CORROSION EVALUATION

LVP-HTR-00002
Catalytic Oxidizer Electric Heater

Contents of this document are Dangerous Waste Permit affecting

Results

Materials Considered:

Material (UNS No.)	Acceptable Material
Type 304L (S30403)	
Type 316L (S31603)	
Type 347 (S34700)	X (exc. heating elements)
Incoloy® 800/825 (N08800/N08825)	X (heating elements)

Recommended Material Types:

Materials in contact with the offgas are: Type 347 (S34700)
Incoloy® 800/825 (N08800/N08825)

Heating elements will be Incoloy® 800/825 (N08800/N08825)

Minimum Corrosion Allowance: 0.010 inch (surfaces in contact with offgas)
No corrosion allowance required for heating elements.

Inputs and References

- Operating Temperature, inlet (°F): (nom/max): 624/680 (24590-LAW-M4E-LOP-00009)
- Operating Temperature, outlet (°F): (nom/max): 750/750 (24590-LAW-M4E-LOP-00009)
- Corrosion allowance (in contact with offgas, excluding heat transfer surfaces): 0.010 inch (24590-WTP-SRD-ESH-01-001-02)
- Corrosion allowance (heat transfer surfaces): 0.00 inch (24590-WTP-GPG-M-047)
- Location: room L-0304F; out cell (24590-LAW-P1-P01T-00005)
- Operating conditions are as stated in the applicable section of *WTP Process Corrosion Data - Volume 4* (24590-WTP-RPT-PR-04-0001-04)

Assumptions and Justification (refer to Section 19 – References)

- Operating conditions presented on the Process Corrosion Datasheet (PCDS) are conservative with respect to corrosion.[7]

Operating Restrictions

- Develop a procedure for decontamination.
- Develop procedure to control lay-up and storage (mitigation of condensation in accordance with *Manual - Operation, Maintenance And Installation Instructions For LAW Thermal Catalytic Oxidizer / Reducer (TCO) And Ammonia Dilution Skid*,24590-CD-POC-MBT0-00007-05-00004); including both before plant is operational and during inactive periods during plant operation.
- Procedures are to be reviewed and accepted by MET prior to use.

Concurrence _____
Operations

REV	DATE	REASON FOR REVISION	ORIGINATE	CHECK	REVIEW	APPROVE
3	06/25/15	To expand material selection information and references to address ORP and Ecology comments.	DLAdler	TErwin	RBDavis	JLeam
2	12/16/14	Complete re-write; no rev bars shown New format Revised design temperature Revise Ops restrictions Incorporate revised PCDS Update references	DLAdler	JRDivine	RBDavis	TErwin
1	7/18/12	Incorporate revised PCDS Update design pressure AEA Notice	DLAdler	RBDavis	NA	DJWilsey
0	3/13/08	Initial Issue	DLAdler	JRDivine	RBDavis	SWVail

CORROSION EVALUATION

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.

This bound document contains a total of 13 sheets.

CORROSION EVALUATION

Corrosion/Erosion Detailed Discussion

The electric heater is used to supplement the heat recovery exchanger (LVP-HX-00001) primarily during startup and when operating with low NOx concentrations. Once the system is up to temperature, demand on the electric heater will be minimal.

1 General/Uniform Corrosion Analysis

a Background

General corrosion or uniform corrosion is corrosion that is distributed more-or-less 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 usually 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 micro-anodes and cathodes that facilitate the corrosion process.

b Component-Specific Discussion

Offgas corrosion, like atmospheric corrosion, depends on the development of corrosion cells or electrochemical cells consisting of the base metal, corrosion products, deposition products, anode, cathode, electrolyte, and current path. Stainless steels also have the added influence of the protective passive film. Because the corrosion process is electrochemical, an electrolyte must be present on the surface for corrosion to occur. In the absence of moisture, corrosion will not take place. As an example, where temperatures are less than freezing, corrosion is minor because the ice is not a good conductor; or when the relative humidity is low, the water condensation is negligible and corrosion is negligible. Offgas corrosion is also influenced by the deposition of particulates, dust, and thin monolayers of gas constituents. The physically adsorbed molecules on the surface (HCl, HNO_3, and H_2SO_4) will form an acid droplet from the deliquescence of water molecules. Moisture is needed to activate the corrosion process, typically a relative humidity of 60% to 80% is necessary to support corrosion; below this range corrosion does not occur. The relative humidity range for corrosion is discussed in Coburn (1978), Dean and Lee (1986), Dean and Rhea (1980), Schweitzer (1988), and in the *ASM Metals Handbook, Volume 13*. Normal operating conditions for the components of the thermal catalytic oxidizer (TCO) skid are dry, and relatively humidity is very low (0.04% relative humidity, as shown in the PCDS). The anticipated dry-air conditions are not conducive to general corrosion and none is expected. Further, operating restrictions are in place to ensure that dry-air conditions are maintained.

The stabilized austenitic Type 347 stainless steel is suitable for the offgas conditions. The selection of Type 347 austenitic stainless steel is an enhancement over that of a Type 300 stainless steel. The corrosion rates are a product of the alloy chemistry, and the only difference between Type 347 and Type 304L is the increase in carbon content that improves the high temperature properties. The carbon increase is offset with niobium and tantalum alloyed to decrease the tendency for carbide precipitation during fabrication and welding. Type 347 alloy has improved oxidation resistance and high temperature properties and is a good choice for the TCO components. Type 347 was selected for the following reasons: improved thermal properties, readily available in most product forms, standard stainless steel fabrication practice (tools and processes), and lower cost per pound than the higher nickel or duplex alloys (*High-Temperature Characteristics of Stainless Steels,* NIDI Publication No. 9004).

INCOLOY® alloy 800 is a nickel-iron-chromium alloy with tensile strength between 75 and 100 ksi and good toughness, with elongation between 60 and 30%. The alloy exhibits resistance to oxidation, carburization, and elevated temperature corrosion. The alloy has a carbon content of 0.1% for improved high temperature strength, copper is added to improve the passive/oxide protective film from spalling, titanium is used to stabilize carbide formation, and aluminum is added to control the grain size to optimize stress-rupture properties. The electric heater is operated at elevated temperatures, and both creep and oxidation are considered as part of this corrosion evaluation. The recommended alloy for the elevated temperature sections is Type 347 austenitic stainless steel or Incoloy® alloys. Also, the higher carbon content and added niobium to prevent sensitization improve the oxidation resistance (*High-Temperature Characteristics of Stainless Steels*, NIDI No. 9004, Nickel Development Institute).

At the stated operating temperature, the use of Type 347stainless steel is suitable and is recommended. Incoloy® 800 is recommended for the heating elements.

The skid base frame is not considered as a material in contact with the offgas. If structural materials are not welded to the pressure boundary of the heater, they are outside the scope of this corrosion evaluation.

2 Pitting Corrosion Analysis

Pitting is localized corrosion of a metal surface that is confined to a point or small area and that takes the form of cavities. Pitting corrosion will only be a concern if sufficient moisture is present. The heater normally operates at temperatures above the dew point of the dry offgas, and therefore sufficient moisture is not present to act as an electrolyte for corrosion processes to proceed. It is assumed that there will be no condensation in the unit.

Justification for this position is that corrosion will not proceed without an electrolyte present.

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 offgas humidity is controlled so that there will be no condensation.

CORROSION EVALUATION

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 no 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. Either an "L" grade, low carbon, stainless steel or a niobium-stabilized stainless steel is specified to negate sensitization from becoming a corrosion issue. It is assumed that there will be no condensation in the unit; therefore, the heater will not undergo stress corrosion cracking because insufficient moisture will be present.

This position is justified because of the temperature of the gas during operation will be greater than the dew point. Corrosion will not take place or initiate when no electrolyte is present.

5 End Grain Corrosion Analysis

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. The electric heater design does not expose the pressure boundary cut ends to offgas. Also, end grain corrosion will not take place in the component because of the absence of sufficient moisture.

End grain corrosion is not expected to occur in the heater because the temperature of the gas will be greater than the dew point of the gas therefore corrosion will not occur in the absence of an 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.

This position is justified because the operating temperature and dry air conditions will not corrode because of the lack of the electrolyte for corrosion.

7 Microbiologically Influenced Corrosion Analysis

Microbiologically Influenced Corrosion (MIC) refers to corrosion affected by the presence or activity, or both, of microorganisms.

Typically, with the exception of cooling water systems and stagnant water, MIC is not observed in operating systems. The electric heater will operate at elevated temperatures and the offgas is dry. In this system, the stated operating conditions are not suitable for microbial growth.

8 Fatigue/Corrosion Fatigue Analysis

Corrosion-fatigue is the result of the combined action of cyclic stresses and a corrosive environment. The fatigue process is thought to cause rupture of the protective passive film, upon which stainless steel can actively corrode in the localized area of the film rupture. The corrosive environment may also act to reduce the stress necessary for film rupture. The result is that a metal exposed to a corrosive environment and cyclic mechanical load may initiate cracking at conditions at stress levels less than the endurance limit for the material.

The electric heater is not cyclically operated; offgas flow is constant, steady and dry. Thermal cycles and therefore thermal stress is low and associated with the start-up and shut down of the offgas system. Corrosion fatigue will not be observed in the recuperative electric heater (24590-LAW-MVC-LVP-00004, *LVP-SKID-00002, LAW Thermal Catalytic Oxidizer / Reducer, Stress Analysis with ANSYS.*).

The conclusion that corrosion fatigue will not be a problem is based on the low mechanical and thermal cycling, as well as the lack of an 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 HNO_3; however, these are present in low concentrations in the gas and are of less concern because of the dry and heated conditions. 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 heater conditions because the operation conditions for this component preclude sufficient moisture and concentrations of acid gas forming components.

CORROSION EVALUATION

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. The WTP waste is a slurry consisting of water, waste oxide particles, and / or precipitated salts. 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". Prior to reaching the recuperative electric heater, the offgas 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 erosion is not a concern.

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.

Galling is most commonly found in metal surfaces that are in sliding contact with each other. It is especially common where there is inadequate lubrication between the surfaces. Softer metals will generally be more prone to galling; austenitic stainless steel is relatively soft and ductile and is known to gall easily. Martensitic stainless steel or precipitation hardened stainless steel or nitrogen strengthened austenitic stainless steels have higher surface hardness and therefore are resistant to galling.

The electric heater does not have any moving surfaces.

12 Fretting/Wear Analysis

Fretting corrosion refers to corrosion damage caused by a slight oscillatory slip between two surfaces. Similar to galling but 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.

The electric heater does not have moving parts and design precludes the use of tube support plates that would normally become a fretting corrosion problem in tube-and-shell heat exchangers. Fretting corrosion is not expected in this component.

13 Galvanic Corrosion Analysis

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. The potential difference for more than 200 mV is needed for sufficient driving force to make a difference. 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.

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 Analysis

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 offgas system

15 Creep Analysis

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 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. The creep temperature is different for each alloy, the Nickel Development Institute has cataloged the creep properties of Type 304, Type 316, and Type 347 austenitic stainless steels (*High-Temperature Characteristics of Stainless Steels,*

CORROSION EVALUATION

NIDI No. 9004, Nickel Development Institute). The material creep properties at 1000 °F indicate a difference of several hundred degrees over the maximum heater temperature of 750 °F.

The maximum operating temperature for the heater is less than the creep temperature; creep will not occur.

16 Inadvertent Addition of Nitric Acid

Addition of nitric acid to the offgas lines is not a plausible scenario.

17 Conclusion and Justification

The conclusion of this evaluation is that for other than the heating elements, LVP-HTR-00002 can be fabricated from Type 347 stainless steel and that Type 347 stainless steel is capable of providing 40 years of service. Incoloy® 800 is recommended for the heating elements. Providing the reported dry-air conditions are maintained, Type 347 stainless steel is expected to be resistant to uniform and localized corrosion. The probable uniform corrosion is negligible; a minimum allowance of 0.010 inch for surfaces in contact with the offgas (except heat transfer surfaces) is recommended for conservatism. No corrosion allowance is recommended for the heat transfer surfaces. Conditions in the heater do not promote erosion so no erosion allowance is necessary.

Incoloy® 800 with a 30-35% nickel content produces an alloy resistant to both chloride stress-corrosion cracking and to embrittlement from precipitation of sigma phase. Incoloy® 800 is primarily used in applications with temperatures up to 1500 °F. Incoloy® 800 (UNS N08800), which is often used for heat exchangers, heating-element sheathing, carburizing equipment, and nuclear steam-generator tubing, is recommended for the heating elements (*High-Temperature Characteristics of Stainless Steels*, NIDI No. 9004, Nickel Development Institute).

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." In the reported dry-air conditions, there is no electrolyte. If there is no electrolyte, there can be no corrosion. The system is designed with a uniform corrosion allowance of 0.010 inch based on the range of inputs, system knowledge, and engineering judgment/experience. The service conditions used for materials selection have been described above and result in negligible uniform loss. The specified minimum corrosion allowance exceeds the minimum required corrosion allowance which provides margin. The uniform corrosion design margin for the operating conditions is sufficient to expect a 40 year operating life and is justified in the referenced calculation.

Localized erosion of this component is not expected. Prior to reaching the heater, the offgas 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 corrosion protection is not required.

This component contains no fluids or electrolyte to promote localized corrosion. As shown in the PCDS summary table (page 8, below), the unit operates at high temperatures and low humidity (0.04% at the outlet) and is described in the PCDS. While not quantifiable, the largest contributor to the total localized corrosion design margin is the absence of sufficient moisture to form a corrosive electrolyte. During inactive periods of plant operations and prior to initial plant startup, layup and storage procedures will monitor and control condensation.

CORROSION EVALUATION

19 References:

1. 24590-CD-POC-MBT0-00007-05-00004, *Manual - Operation, Maintenance and Installation Instructions for LAW Thermal Catalytic Oxidizer / Reducer (TCO) and Ammonia Dilution Skid.*
2. 24590-LAW-3YD-LOP-00001, *System Description for the LAW Primary Offgas (LOP) and Secondary Offgas/Vessel Vent (LVP) Systems.*
3. 24590-LAW-M4C-LOP-00001, *LAW Melter Offgas System Design Basis Flowsheets, with change notice 24590-LAW-M4E-LOP-00009.*
4. 24590-LAW-MVC-LVP-00004, *LVP-SKID-00002, LAW Thermal Catalytic Oxidizer / Reducer, Stress Analysis with ANSYS.*
5. 24590-LAW-P1-P01T-00005, *LAW Vitrification Building General Arrangement Plan at El. 48 Feet - 0 Inches.*
6. 24590-WTP-GPG-M-047, *Preparation of Corrosion Evaluations.*
7. 24590-WTP-RPT-PR-04-0001-04, *WTP Process Corrosion Data-Volume 4.*
8. 24590-WTP-SRD-ESH-01-001-02, *Safety Requirements Document Volume II.*
9. ASM Metals Handbook, Volume 13, *Corrosion.* 1987. ASM International, Materials Park, OH.
10. Coburn SK. 1978. *Atmospheric Factors Affecting the Corrosion of Engineering Metals - STP 646.* ASTM International, West Conshohocken, PA.
11. Dean SW and Lee TS. 1986. *Degradation of Metals in the Atmosphere - STP 965.* ASTM International, West Conshohocken, PA.
12. Dean SW and Rhea EC. 1980. *Atmospheric Corrosion of Metals - STP 767.* ASTM International, West Conshohocken, PA.
13. NIDI. *High-Temperature Characteristics of Stainless Steels,* Publication No. 9004, Nickel Development Institute. Toronto, Ontario, Canada.
14. Schweitzer PA. 1989. *Corrosion and Corrosion Protection Handbook.* Marcel Dekker, Inc., New York, NY.

Additional Reading

- 24590-LAW-MKD-LVP-00012, *Mechanical Data Sheet for 24590-LAW-MX-LVP-SKID-00002 24590-LAW-MX-LVP-00003 - LAW Catalytic Oxidizer / Reducer.*

CORROSION EVALUATION

Component(s) (Name/ID #) Catalytic Oxidizer Electric Heater (LVP-HTR-00002)

Facility LAW

In Black Cell? NO

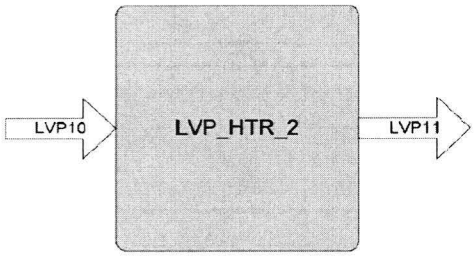
		Stream ID LVP11
Chemicals	Unit	**GASEOUS**
CO2	ppmV	26,053
HCl	ppmV	9
HF	ppmV	5
NH3	ppmV	22
NO	ppmV	2111
NO2	ppmV	10
O2	ppmV	188,778
SO2	ppmV	10
RH	%	0.04
Suspended Solids	wt%	0
Temperature	°F	750

CORROSION EVALUATION

Figure C- 28 LVP-HTR-00002 Gaseous PCDS

Vessel : LVP_HTR_2

	Stream ID	
	LVP10	LVP11
Properties		
Suspended Solids [wt %]	0	0
Total Salts [wt %]	0.00	0.01
Sodium Molarity [M]	n/a	n/a
Relative Humidity [%]	0.06	0.04
pH	n/a	n/a
Anti-Foam Agent [ppm]	0	0
TOC [kg/h]	2.70E-03	2.70E-03
Pressure [bar]	0.92	0.92
Temperature [C]	360.00	398.89
Temperature [F]	680.00	750.00
Water Flow Rate [kg/hr]	303.79	303.79
Total Aqueous Flow Rate [kg/hr]	303.79	303.79
Total Flow Rate [kg/hr]	5.19E+03	5.19E+03
UserNote	VIT VAPOR Energy Recovery Heat Exchanger Cold Offgas Discharge	VIT VAPOR Catalyst Unit Electric Heater Offgas Discharge
GASEOUS [ppmV or mg/m³]		
Ar	8266	8266
CH3I	0	0
Cl2	0	0
CO	431	431
CO2	26053	26053
F2	0	0
H2	0	0
HCl	9	9
HCN	0	0
HF	5	5
I2	0	0
N2	699668	699668
NaCl(s)	0	0
NaCN(s)	0	0
NaF(s)	0	0
NaI(s)	0	0
NH3	22	22
NO	2111	2111
NO2	10	10
O2	188778	188778
P2O5(s)	0	0
PO2	0	0
SO2	10	10
SO3(s)	0	0



Note: Concentrations for constituents representing particulates (as denoted by suffix "(s)" in their name) are reported in units of mg/m3; all others are reported in units of ppmV

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 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.*

6.6 LVP System

6.6.1 Description of Vessel/Equipment

The LAW Secondary Offgas/Vessel Vent Process (LVP) System is designed to treat the offgas from the LAW Primary Offgas Process (LOP) System and the LAW Facility vessel vents. The purpose of the LVP System is to remove almost all remaining particulates, miscellaneous acid gases, nitrogen oxides, VOCs, and mercury from the LAW Facility offgas that have not been removed by the LOP system.

Figure 10 is a sketch of the input and output arrangement of streams for all equipment within the LVP System. Streams that are not primary routes (infrequent transfers) are represented with dashed lines.

Figure 10a LVP System Sketch

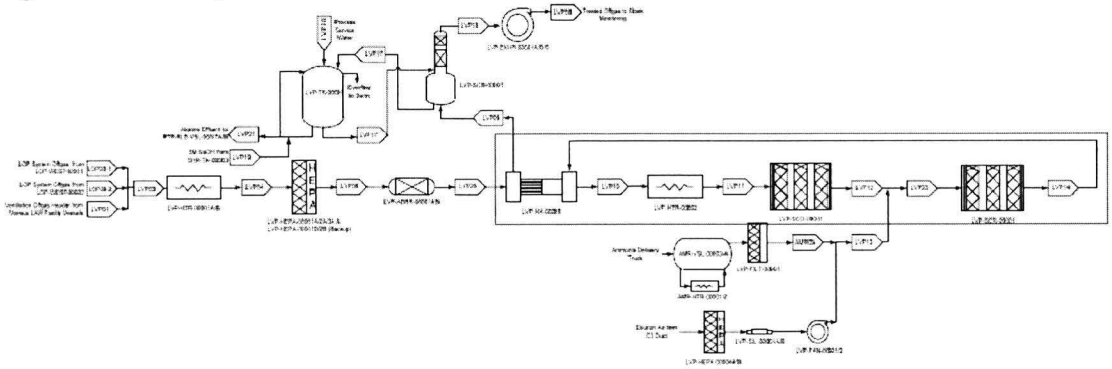
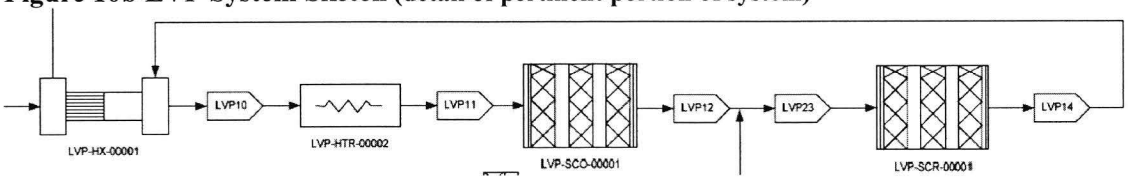


Figure 10b LVP System Sketch (detail of pertinent portion of system)



6.6.2 System Functions

The process functions of this system are as follows:

- Receive LAW Offgas from LOP System and LAW Facility Vessel Ventilation Streams
- Receive Reagents Streams Such as Ammonia or Dilution Air to Ensure Offgas Component Destruction
- Treat Offgas to Ensure Requirements are Met Before Emitting to Atmosphere
- Transfer Offgas to Stack
- Transfer Liquid Effluents to RLD-VSL-00017A/B

These vessels perform additional system functions beyond the process functions, but these are outside the scope of this document. The non-process functions are not discussed any further in this document. However, they are listed below for completeness:

- Confine Hazardous Materials
- Flush System Components
- Report System Data

6.6.3 Description of Process Functions

All process streams have been taken from Process Flow Diagrams 24590-LAW-M5-V17T-00010 and 24590-LAW-M5-V17T-00011 and associated drawing change notices (DCNs) 24590-LAW-M5N-V17T-00012/15/17/29 and 24590-LAW-M5N-V17T-00012/19/23/29, respectively. The P&IDs have also been looked at to obtain the most accurate flow diagram. These are as follows: 24590-LAW-M6-LVP-00001001 / 1002 / 1003 / 1004 / 1005 / 1006 / 2001 / 2002 / 2003 / 2004 / 2005 / 2006 / 3001 / 4001 / 4002 / 4003 / 5001 / 5002 and 24590-BOF-M6-AMR-00002001 / 2002 / 3001 / 3002 / 5001. See Section 7.1.3 for corresponding references in this section. A description of the process function of each piece of equipment is listed as follows:

Equipment	Process Function
LVP-HTR-00002	The electric heater is used to supplement the heat recovery exchanger (LVP-HX-00001) primarily during startup and when operating with low NO_x concentrations. Once the system is up to temperature, demand on the electric heater will be minimal.

6.6.3.1 Receipt Streams

The LVP system primarily receives LAW offgas from the LOP system and LAW Facility vessel ventilation streams. Other LVP system equipment receives various streams to help process the offgas. The receipt streams for each piece of equipment are listed as follows, by vessel, in order of process flow:

LVP-HTR-00002

- LVP10 - Offgas from LVP-HX-00001

6.6.3.1.6 LVP10 - Offgas from LVP-HX-00001

Stream LVP10 is the offgas from the heat exchanger that enters the electric heater.

Molarity
N/A

Temperature
The temperature of stream LVP10 will normally be 624°F (24590-LAW-M4E-LOP-00009, pg. 11, Cell Q36, Ref. 7.1.4(13)). The maximum temperature is 680°F (24590-LAW-M4E-LOP-00009, pg. 15, Cell Q36, Ref. 7.1.4(13)).

CORROSION EVALUATION

Solids Concentration
The solids concentration for stream LVP10 will normally be near zero or trace solids.

Vapor Density
The vapor density of stream LVP10 will normally be 2.56E-2 lb/ft^3 to 2.25E-2 lb/ft^3 (24590-LAW-M4E-LOP-00009, pg. 11, Cell AI36; pg. 15, Cell AI36, Ref. 7.1.4(13)).

Liquid pH
N/A

6.6.3.2 Outlet Streams

The outlet streams for each piece of equipment are listed as follows, by vessel, in order of process flow:

6.6.3.1.7 LVP11 - Offgas from LVP-HTR-00002

Stream LVP11 is the offgas from the electric heater to the selective catalytic oxidizer.

Molarity
N/A

Temperature
The temperature of stream LVP11 will normally be 750°F (24590-LAW-M4C-LOP-00001, pg. 37, Cell Q37, Ref. 7.1.4(12)). The maximum temperature is 750°F (24590-LAW-M4C-LOP-00001, pg. 41, Cell Q37, Ref. 7.1.4(12)).

Solids Concentration
The solids concentration for stream LVP11 will normally be near zero or trace solids.

Vapor Density
The vapor density of stream LVP11 will normally be 2.29E-2 lb/ft^3 to 2.10E-2 lb/ft^3 (24590-LAW-M4C-LOP-00001, pg. 37, Cell AI37; pg. 41, Cell AI37, Ref. 7.1.4(12)).

Liquid pH
N/A

[Relevant section of the system process conditions table is shown]

6.6.5 Summary of Processing Conditions for LVP System

6.6.5.1 Normal Operations

The following table summarizes the normal processing modes for LVP System equipment.

Stream Number	Weight % UDS		Na Molarity		Temperature (°F)	
	normal	upper	normal	upper	normal	upper
LVP-HTR-00002						
LVP10 (in)	0	trace	n/a	n/a	624	680
LVP11 (out)	0	trace	n/a	n/a	750	750

CORROSION EVALUATION

6.4.1.3 Catalytic Oxidizer/Reducer (LVP-SKID-00001 and LVP-SKID-00002)

The offgas has potentially high levels of NO_x because the melter decomposes the parent nitrate/nitrite compounds. Some of the resultant NO_x is decomposed to nitrogen and water in the melter, and some is removed by scrubbing in the SBS. VOCs are also present in the offgas stream. Both the VOCs and the remaining NO_x require removal.

The offgas is passed through a catalytic oxidizer/reducer skid (LVP-SKID-00002) housing a heat recovery exchanger (LVP-HX-00001), an electric heater (LVP-HTR-00002), VOC catalyst (LVP-SCO-00001), and SCR catalyst (LVP-SCR-00001). The skid is located in room L-0304F at the 48-foot elevation and approximate dimensions for the skid are 36 ft long by 11 ft high by 8 ft wide. The heat recovery exchanger first raises the offgas temperature using the hot offgas from the catalyst beds. This heat exchanger is designed to be of a plate and frame design to eliminate the problems associated with tube to plate joints. The hot side of the heat exchanger cools the offgas prior to discharge from the skid. [4.3.3.17]

The electric heater is used to supplement the heat recovery exchanger primarily during startup and when operating with low NO_x concentrations. Once the system is up to temperature, demand on the electric heater will be minimal.