is not a major concern. Type 316L is recommended. Justification for this position begins with the understanding that this is an air handling unit operating at elevated temperatures, above the dew point. Corrosion will not take place or initiate when insufficient electrolyte is present.

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). In addition, sensitization of the grain boundaries is prevented with the materials recommended. The "L" grade (low carbon) stainless steel specified tends to negate sensitization from becoming a corrosion issue. It is assumed that condensation in the unit will be prevented; therefore, the exhauster will not undergo stress corrosion cracking because insufficient electrolyte will be present.

5 End Grain Corrosion Analysis

End grain corrosion is preferential aqueous corrosion that occurs along the worked direction of wrought stainless steels exposed to highly oxidizing acid conditions. End grain corrosion typically is not a major concern; it propagates along the rolling direction of the plate, not necessarily through the cross-sectional thickness. In addition, end grain corrosion is exclusive to metallic product forms with exposed end grains from shearing or mechanical cutting. Such conditions are not present in this component.

End grain corrosion is not expected to occur in the exhausters because corrosion will not occur in the absence of sufficient electrolyte.
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.

Corrosion at welds is not expected to occur in the exhausters because corrosion will not occur in the absence of sufficient electrolyte.

7 Microbiologically Influenced Corrosion Analysis

Microbiologically influenced corrosion (MIC) refers to corrosion affected by the presence or activity, or both, of microorganisms. In this system, the stated operating conditions are not suitable for microbial growth. The exhausters will operate at elevated temperatures and the presence of condensation is unlikely.

8 Fatigue/Corrosion Fatigue Analysis

Corrosion-fatigue is the result of the combined action of high cyclic stresses and a corrosive environment. Rotating equipment is designed for normal operating loads as well as a limited number of stops and starts. For rotating equipment operated with high cyclic stresses (on/off loads) or random equipment loads due to imbalance, the fatigue process is thought to cause localized rupture of the protective passive film, which could allow stainless steel to experience anodic dissolution until repassivation. Multiple initiation sites are common when corrosion is involved, and the cracking that follows tends to be transgranular and branched. Distortions due to local yielding may increase vibrational loads, acting to shorten the component life.

Corrosion fatigue will not be a problem due to the low mechanical and thermal cycling, as well as the lack of sufficient electrolyte for corrosion.

9 Vapor Phase Corrosion Analysis

Vapor phase corrosion considers the gas and vapor constituents that form acidic condensate and the alloy corrosion resistance. The aggressive constituents are HCl, HF, and HNO3; however, these are present in low concentrations in the gas. The upstream equipment removes acid gas-forming constituents; therefore, vapor phase corrosion is negligible. The formation of acidic condensate requires moisture condensing on the surface and mixing with the adsorbed surface constituents to produce an aggressive environment. Condensation on the surface is not likely during normal operation.

Vapor phase corrosion will not occur in the exhauster because the maximum operation conditions for this component preclude the presence of sufficient electrolyte and concentrations of acid gas forming components.

10 Erosion Analysis

Erosion is the progressive loss of material from a surface resulting from mechanical interaction between a particle and that surface. Solid particle erosion can occur in air, steam, and water fluid systems. When the fluid propels the solid particles at a sufficient velocity and the particle mass is sufficient, the surface can be damaged by the combined effect of millions of individual erosion "scars". The conditions expected for this component are not severe. Prior to reaching the exhausters, the offgas passes through a high efficiency particulate filter (HEPA) so should be free of particulates, and the flow through the exhauster is relatively low. The impingement erosion is not likely when there are very low particulates and moisture in the gas stream.

No erosion is expected so no general erosion allowance is necessary.

11 Galling of Moving Surfaces Analysis

Galling is a form of wear caused by a combination of friction and adhesion between moving surfaces. Under high compressive forces and movement, the friction temperatures cold-weld the two surfaces together at the surface asperities. As the adhesively bonded surface moves some of the bonded material breaks away. Microscopic examination of the galled surface shows some material stuck or even friction welded to the adjacent surface, while the softer of the two surfaces appears gouged with balled-up or torn lumps of material stuck to its surface.

The corrosion evaluation is specific to the process fluid and the inside components of the exhauster. Although the rotating shaft will have a bearing set, the set should be on the outside of the seals. Inside the exhauster, the metallic surfaces will not contact and therefore galling is not possible.

Conditions which lead to galling are not present in this component, 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. 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, classic 3-body wear problem. This damage is induced under load and repeated relative surface motion, as induced for example by vibration. Pits or grooves and oxide debris characterize this damage, typically found in machinery, bolted assemblies and ball or roller bearings. Contact surfaces exposed to vibration during transportation are exposed to the risk of fretting corrosion.
CORROSION EVALUATION

The corrosion evaluation is specific to the process fluid and the inside components of the exhauster. Although the rotating shaft will have a bearing set, the set should be on the outside of the seals. Inside the exhauster, the metallic surfaces will not contact and therefore fretting wear is not possible.

Conditions which lead to fretting are not present in this component; therefore, fretting is not a concern.

13 Galvanic Corrosion

Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially to another when both metals are in electrical contact, in the presence of an electrolyte. Dissimilar metals and alloys have different electrode potentials, and when two are in contact in an electrolyte, one metal acts as anode and the other as cathode. The electropotential difference between the dissimilar metals is the driving force for an accelerated attack. A potential difference of more than 200 mv is needed for sufficient driving force. Galvanic compatibility is one of the attributes used to select the WTP alloys. Austenitic stainless steels in contact with other austenitic stainless steels do not have sufficient electropotential difference to significantly influence the metal loss.

No sufficiently dissimilar metals are present. The gas is dry and contains insufficient moisture to act as an electrolyte. Galvanic corrosion is not expected to be a corrosion issue under these conditions.

14 Cavitation

Cavitation corrosion is defined as another synergistic process, the combined influence of mechanical disruption of the metal surface and the corrosion of the active metal. Cavitation occurs when the local fluid pressure drops below the vapor pressure of the fluid resulting in a liquid vapor interface or bubbles to form. Their collapse on the metal surface has sufficient energy to rupture the oxide film and depending on alloy, may be capable of removing metal. The fluid chemistry and alloy define corrosion characteristics of the oxide film; where localization of the cavitation produces a condition where the bubble collapse rate is greater than the ability to passivate, the normally passive alloy can experience accelerated loss. This is most likely to occur in pumps, valves (flow control), orifices, ejectors/eductors, and nozzles. Cavitation is not expected in an ventilation system.

15 Creep

Creep is defined as a time-dependent deformation at elevated temperature and constant stress, creep is a thermally activated process. The temperature at which creep begins depends on the alloy composition. Creep failures and stress rupture failures follow the same mechanism and are influenced by similar variables like temperature. Stress rupture is defined as bi-axial creep restricted to pipe like geometries. Creep is found in components subjected to heat for long periods, and the creep rate generally increases as the temperature nears the melting point. At 180 °F, the maximum operating temperature for the exhausters is far too low to experience creep; therefore, creep is not a concern.

16 Inadvertent Addition of Nitric Acid

Inadvertent introduction of nitric acid into the ventilation system is not a plausible scenario. Nitric acid and decontamination agents may be used over short durations. Procedures will be used to control exposures and corrosion loss.

17 Conclusion & Justification

The conclusion of this evaluation is that DVP-EXHR-00001A/B can be fabricated from Type 316 stainless steel and that Type 316 stainless steel is capable of service for the design life. Providing the reported dry-air conditions are maintained, Type 316 stainless steel is expected to be resistant to uniform and localized corrosion. The probable uniform corrosion is negligible, no corrosion allowance is required. Conditions in the exhauster do not promote erosion so no erosion allowance is necessary.

Sections of the issued Process Corrosion Data report (PCDS) (attached to the corrosion evaluation) include several references to the Process Inputs Basis of Design (PIBOD) for LAW and EMF, 24590-WTP-DB-PET-17-001 which was not issued at the time the PCDS was issued. The PIBOD for LAW and EMF has been issued. Any variance in the values between the PIBOD and PCDS associated with streams and stream characteristics used to evaluate corrosion and erosion have been reviewed and evaluated. The evaluation concluded that the analysis described in this corrosion evaluation was bounding and the material selection recommendations remain as initially issued.

Based on preliminary Vendor data, the PIBOD shows a normal operating range of 243 to 246 °F, with a resulting relative humidity of 2%. The PIBOD conditions have been evaluated from a materials perspective. The material selection recommendation is unchanged.

18 Margin

Per 24590-WTP-SRD-ESH-01-001-02, Appendix H "When erosion and corrosion effects can be shown to be negligible or entirely absent, a design corrosion allowance need not be specified." Localized corrosion or erosion of this component is not expected. Prior to reaching the exhausters, the ventilation stream passes through a high efficiency particulate filter (HEPA) and, therefore, should be free of particulates.

The solids content and gas velocity are sufficiently low that localized erosion is not a concern. Since localized erosion effects are not present, additional localized erosion protection is not required. In the reported dry-air conditions, there is insufficient electrolyte to drive corrosion. No corrosion and therefore no corrosion allowance is necessary. The exhauster requires routine maintenance and can be replaced. Based on the range of inputs, system knowledge, and engineering judgment/experience, there is no margin associated with corrosion or erosion, however, the design margins remain in place.

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CORROSION EVALUATION

19 References

2. 24590-BOF-MVC-M801-00001, DFLAW EMF Vessel Cyclic Datasheet Inputs and Fatigue Evaluation.
3. 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.
5. 24590-WTP-DB-PET-17-001, Process Inputs Basis of Design (PIBOD) for LAW and EMF.
7. 24590-WTP-SRD-ESH-01-001-02, Safety Requirements Document Volume II.

Additional Reading

- Hamner, NE, 1981, Corrosion Data Survey, Metals Section, 5th Ed, NACE International, Houston, TX 77218
- Van Delinder, LS (Ed), 1984, Corrosion Basics, NACE International, Houston, TX 77084
## PROCESS CORROSION DATA SHEET (extract)

Component(s) (Name/ID #) | Process Ventilation Exhauster (DVP-EXHR-00001A/B)
--- | ---
Facility | EMF
In Black Cell? | NO

### Stream ID
- **DEP18**

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<tr>
<th>Chemicals</th>
<th>Unit</th>
<th>GASEOUS</th>
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</tr>
<tr>
<td>SO2</td>
<td>ppmV</td>
<td>0</td>
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</tbody>
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<th>Chemicals</th>
<th>Unit</th>
<th>GASEOUS</th>
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<tr>
<td>RH</td>
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<tr>
<td>Temperature</td>
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</table>
**GENERAL NOTE FOR USE OF PCDS:**

- The information provided by the PCDS report is intended solely for use in support of the vessel material selection process and Corrosion Evaluations. The inputs, assumptions, and computational/engineering models used in generating the results presented herein are specific to this effort. Use of the information presented herein for any other purpose will require separate consideration and analysis to support justification of its use for the desired, alternative purpose.

- The process descriptions in this report cover routine process operations and non-routine (infrequent) process operations, when such exist, that could impact corrosion or erosion of process equipment.

- The data in the non-shaded columns of the PCDSs has NOT been adjusted to comply with the highest expected, vessel-specific operational conditions.

- The process descriptions provided in this report are for general information and reflective of the corrosion engineer's analysis for transparency, the information is current only at the time this document is issued. These process descriptions should not be referenced for design.
4.10 DVP System

4.10.1 Description of Equipment

The DFLAW EMF Vessel Vent Process System (DVP) receives the vessel vent streams from each of the EMF process vessels. The vessel vent streams are combined in a vent header and then sent through the ventilation system. The ventilation system consists of two identical trains, with one in service and one as backup. Each train has a preheater (DVP-HTR-00001A/B), two-stage high efficiency particulate air (HEPA) filters (DVP-HEPA-00003A/B and 00004A/B), and a fan (DVP-EXHR-00001A/B). The ventilation stream is then exhausted to the atmosphere via a stack.

Figure 11 is a sketch of the input and output arrangement of streams for the DVP.

![DVP System Sketch](image)

4.10.2 System Functions

The process functions of the DVP system are as follows:

- Draw air
- Remove particulates
- Exhaust air

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
- Report system conditions

Figure 11 – DVP System Sketch
4.10.3.3 Exhaust Air

The following process stream taken from PFD 24590-BOF-M5-V17T-000013 (Ref. 5.1.3(3)) and P&ID 24590-BOF-M6-DVP-00001001 (Ref. 5.1.3(30)) is the output from the DVP system.

- DEP18 – Exhaust to stack

4.10.3.3.1 DEP18 – Exhaust to stack

DEP18 is the combined exhaust stream for the two ventilation trains after the exhaust fans. The gas is exhausted to the atmosphere through a stack.

**Sodium Molarity**
N/A, this is a gas stream

**Temperature**
The range for temperature in stream DEP18 during normal operations will be established in the LAW/EMF PIBOD. The maximum temperature is equal to 180°F (Ref 5.1.4(9)).

**Solids Concentration**
N/A, this is a gas stream

**Density**
The range for density in stream DEP18 during normal operations will be established in the LAW/EMF PIBOD.

**pH**
N/A, this is a gas stream

**Relative Humidity**
The range for relative humidity in stream DEP18 during normal operations will be established in the LAW/EMF PIBOD.
4.10.4 Process Modes

4.10.4.1 Normal Operations

Based on the assessment of streams frequently transferred in and out of the DVP system, the following normal processing modes are considered:

- DEP15 – Vessel Vent Collection Header
- DEP16 – Vent stream between the preheater and the first stage HEPA filter
- DEP17 – Vent stream between the second stage HEPA filter and the fan
- DEP18 – Exhaust to stack

Section 4.10.5.1 summarizes these processing modes in tabular form.

4.10.4.2 Infrequent Operations

There are no infrequent operations for the EMF process vent system.

4.10.5 Summary of Processing Conditions for the DVP

4.10.5.1 Normal Operations

The following table summarizes the normal processing modes for DVP.

**Table 4-12 - EMF Process Vent System Normal Conditions**

<table>
<thead>
<tr>
<th>Stream Number</th>
<th>Na Molarity (mol/L)</th>
<th>Temperature (°F)</th>
<th>UDS</th>
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