

Abstract

The purpose of this presentation is to convey the concentration levels of the chemical components of interest present within the waste feed which will be sent to the Hanford Site Low-Activity Waste Pretreatment System (LAWPS) and facilitate material selection for LAWPS components. Additionally, research was conducted on the effects of chemical constituents found in low activity waste (LAW) on the stainless steel transfer lines transporting them. The objectives are to conduct research on the corrosion-causing chemical constituents, their role in the degradation/dissolution of the passive layer, and their ability to corrode stainless steel. Also, to evaluate the concentration levels of corrosion-causing chemical constituents, and to facilitate material selection for LAWPS components.

Introduction

Summer Internship Purpose:

- Conduct research to facilitate LAWPS component material selection (applicable corrosion mechanisms).
- Analyze feed streams to LAWPS for corrosion-causing constituents.
- SS 304, 304L, 316, 316L are the choices for the material to be selected for LAWPS components.

Internship Overview:

- LAWPS Feed Parameters for Material Selection Computation
- WRPS-1502970, Low-Activity Waste Pretreatment System Facility Feed Properties for Material Selection
- RPP-RPT-58834-00, Stainless Steel Corrosion: Feed Properties Affecting Material Selection for LAWPS Piping at Hanford Site

Assumptions Made:

- All of the data applied in creating the LAWPS waste feed parameter for concentration profiles were obtained through the Hanford Tank Waste Operations Simulator (HTWOS) model run MMR-50043.
- HTWOS model run MMR-50043 is the final Reference Operating Scenario (ROS) for fiscal year 2015.
- Temperature of the LAW passing through the transfer lines is not to exceed 45°C, which is consistent with RPP-SPEC-56967.
- Flow conditions for LAW to LAWPS is assumed to be turbulent, which coincides with LAWPS feed rate and expected flow conditions.

Transfer ID	Total Volume (Liters)	Total g-moles/liter Cl-	Total g-moles/liter F-	Total g-moles/liter NO2-	Total g-moles/liter NO3-	Total g-moles/liter OH-	Total g-moles/liter SO4-2	Total g-moles/liter Na+
353	4.36E+06	8.63E-02	5.46E-02	9.60E-01	1.46E+00	3.91E+00	7.94E-02	5.81E+00
363	3.86E+06	8.70E-02	1.94E-02	1.18E+00	1.60E+00	3.27E+00	6.28E-02	5.83E+00
400	3.71E+06	7.21E-02	2.21E-02	1.09E+00	1.62E+00	3.63E+00	4.09E-02	5.61E+00
502	4.33E+06	7.05E-02	2.50E-02	1.04E+00	1.66E+00	3.56E+00	3.74E-02	5.54E+00
576	3.43E+06	7.44E-02	1.53E-02	1.19E+00	1.34E+00	3.52E+00	6.24E-02	5.60E+00
642	4.20E+06	5.27E-02	2.37E-02	8.58E-01	1.45E+00	3.13E+00	3.15E-02	5.41E+00
717	3.54E+06	7.35E-02	1.95E-02	1.02E+00	1.45E+00	3.61E+00	5.09E-02	5.59E+00
807	4.01E+06	7.07E-02	2.09E-02	1.10E+00	1.46E+00	3.15E+00	1.07E-01	5.60E+00
928	3.71E+06	6.96E-02	1.62E-02	2.00E+00	1.15E+00	3.17E+00	5.07E-02	5.60E+00
1022	4.01E+06	6.47E-02	1.29E-02	2.21E+00	1.10E+00	3.15E+00	5.01E-02	5.60E+00
1115	3.71E+06	7.47E-02	6.94E-03	1.77E+00	1.24E+00	3.45E+00	4.55E-02	5.60E+00
1188	1.30E+06	7.65E-02	8.36E-03	1.46E+00	1.49E+00	3.40E+00	4.93E-02	5.60E+00
1266	2.87E+06	7.60E-02	8.21E-03	1.50E+00	1.48E+00	3.38E+00	4.94E-02	5.60E+00
1335	3.46E+06	7.14E-02	6.58E-03	1.88E+00	1.44E+00	3.12E+00	5.03E-02	5.60E+00
1420	4.22E+06	6.84E-02	4.24E-03	1.82E+00	1.79E+00	3.25E+00	4.79E-02	5.60E+00
1502	4.22E+06	6.80E-02	7.60E-03	1.52E+00	2.20E+00	3.20E+00	5.20E-02	5.60E+00
1506	1.60E+06	6.89E-02	5.37E-03	1.98E+00	1.99E+00	3.19E+00	7.15E-02	5.60E+00
1611	4.15E+06	6.10E-02	1.42E-03	1.98E+00	1.99E+00	3.19E+00	7.15E-02	5.60E+00
1722	3.62E+06	7.08E-02	9.88E-03	1.56E+00	2.39E+00	3.46E+00	6.54E-02	5.60E+00
1841	3.99E+06	6.83E-02	9.59E-03	2.02E+00	1.91E+00	3.19E+00	5.37E-02	5.60E+00
1945	3.21E+06	6.83E-02	1.13E-02	1.56E+00	2.11E+00	3.26E+00	5.89E-02	5.60E+00

Table 1: Summary Calculations for LAWPS Feed Parameters for Material Selection Computation

Background

Stainless Steel

SS 304

- An austenitic stainless steel
- Comprised of (by wt%): carbon (~.08), manganese (~2.00), phosphorus (~.045), sulfur (~.03), silicon (~.75), chromium (~18-20), nickel (~8-12), nitrogen (~.10), and iron (balance)
- Higher chromium and lower carbon content
- Forms passive layer of chromium oxide (Cr₂O₃)

SS 316

- An austenitic stainless steel
- Comprised of (by wt%): carbon (~.08), manganese (~2.00), phosphorus (~.045), sulfur (~.03), silicon (~.75), chromium (~16-18), nickel (~8-12), molybdenum (~2-3), nitrogen (~.10), and iron (balance)
- Higher chromium and lower carbon content, with the addition of molybdenum
 - Molybdenum attributes to superior corrosion resistance in comparison to SS 304
- Forms passive layer of chromium oxide (Cr₂O₃)

Passivity

- Process of creating a passive layer upon the surface of a material
- When an alloy is manufactured, it is subjected to pickling which leads to passivation
- Pickling refers to the submersion of the alloy in an acid solution to remove surface contamination
- Passivation is the critical parameter for stainless steel selection for LAWPS components

Corrosion

- Corrosion is the deterioration of a metal due to a reaction with its environment
- The following five corrosion mechanisms were researched based off of LAWPS flow conditions:

Pitting Corrosion

- Develops in localized areas on surface of metal
- Leaves cavities throughout the surface

Crevice Corrosion

- Occurs when a stagnant solution is entrapped within a crevice
- Stagnant solution acidifies within the crack
- Corrosion is accelerated where the oxygen concentration dwindles

Erosion Corrosion

- Attributes to the degradation of a metal by means of abrasion
- Erosion leads to the degradation and dissolution of the passive layer
 - This leaves the active metal unshielded
 - Allows corrosive medium to corrode the metal

Intergranular Corrosion

- Attacks locally along the grain boundaries of the metal due to:
 - The depletion of an alloying element
 - Impurities along the boundaries of the alloy

Cavitation Corrosion

- The formation and collapse of vacuum bubbles
 - Explosive force to the metal
- Takes place at the surface of the metal
- Occurs due to high flow rates and rapid pressure changes



Figure 1: Pitting Corrosion



Figure 2: Crevice Corrosion



Figure 3: Erosion Corrosion

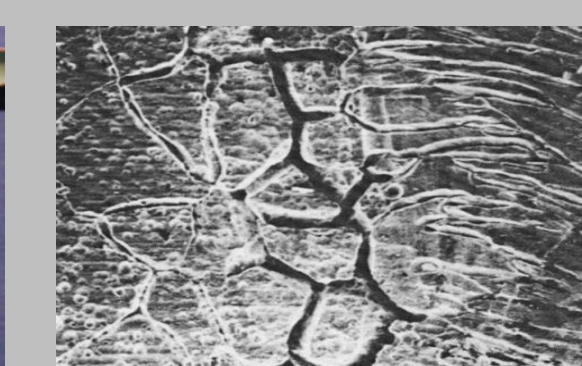


Figure 4: Intergranular Corrosion

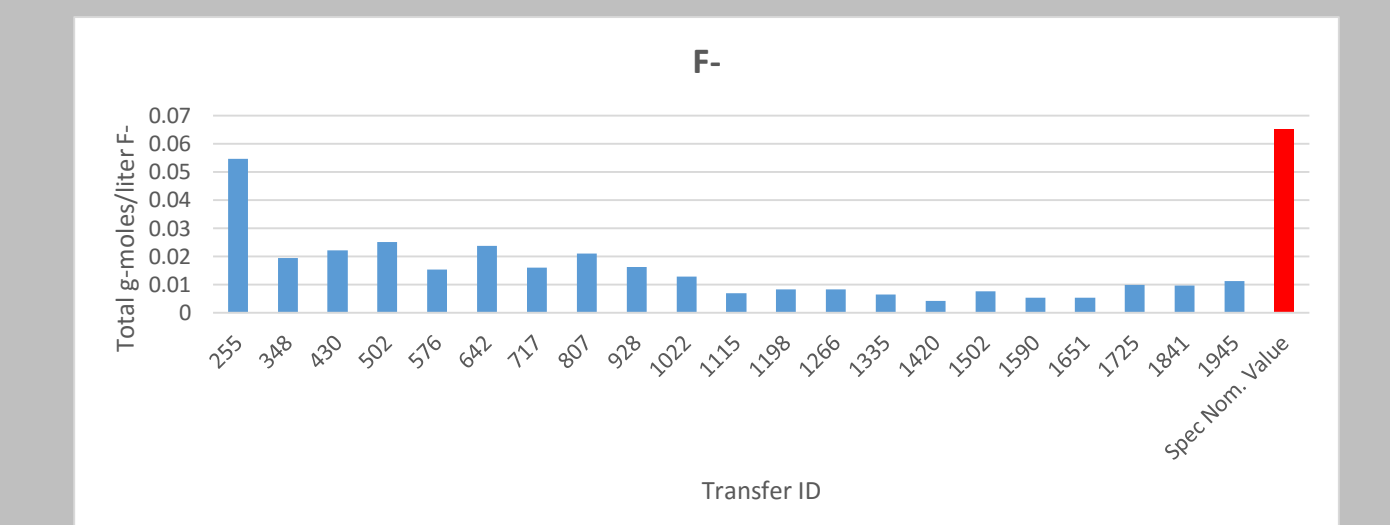
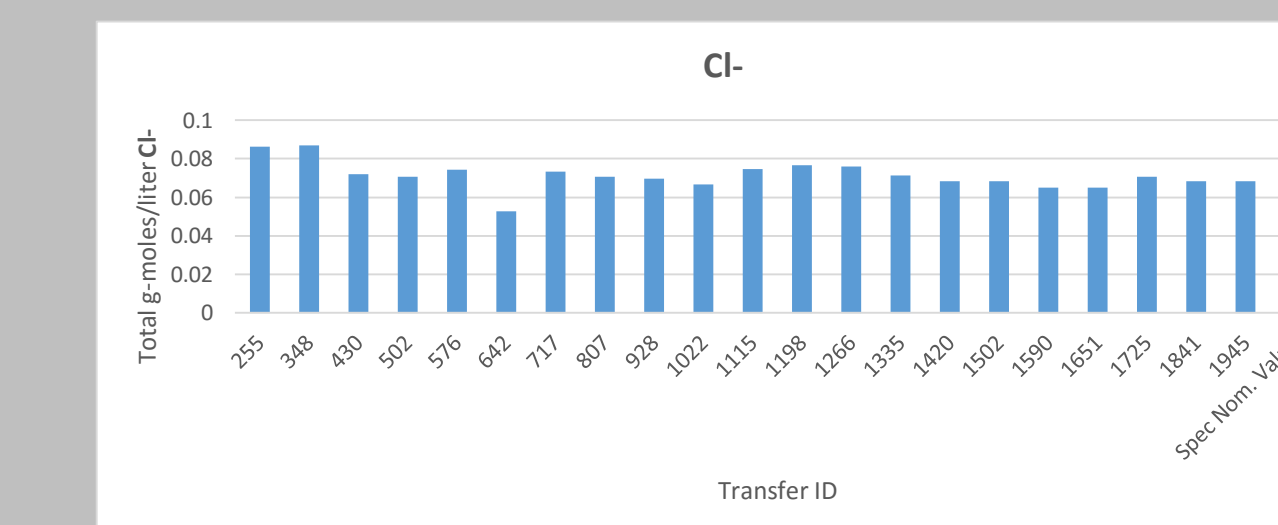


Figure 5: Cavitation Corrosion

Results and Conclusions

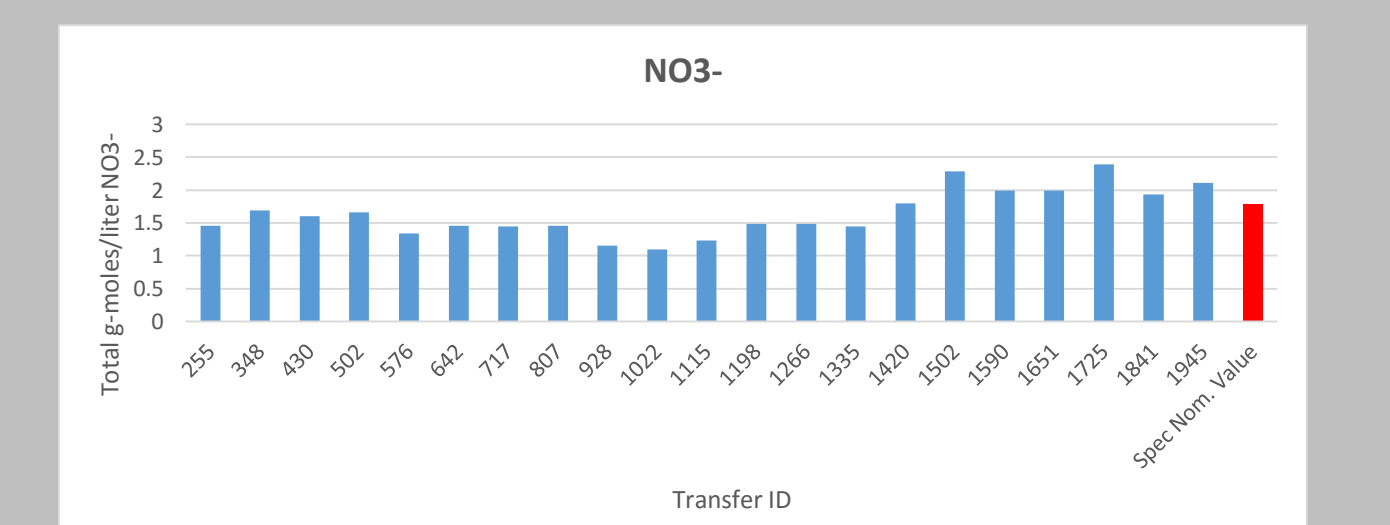
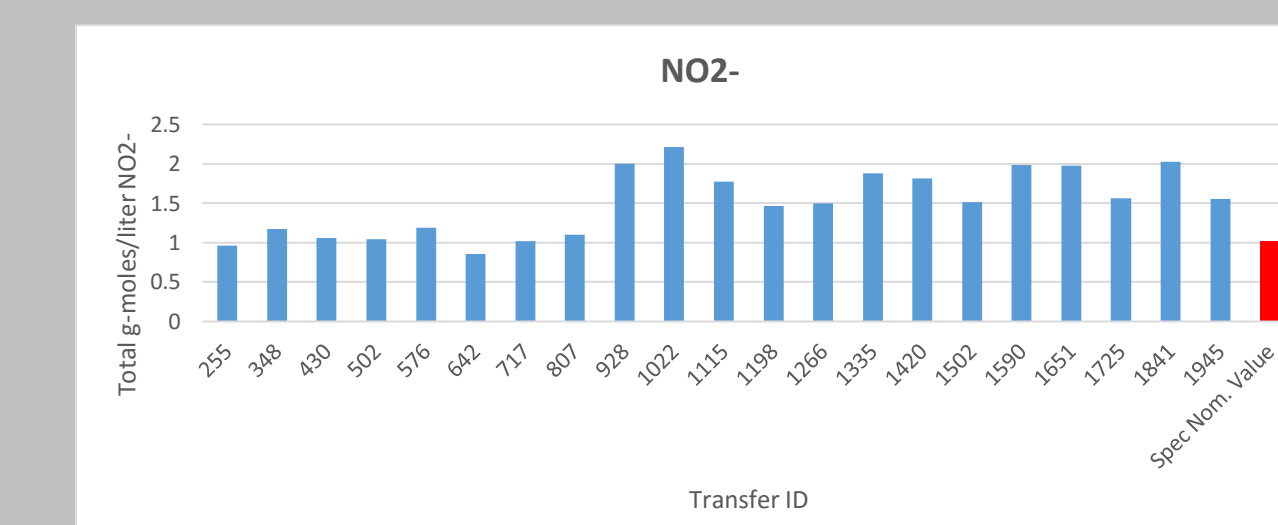
Chloride and Fluoride:

- The halides have the ability to penetrate the passive layer.
- They are very aggressive in respect to corrosion.
- Both chemicals are detrimental to SS.
- Chloride has the greatest electron affinity for metal ions, followed by fluoride.



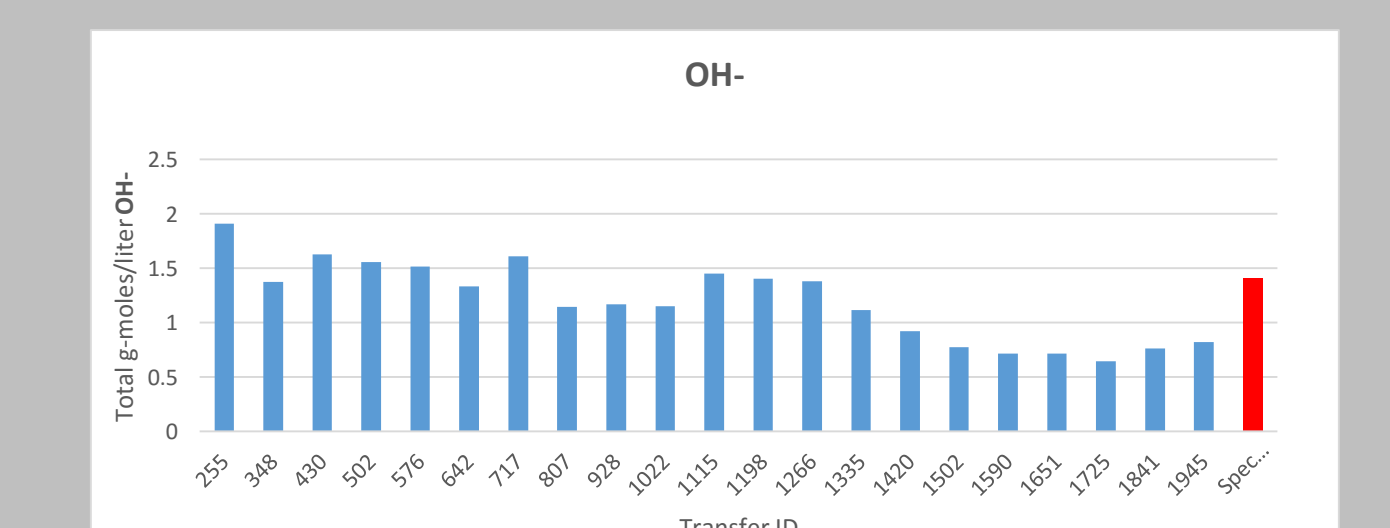
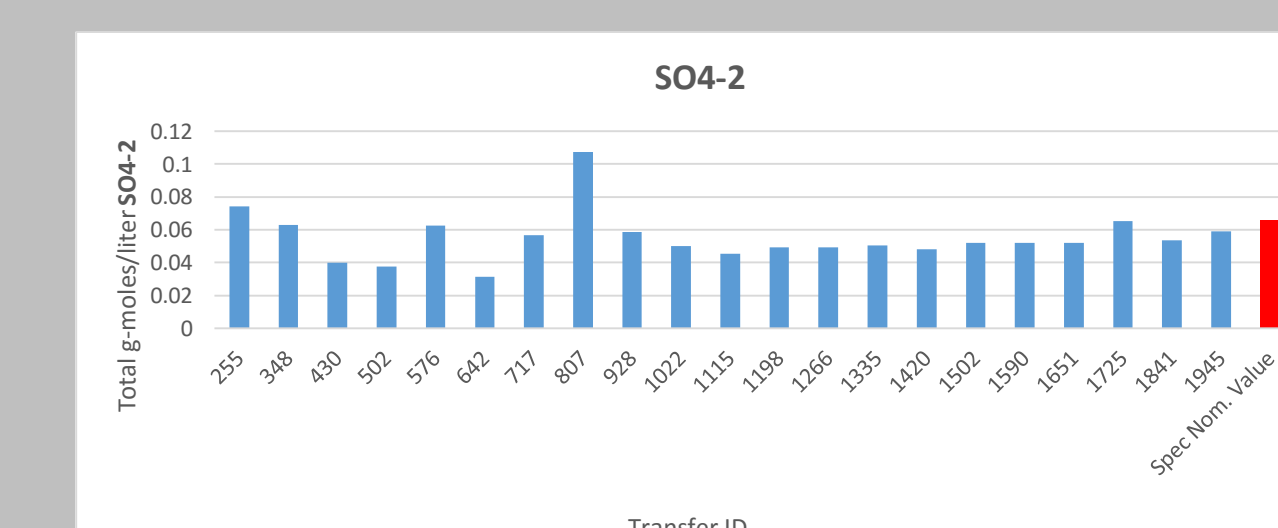
Nitrite and Nitrate:

- Following the assumption that transported LAW to LAWPS will not exceed 45°C, nitrite and nitrate should not be problematic in the corrosion of SS.
- Neither chemical possesses the ability to permeate the passive layer of SS.
- If the passive layer is stripped from the metal (through abrasion due to turbulent flow) both of these chemical constituents will lead to corrosion.



Hydroxide and Sulfate:

- Following the assumption that transported LAW to LAWPS will not exceed 45°C, hydroxide and sulfate should not play an integral role in the corrosion of SS.
- Neither chemical possesses the ability to permeate the passive layer of SS.
- If the passive layer is stripped from the metal (through abrasion due to turbulent flow) both of these chemical constituents will lead to corrosion.



Acknowledgements

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