



Universitetet
i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

MASTER'S THESIS

Study programme/specialisation: Master of Science in Engineering Structures and Materials/ Mechanical systems	Spring semester, 2018 <u>Open</u> /Confidential
Author: Jan Inge Thomassen (signature of author)
Faculty supervisor: Torfinn Havn Supervisor: Stian Strømstad	
Title of master's thesis: Investigation of the corrosion properties of 316L in marine atmosphere and assessment of the effectiveness of different surface repassivation products	
Credits(ECTS): 30	
Keywords: 316L Repassivation Pitting Corrosion Pitting Potential General Corrosion Chemical Composition Marine Atmosphere	Number of pages: 67 +enclosure: 6 (Appendix) Stavanger, 15 June, 2018 date/year

Abstract

The major purpose of this thesis was to investigate and assess what effect of repassivation product has on corrosion resistance of 316L in marine atmosphere. Additionally, compare the chemical composition with the certificate.

Several methods was performed to break down the passive layer, where the most successful method was used further to achieve general corrosion, after being exposed for simulated marine atmosphere. Visual inspection was observed before and after repassivation, and electrochemical test was done to find the pitting- and repassivation potential. The electrochemical test was performed according to standard ASTM G61-86 with a few adjustments. Similarly, the chemical composition was compared with the certificate.

General corrosion was obtained after being exposed for simulated marine atmosphere, before it was exposed for a rotary steel brush with hard braided threads equipped by a grinder to break down the passive layer. The visual inspection and ASTM G61-86 test showed Valhall UltraGel as the best environmentally friendly product and Avesta, with pickling, as the best product used with waste water treatment system. Chemical analysis showed that the chemical composition match with the certificate.

Acknowledgement

The thesis has been given by AkerBP where Kristian Eriksen has been a huge influence and Stian Strømstad has been my supervisor. Prof. Torfinn Havn by University of Stavanger has been the faculty supervisor for this thesis. AkerBP, Voestalpine Böhler Welding, Norkem AS, TechnipFMC, Valhall Nordic Green Products and Norsk Overflate Teknisk (NOT) AS has also contributed and donated supplies.

I want to thank Prof. Torfinn Havn, Stian Strømstad and Kristian Eriksen for good inspiration, input and guidance throughout this thesis. A special thanks to Mona Wetrhus Minde and Wakshum Mekonnen Tucho for great help with chemical composition analysis. Thanks to Tor Gulliksen and Jan Magne Nygård for good input with the machine hall. Additionally, I would like to thank Utsav Raj Dotel for contribute with G61-86 experiment. Finally, I want to thank my family and friends for their motivation and support through my thesis.

Table of contents

Abstract	i
Acknowledgement	ii
Table of contents	iii
Figure list	v
Table list	vii
1 Introduction	1
2 Theory	2
2.1 Corrosion	2
2.2 Mechanism of Corrosion	2
2.3 Types of Corrosion	3
2.3.1 General Corrosion	4
2.3.2 Localized Corrosion	4
2.4 Polarization	4
2.5 Mixed Potential Theory	5
2.6 Pitting Corrosion	6
2.6.1 Mechanism of Pitting Corrosion	6
2.7 Crevice Corrosion	8
2.7.1 Mechanism of Crevice Corrosion	8
2.8 Austenitic Stainless Steel	9
2.8.1 Austenitic Stainless Steel 316L/UNS S31603	10
2.9 Marine Atmosphere Corrosion	11
2.10 Passivation	12
2.11 Pickling	12
2.12 Electrochemical Testing	13
2.12.1 Method for Cyclic Potentiodynamic Polarization	14
2.13 X-ray	14
2.13.1 Detection of X-rays using Energy Dispersive Spectrometer (EDS)	14
2.13.2 Characteristic X-rays	15

2.13.3 Quantitative X-rays analysis	16
2.13.4 X-ray Fluorescent (XRF)	16
2.13.4.1 Positive Material Identification (PMI) Testgun	16
3 Material and methods	17
3.1 Background of the thesis	19
3.2 Material Certificate	19
3.3 Machining and performance	20
3.4 Pre samples for generate corrosion	22
3.5 Specimen Preparation for generate corrosion	25
3.6 Repassivation	25
3.7 ASTM G61 Test	27
3.7.1 Preparation	27
3.7.2 Apparatus/equipment	29
3.7.3 Producers	29
3.7.4 Deviation from Standard ASTM G61-86	31
3.8 Scanning Electron Microscope (SEM)	31
3.9 Positive Material Identification (PMI)	32
3.10 Health, Safety and Environment (HSE)	32
4 Results	33
4.1 Analysis of pre samples for generate corrosion	33
4.2 Analysis of samples for generate corrosion and repassivation	36
First time exposed for marine atmosphere repassivation	37
Second time exposed for marine atmosphere and repassivation	43
4.3 Analysis of ASTM G61-86 Test on 316L	45
Samples without treatment	47
Reference samples	49
Samples treated with Valhall GreenGel	50
Samples treated with Valhall Ultragel	52
Samples treated with Valhall CleanGel	53

Samples treated with Corrogel Offshore	54
Samples treated with Avesta with pickling	55
Samples treated with Avesta without pickling	56
Samples treated with Innotek	58
4.4 Analysis of Scanning Electron Microscope	59
4.5 Analysis of PMI	60
5 Discussion	61
6 Conclusion and Recommendations	65
References	66
Appendix	68
Appendix A	68
Appendix B	69
Appendix C	128
Appendix D	136
Appendix E	139
Appendix F	141

Figure list

Figure 1: Corrosion cycle of steel.[8].....	2
Figure 2: Electrochemical process. [10].....	3
Figure 3: Evans diagram for iron in acid environment.[16]	5
Figure 4: Process of pitting corrosion.[9].....	7
Figure 5:a)initial conditions: occurs uniform over the surface and inside the gap. b) final conditions: occurs only inside the crevice.[5]	9
Figure 6: Family tree for stainless steel alloys.[15]	10
Figure 7: setup for a polarization cell.[33].....	13
Figure 8: Potentiodynamic cyclic polarization curves.[14]	14
Figure 9: The plate scissor.....	20
Figure 10: left: sanding belt, middle: sandblaster and right: wire brush.....	21
Figure 11: left: high-speed air compressor, middle grinder and right: battery operated drill.....	21

Figure 12: rotary steel brush, left: hard- and right: soft threads.....	21
Figure 13: Sample 0.1-0.5.	22
Figure 14: Top left: 0.3, top middle: 0.5, top right: 0.4, bottom left: 0.2 and bottom right: 0.1.	23
Figure 15: Sample 0.5 exposed for marine atmosphere.....	24
Figure 16: Sample 0.6 and 1.1.1-3.8.3 before any preparations.	24
Figure 17: Some samples exposed for marine atmosphere.....	25
Figure 18: Hardware settings for OCP.....	28
Figure 19: Experimental setup for cyclic polarization test.	29
Figure 20: Experiment setup.	30
Figure 21: Sample a and b, and SEM Zeiss SUPRA 35 VP.....	32
Figure 22: PMI pistol.....	32
Figure 23: sample 0.1 after been exposed for sanding belt and seawater.....	33
Figure 24: sample 0.2 after damaged by a steel brush and exhibited by seawater.	33
Figure 25: Sample 0.3 exposed for sandblasting and seawater.	34
Figure 26: Sample 0.4 exposed by a rotary steel brush with soft threads equipped on a battery operated drill and exhibited by seawater.	34
Figure 27: Sample 0.5 exposed by a rotary steel brush with soft threads equipped on a high-speed air compressor exhibited by seawater and marine atmosphere.....	35
Figure 28: Sample 0.6 exposed by grinder with rotary steel brush with hard braided threads and exhibited for marine atmosphere.....	35
Figure 29: Samples exposed for grinder and marine atmosphere.....	36
Figure 30: Sample 1.1.X only exposed for grinder.....	36
Figure 31: Samples 2.1.x and 3.1.x with non repassivation.	37
Figure 32: Samples 2.2.X and 3.2.X frontside treated with Valhall GreenGel.....	38
Figure 33: Samples 2.2.X and 3.2.X backside treated with Valhall GreenGel.....	38
Figure 34: Samples 2.3.X and 3.3.X frontside treated with Valhall UltraGel.....	39
Figure 35: Samples 2.4.X and 3.4.X bakcside treated with Valhall CleanGel.....	39
Figure 36: Samples 2.5.X and 3.5.X frontside applied with Corrogel Offshore.	40
Figure 37: samples 2.5.X and 3.5.X backside applied with Corrogel Offshore.	41
Figure 38: Avesta with pickling.....	42
Figure 39: Avesta without applied pickling.....	42
Figure 40: Samples 2.8.X and 3.8.X exposed with Innotek.....	43
Figure 41: Samples 3.1.X exposed second time for marine atmosphere.....	43
Figure 42: Samples 3.2.X after second repassivation with Valhall GreenGel.....	44
Figure 43: After applying Corrogel Offshore second time on samples. 3.5.X.	44
Figure 44: Samples 3.7.X afterwards exhibited for Avesta without pickling.....	44

Figure 45: Repassivation of samples 3.8.X with Innotek.....	45
Figure 46: Post chart of OCP vs Corrosion potential.....	47
Figure 47: Post chart of pitting- and repassivation potential.....	47
Figure 48: Cyclic polarization curves for sample 1.1.X.....	48
Figure 49: Cyclic polarization curves for samples 2.1.X.....	48
Figure 50: Cyclic polarization curves for samples 3.1.X.....	49
Figure 51: Cyclic polarization curves for samples 1.2.X.....	50
Figure 52: Cyclic polarization curves for samples 1.3.X.....	50
Figure 53: Cyclic polarization curves for samples 2.2.X.....	51
Figure 54: Cyclic polarization curves for samples 3.2.X.....	51
Figure 55: Cyclic polarization curves for samples 2.3.X.....	52
Figure 56: Cyclic polarization curves for samples 3.3.X.....	53
Figure 57: Cyclic polarization curves for samples 2.4.X.....	53
Figure 58: Cyclic polarization curves for samples 3.4.X.....	54
Figure 59: Cyclic polarization curves for samples 2.5.X.....	54
Figure 60: Cyclic polarization curves for samples 3.5.X.....	55
Figure 61: Cyclic polarization curves for samples 2.6.X.....	56
Figure 62: Cyclic polarization curves for samples 3.6.X.....	56
Figure 63: Cyclic polarization curves for samples 2.7.X.....	57
Figure 64: Cyclic polarization curves for samples 3.7.X.....	57
Figure 65: Cyclic polarization curves for samples 2.8.X.....	58
Figure 66: Cyclic polarization curves for samples 3.8.X.....	58
Figure 67: EDS-analysis from one sample.....	59
Figure 68: Reults of Pitting- and repassivation potential without invalid results.....	64

Table list

Table 1: Chemical properties of 316L.....	11
Table 2: Mechanical properties of 316L.....	11
Table 3: Physical properties of 316L.....	11
Table 4: Overview of exposed environments on the samples.....	18
Table 5: Overview of pickling or/and repassivation products used on the samples.....	18
Table 6: Mechanism properties.....	19
Table 7: Chemical composition.....	20
Table 8: Overview of what the products contain and environmentally friendly.....	27
Table 9: Results obtained from ASTM G61-86.....	46
Table 10: Chemical composition for sample 1, sample 2 and the certificate.....	59

Table 11: Chemical composition performed with PMI for sample 1, sample 2 and the certificate.
.....60

Table 12: Valid results from G61-86.....64

1 Introduction

316L belongs to austenitic stainless steel, and can be divided into 300-series, which is the most common of stainless steel. The 300-series contains chromium-nickel (16-26%Cr-6-22%Ni) alloys with high resistance properties for corrosion and are relatively cheap. [1, 2] However, there are big challenges with external pitting- and crevice corrosion of 316L pipelines used in Oil and Gas Industry, especially in marine atmosphere.[3] These challenges are handled with inspection and washing off with freshwater. There has also been used gel products that will repassivate the surface, but it is uncertain of how effective it is and the long-term effect. In addition, where there has also been used paint in the most critical lines to get an external barrier against corrosion.

In this thesis there will investigate and asses the pitting and crevice corrosion resistance of 316L in a marine atmosphere. The effectiveness of different repassivation products will be tested and compared. There will be performed electrochemical testing according to ASTM standard G61-86. The testing will investigate the chemical composition and compare to the certification. Additionally, there will be a written literature study focusing on the corrosion properties of 316L, mainly in a marine atmosphere. The thesis has been done in cooperation and provided by AkerBP. Voestalpine Böhler Welding, Norkem AS, TechnipFMC, Valhall Nordic Green Products and Norsk Overflate Teknikk (NOT) AS has also contributed and donated supplies.

The first part of the thesis consists of a literature study and theory that underlies the problem of the task. Then the procedure of the experimental work, followed by the results that were found in the experimental work. Finally, a discussion of the results, with a conclusion and further investigation based on this thesis.

2 Theory

2.1 Corrosion

Corrosion is defined as the chemical or electrochemical reaction between a material and its environment, which inhibits the material and its property. Materials corrode due to its tendency to lower its (free) energy. Materials in metallic form have high energy and want to change back to nature form of compounds (ore/minerals). [4] The marine environments are probably one of the most aggressive environments where metals operate. [5]. Thorough understanding of corrosion, is important to reduce the rate to an acceptable level with focus on environmental safety and cost-effective manner, and how to handle existing and future problems [6]. Corrosion is a major cost for society and has a significant effect on the national economy. National Association of Corrosion Engineers (NACE) published a report dealing with communication, investment in corrosion prevention and economic techniques. In general, Corrosion cost between 2-4% of GNP, where approximately 25% could be avoidable. [7] The figure below shows the corrosion cycle of steel.

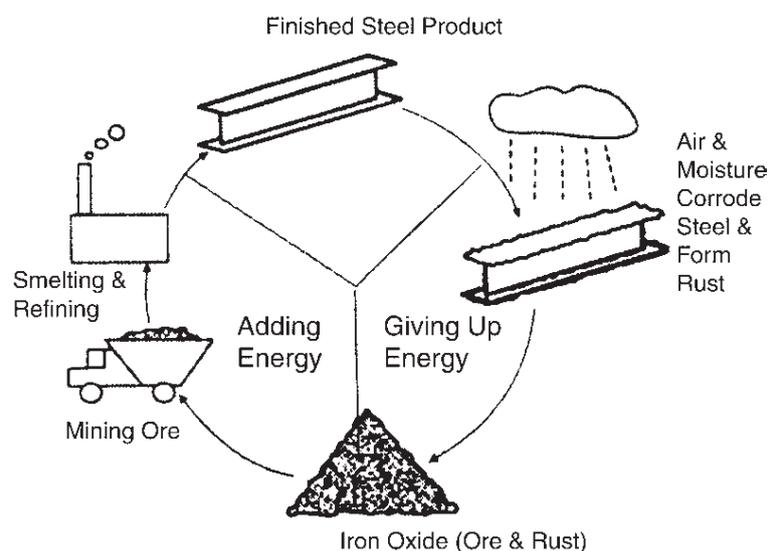


FIGURE 1: CORROSION CYCLE OF STEEL.[8]

2.2 Mechanism of Corrosion

For corrosion to occur, electrochemical reactions have to take place. This involves transfer of electrons by two partial reactions, called oxidation and reduction. Through a chemical reaction, oxidation give away electrons, while reduction is consuming them. Both reactions are required to maintain the conservation of electric charge. This

electrochemical process take place in an electrochemical cell, which exist of an anode and a cathode in an electrolyte environment. [1] In the electrolyte, positive charge electron passes from anode to cathode as cations. [9] Anode reaction takes place at the surface, where electrons are donated. Similarly, where cathode electrons are consumed. [1]

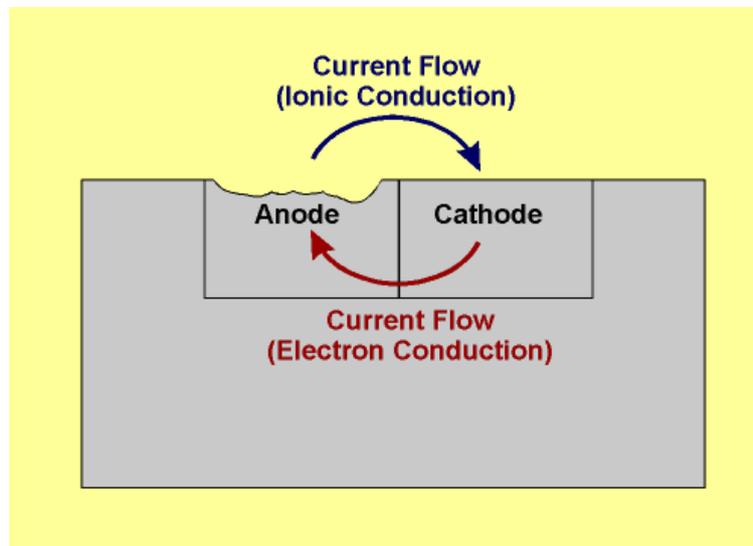
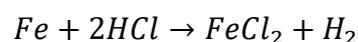
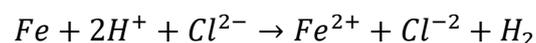


FIGURE 2: ELECTROCHEMICAL PROCESS. [10]

Consider a case involving pure iron immersed in hydrochloric acid. The chemical reactions start, resulting the iron to oxidize while the solution begin to bubble violently. The reaction can be written as:



This equation results in removing iron and hydrogen bubbles will then rise rapidly up to the surface. Another reaction will also occur, changing electrons:



The equation above show iron oxidizes and hydrogen reduced. [11]

2.3 Types of Corrosion

In 1989, ASM published a book "Corrosion" volume 13th, that there are several different categories and types of corrosion. The types of corrosion are divided into General and Localized, and is described below.

2.3.1 General Corrosion

General corrosion can be uniform or non-uniform and is the most general form of corrosion. The metal surface is exposed by a chemical or electrochemical reaction. This results in thinner metal surface until failure. [7] Typical environments that are exposed to corrosion are: liquid electrolyte, gas electrolyte or hybrid electrolyte. Some types of general corrosion are listed below [12]:

- Atmospheric corrosion
- Galvanic corrosion
- High-temperature corrosion
- Liquid-metal corrosion
- Molten-salt corrosion
- Biological corrosion
- Stray-current corrosion

2.3.2 Localized Corrosion

Local corrosion is unpredictable and occurs after a short period of exposure. They are unpredictable due to it corrode non-uniform. [13] Specific parts of the metal surface are exposed for electrolyte and starts to corrode. Localized corrosion can be categorized in[12]:

- Pitting corrosion
- Crevice corrosion
- Filiform corrosion
- Oral corrosion
- Biological corrosion
- Selective leaching corrosion

2.4 Polarization

Polarization is the different potential for a metal-(anode) and a solution ions (cathode), above the equilibrium potential. Polarization are used to measure the corrosion rate and are symbolized with η . The potential for this electrochemical process are evened out when current flows through the interface of metal and solution, leading to corrosion.

The most common polarization techniques are electrochemical methods due to the basis of corrosion process. Some methods are mentioned below:[14, 15]

- Tafel Extrapolation
- Polarization resistance methods
- Electrochemical impedance methods

2.5 Mixed Potential Theory

The mixed potential theory is the value of all anodic reactions equal to all cathodic reactions expressed by symbol E_{corr} (corrosion potential), and is measured by i_{corr} , called corrosion current density. [15] This theory is used when a certain amount of electrochemical reactions occur simultaneously at the same metal-liquid interface. The diagram below is called “The Evans diagram” and here the iron consists in an acidic environment as an example. There are four theoretical reactions, but only two feasible reactions drawn in solid lines. They are drawn with use of extrapolation and give an intersection at the corrosion potential E_{corr} and corrosion current density i_{corr} . In some cases, by holding the potential under the corrosion potential line, corrosion will stop and if it held over, corrosion will increase. [16]

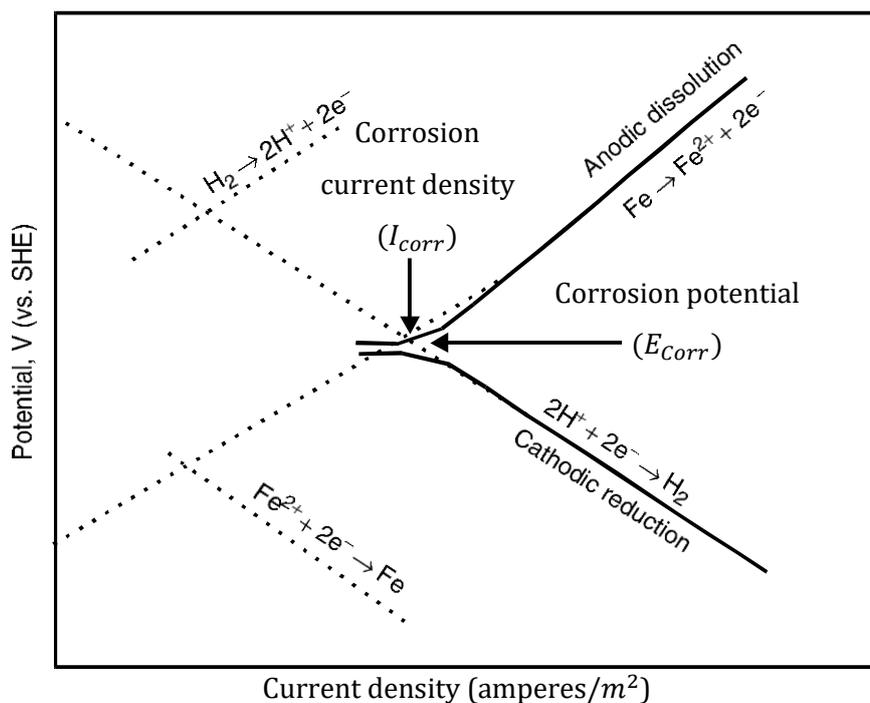


FIGURE 3: EVANS DIAGRAM FOR IRON IN ACID ENVIRONMENT.[16]

Four important parameters can be obtained from the figure above, corrosion potential E_{corr} , corrosion current i_{corr} , the anodic (β_{anode}) Tafel constant and cathodic ($\beta_{cathode}$) Tafel constant. The diagram can also obtain straight lines by moving away from corrosion potential, determine corrosion rate with different corrosion current, expressed below.[16]

Positive slope, $+\Delta E$:

$$\eta_{anodic} = E - E_{corr} = \beta_{anode} \log \left(\frac{i_{app}}{i_{corr}} \right)$$

Negative slope, $-\Delta E$:

$$\eta_{cathode} = \beta_{cathode} \log \left(\frac{i_{app}}{i_{corr}} \right)$$

2.6 Pitting Corrosion

Pitting corrosion is a form of localized attack on metal surface, [7] where specific fixed areas starts to corrode, while the rest of the surface remains unattacked. This happens due to breakdown of the passive film that usually causes by presence of aggressive anions ions as sulfate (SO_4^{2-}), chloride (Cl^-), bromide (Br^-) and Iodide (I^-) in marine environments.[9] The passive films are usually attacked by weak sites, either by adsorption and penetration, or by penetration and migration of aggressive halide ions. Inclusions, second phase precipitates, grain boundaries, slip steps and segregated interface are typical locations of weak sites on the surface.[17] Pitting corrosion is considered one of the most destructive corrosion due to its insidious form, and can cause failure of an entire structure. [9]

2.6.1 Mechanism of Pitting Corrosion

Pitting attack is recognized as two stages, the nucleation of pits on the passivated metal surface and the growth of pits.[17] Pitting corrosion initiates its attack by breaking down the passive layer. This will expose the metal surface for anodic and cathodic reactions in several local locations. This is illustrated by the figure below. [18]

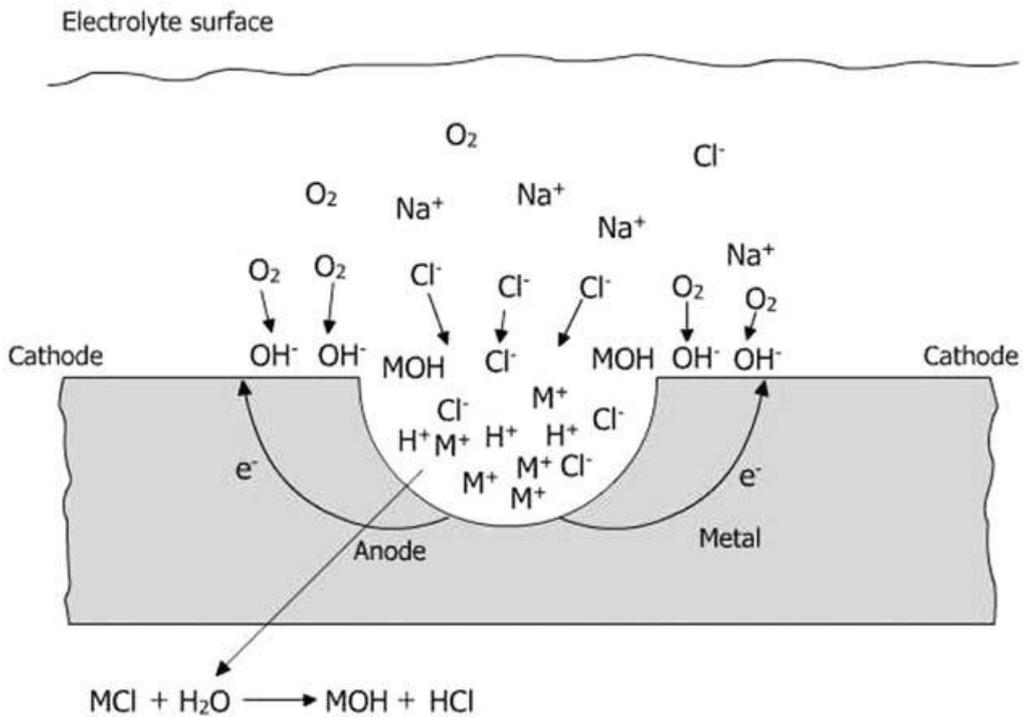
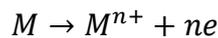


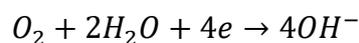
FIGURE 4: PROCESS OF PITTING CORROSION.[9]

The following reactions occur on the metal surface in an environment containing chloride and oxygen.

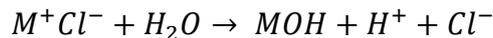
The anodic reaction inside the pit:



It is balanced by cathodic reaction at the top on the surface:



Gradually, the whole surface will be exposed for electrolyte containing oxygen. This leads to reductions of oxygen inside the pit. The metal will continue to dissolve and lead to excess of positive ions M^+ and chloride ions Cl^- migrate from electrolyte to keep neutrally charged.



This formation of $MOH + H^+ + Cl^-$ is called hydrolysis. H^+ ions and chloride are preventing repassivation, generate free acid and lower the pH value at the bottom of the pit. [9]

2.7 Crevice Corrosion

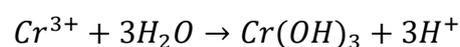
Crevice corrosion is localized attack in shielded areas on the metal surface exposed to corrosive environments. They are unpredictable in chloride containing environments and can lead to various types of failures.[17] Crevice corrosion can be divided into three types of processes: electrochemical reactions, homogeneous chemical reaction and mass transport. The electrochemical reaction imply for dissolution and reduction reactions. The homogenous chemical reactions contain hydrolysis, precipitation reactions and homogeneous oxidation/reduction reactions of the dissolved metal. Generally, mass transport by diffusion and convection leads to large differences in concentration and electrochemical potential. The mechanism of propagation of crevice corrosion is very similar to pitting corrosion. The initiation is different, though pitting corrosion can lead to crevice corrosion.[19]

2.7.1 Mechanism of Crevice Corrosion

Processes for crevice corrosion can be explained with the figure below, where it is considered electrolyte to have uniform composition. The whole metal surface will be exposed for corrosion, and the anode and cathode process occurs, as described in pitting corrosion. In these circumstances, it generates positive metal ions and counterbalanced electrostatically negative hydroxyl ions (see Figure 5 a). With a lack of oxygen inside the gap, the cathodic process is prevented, and resulted in less negative hydroxides. This will give excess of positive ions in the gap and cause negative ions of bulk electrolyte to spread inside and maintain potential energy as low as possible. Complex ions between chlorides, metal ions and water molecules are formed, which lead to hydrolysis that result to lower pH and corrosion. This can be written as followed:



Based on the reaction, hydrogen ions are made, which increase the speed of metal ions and lead to more chlorides inside the gap. Austenitic Stainless Steel contains chromium, hydrolysis of chromium lead higher acidic environment and can be written as follows: [5]



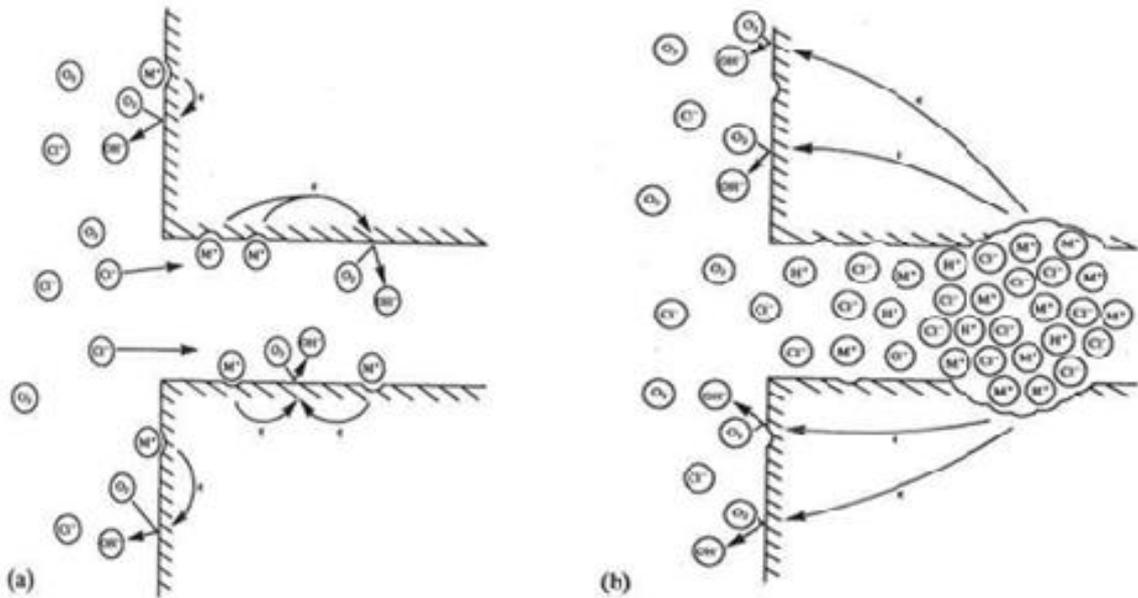


FIGURE 5:A) INITIAL CONDITIONS: OCCURS UNIFORM OVER THE SURFACE AND INSIDE THE GAP. B) FINAL CONDITIONS: OCCURS ONLY INSIDE THE CREVICE.[5]

2.8 Austenitic Stainless Steel

Austenitic stainless steel is divided into standard SAS grades and nonstandard grades, where the standard grades are further subdivided into AISI 200- or 300-series [2] and are the most common of stainless steel. The 300-series contains chromium-nickel (16-26%Cr-6-22% Ni) alloys, and the 200-series replace some of the nickel with manganese and/or nitrogen. Austenitic stainless steel have high resistance properties for corrosion, excellent cryogenic properties and great high-temperature strength. They are also easily welded and nonmagnetic, if they are required in a nonmagnetic area.[1] Due to the chemical composition and microstructure, it has low mechanical strength and poor wear resistance. [20] General structure for austenitic are very tough and ductile, which give a large range of applications. For hardened the steel must be cold deformation instead by quench hardening, because crystal structure should remain austenitic through thermal treatment. The figure below show how different stainless steel are linked together. [1]

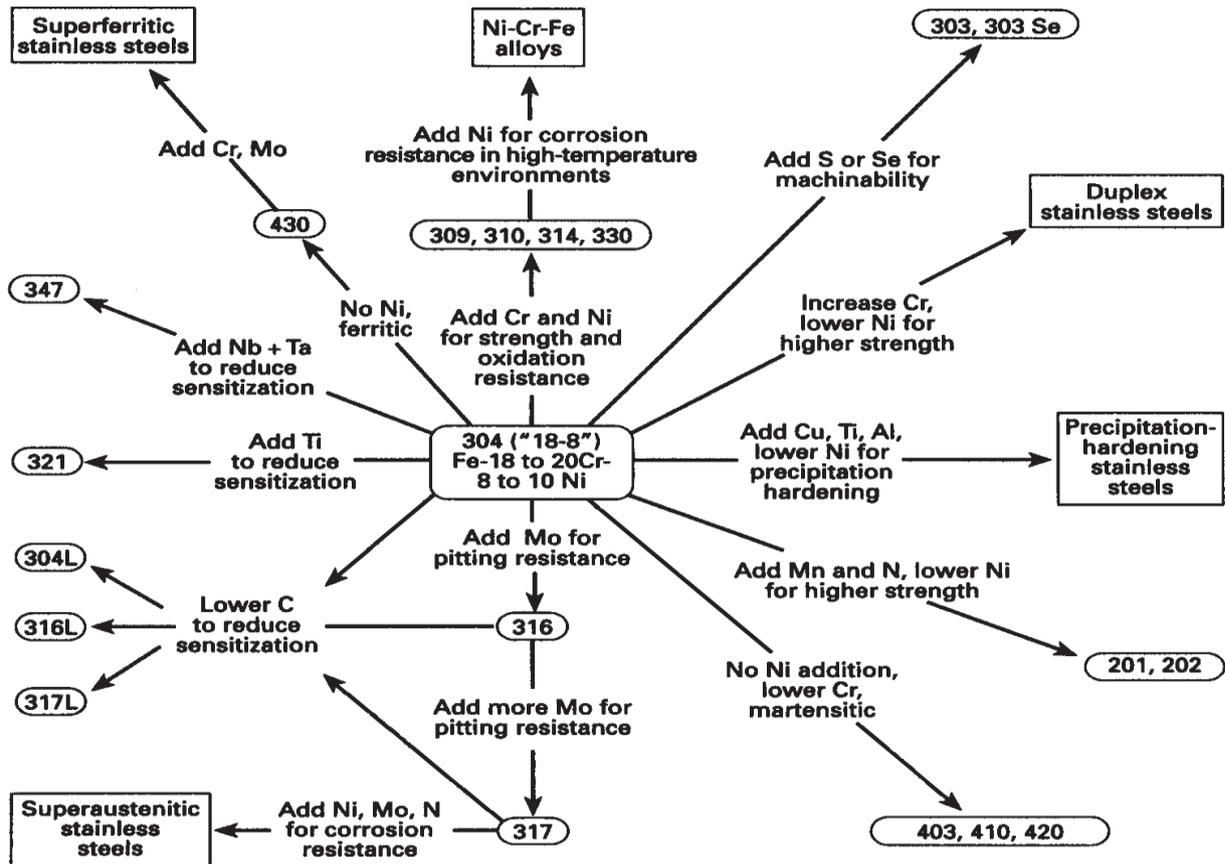


FIGURE 6: FAMILY TREE FOR STAINLESS STEEL ALLOYS.[15]

Austenitic steel contains chromium, nickel, molybdenum copper, silicon, aluminum, titanium, niobium/tantalum and nitrogen to improve the stainless steel. [2]

Molybdenum improve excellent corrosion resistance in oxidizing environments and increases pitting potential. It also strengthens the passive film along with chromium and nickel. In addition, chromium increases the area of passivity, lower down for repassivation and higher pitting potential. [11] For chloride attacks, nitrogen, chromium and molybdenum increases the resistance against it. Nitrogen is also an austenite stabilizer, austenite strengthener and retards sigma-phase formation. [21] Copper is used to increase resistance against sulfuric acid attack. Silicon improves oxidation resistance and corrosion resistance by oxidizing acids.[1] The pitting resistance formula for austenitic stainless steels are written below as:[21]

$$PRE = Cr \text{ wt}\% + (3.3 \times Mo \text{ wt}\%) + (16 - 30 \times N \text{ wt}\%)$$

2.8.1 Austenitic Stainless Steel 316L/UNS S31603

General chemical, mechanical and physical properties of 316L are presented in tables below.[15, 22, 23]

TABLE 1: CHEMICAL PROPERTIES OF 316L

UNS number	Name	Cr%	Ni%	C% max	Mn% max	Si% max	P% max	S% max	N% max	Mo%
S31603	316L	16-18	10-14	0.03	2.0	1.0	0.045	0.030	0.10	2.0-3.0

TABLE 2: MECHANICAL PROPERTIES OF 316L.

Name	Tensile Strength (MPa)	Yield Strength (0.2% offset) (MPa)	Elongation (%)	Hardness Rockwell B
316L	517	220	50	79

TABLE 3: PHYSICAL PROPERTIES OF 316L.

Name	Density (kg/m ³)	Elastic Modulus (GPa)	Mean Co-eff of Thermal Expansion ($\frac{\mu m}{m/^\circ C}$)	Thermal conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Electrical Resistivity (nΩ.m)
			0-100 °C	100°C	500°C		
316L	8000	193	15.9	16.3	21.5	500	740

316L is widely used in marine and chemical industry environment due to excellent pitting resistance. By adding molybdenum, the PRE-value will increase with 6.6- 9.9.[15]

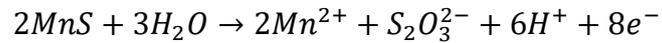
2.9 Marine Atmosphere Corrosion

Marine atmosphere is an extremely corrode environment and is caused of combined effects of the sun, temperature, oxygen, moisture and salt that consist in the air. There are used corrosion-resistant metals, nonmetallic materials and protective coatings to prevent this kind of corrosion. [24] Atmospheric corrosion is an electrochemical process rely on electrolyte that may come from rain, dew, humidity or melting snow.

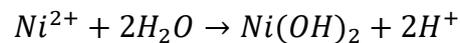
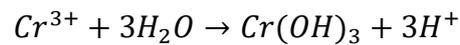
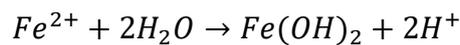
Generally, marine atmosphere corrosion is a combination of dry and wet conditions, called splash zone.[9] Seawater will splash on the metal surface and cyclic drying seawater. The seawater can cause superficial erosion, crystallization of salts and chemical attack by salts like sulfates and chlorides. This can lead to micro cracking, pitting, crevice and other types of corrosion. [25]

Marine environments are mostly exposed to chloride attack, the quantity of chlorides are increasing proportional to the distance from the shore. [11] Chloride ions break

down the passive film, leading to local corrosion. In 316L, pitting initiation may start with dissolution of MnS in the presence of salt water. The reaction formula is written below:



This will decrease the pH value followed by dissolution of alloy elements (Fe, Cr, Ni) leading to pitting corrosion. The dissolved metals ions (Fe^{2+} , Cr^{3+} , Ni^{2+}) creates a hydrolysis reactions with even lower pH that before. This starts a self-catalytic action, leading to deeper and larger pits. Formula is written bellows.[26]



2.10 Passivation

Stainless steel has corrosion resistance due to a passive chromium-rich oxide layer that forms naturally on the surface. This state is called passivation. Generally, passivation develops naturally, but in very aggressive environments it could be necessary to assist the process with oxidizing acid treatments. [27] Passivation process is a chemical treatment with an oxidant acid passivation solution and this process dissolves any carbon steel impurity and sulphide inclusions from the surface. This will spontaneously form a chemically inactive surface exposed for air or other oxygen-containing environments. [28, 29]Some types of advantages of passivation is mentioned below:[30]

- Greater corrosion resistance
- Uniform, smooth appearance and finish
- Cleanliness
- Improved and extended life of the steel

2.11 Pickling

Pickling is used to remove the surface impurities as oxide scales and the Cr-depleted layer at elevated temperatures.[31] This is typically used where steel has been exposed for high heating, like welding, heat treatment or grinding. The surface will be exposed for lack of chromium and this causes lower corrosion resistance. The corrosion properties can be restored by removing the damaged metal layer. Generally, pickling

involves using acid mixture containing hydrofluoric acid (HF) and nitric acid (HNO_3), and frequently sulphuric acid (H_2SO_4).[29] Pickling can be classified in three categorized:[32]

- Pickling with pickling paste/gel
- Pickling with pickling solution
- Pickling in a bath

2.12 Electrochemical Testing

Laboratory testing is used to quality control, materials selection, materials properties and environmental conditions checking for corrosion mechanism. The test is accelerated to save time and budget. [14]

Corrosion is an electrochemical process of oxidation and reduction reactions. During this reaction, metal (oxidation) discharged electrons to elements (reduction) in the corroding solution through electrolyte. The flow of electrons create a current that can be measured and controlled electronically. By controlling this process, corrosion properties of metals can be measured in different kind of electrolyte solutions.

A practical experiment consists of a polarization cell in an electrolyte solution containing a reference electrode, a working electrode (sample) and a counter electrode. A potentiostat is an electronic instrument and used to connect the electrode together. The potentiostat is used to measure the corrosion potential (E_{corr}) between the reference electrode and working electrode. This is illustrated in the figure below.[33]

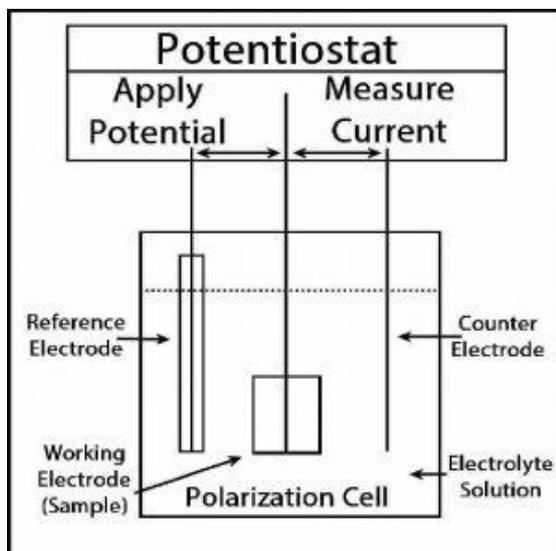


FIGURE 7: SETUP FOR A POLARIZATION CELL.[33]

2.12.1 Method for Cyclic Potentiodynamic Polarization

Cyclic Potentiodynamic polarization is applied to determine relative susceptibility to localized corrosion as pitting and crevice corrosion. This method is used to measure iron-, nickel, or cobalt-based alloys in chloride environments. [14] When analyzing the Potentiodynamic experiments, there are two features to look after: the pitting (breakdown) potential (E_{pitt}) and repassivation potential (E_{re}). The potential takes place when pitting corrosion begins, by increasing potential. The repassivation potential takes place after the hysteresis loop is completed, after a performed reverse scan. As shown in the figure below, when the reverse scan crosses the forward scan at the potential graph, repassivation occurs. This kind of experiments produces analytical data to pitting-, crevice corrosion and passivation behavior. [14, 33] Ideally, the difference between the pitting potential (E_{pitt}) and the repassivation potential (E_{re}) should be as low as possible to give great pitting resistance. [34]

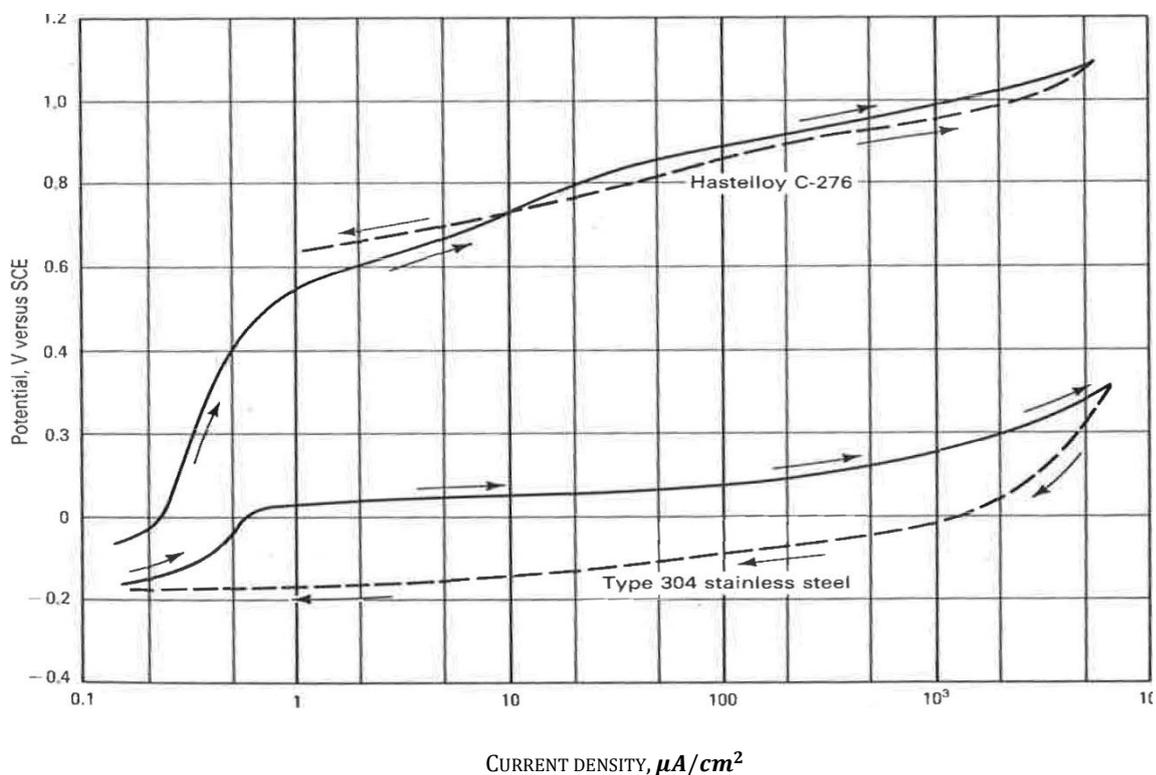


FIGURE 8: POTENTIODYNAMIC CYCLIC POLARIZATION CURVES.[14]

2.13 X-ray

2.13.1 Detection of X-rays using Energy Dispersive Spectrometer (EDS)

EDS or X-rays are an analytical technique used to determine which elements (qualitative) and how large amounts (quantitative), which is present in the sample. This

technique is built around the physical laws of all elements follow, and with this method it is the emission spectrum of the X-rays of the elements studied, the characteristic X-rays.

The detector used to capture the X-ray is a solid-state detector. The detector consists of a silicon crystal doped with lithium. The detector absorbs the energy of the incoming X-rays through ionization. This absorption of X-ray further converts the energy from the individual X-rays to an electrical voltage of a proportional size. This voltage thus corresponds to the characteristic X-ray of the element in the sample.

Another alternative to EDS is wavelength dispersive spectrometer, or WDS. It measures the wavelength of the incoming X-ray signal with use of Bragg's law, and is accurate in detecting specific elements in a sample. [35]

2.13.2 Characteristic X-rays

The characteristic X-rays arise when an electron orbits around an atom, which is then affected so that it changes shells. The process behind this jump will be interaction between incoming electrons in the beam current and the electrons in the inner paths of the element in the sample.

The inner shells from inside-outwards belong to certain energy levels, and are called K-, L- and M-shells.

A photon will be emitted if an atom is excited and afterwards returns to the ground state. This photon or the X-ray will have a certain energy level that matches the difference between the initial and the final shell electron lands in. This is called characteristic X-rays.

The wavelength of the emitted photons decreases as the atomic number increases. The relationship between this is given by Moseley's law:

$$\lambda = \frac{K}{(Z - \sigma)^2}$$

K and σ are constants

Z is atomic number

This ratio allows measuring the wavelength of the emitted photon to find the composition of the element in the sample. [35]

2.13.3 Quantitative X-rays analysis

The most used method of quantitative X-ray analysis is ZAF, and is used for EDS-systems. The principle is to compare the sample with a standard with known composition. For best possible analysis, the sample should as much as possible be equal to the standard. In addition, it also depends on other parameters such as current, acceleration voltage and outlet angle. Molybdenum K-shell critical excitation voltage is 20.01 kV. Due to that, molybdenum K-shell characteristic X-rays won't appear before 25kV spectrum. [35]

2.13.4 X-ray Fluorescent (XRF)

XRF is a method which involves an interaction between X-rays and electron beams.[36] Fluorescence are formed by characteristic X-rays from an element excite atoms in another element. These atoms will then emit characteristic X-rays when they return to ground state. In order for fluorescence to occur, the energy of the characteristic X-ray of one element must be greater than the excitation energy of the other element. [35] Every elements that release fluorescence energy has individual energy in order to categorize it. [37]

2.13.4.1 Positive Material Identification (PMI) Testgun

PMI uses XRF technology to determine elements qualitative and quantitative. They present quick, simple and completely non-destructive analyses for almost every elements between Magnesium to Uranium. This method requires just a clean surface before testing and can also analyze small samples. [38]

3 Material and methods

The main purpose of this work was to study and compare visual effect, pitting potential and repassivation potential after different repassivation treatment, exposed for simulated marine atmosphere for different time periods. The pitting potential and repassivation potential were determined with standard ASTM G61-86. Another interest for this work was to check the certification chemical composition and compare some critical values. It was performed pre-experiments to achieve a uniform layer with general corrosion, and the samples were named 0.1-0.6. The main experiments were performed over three different time periods; none, first and second round in the marine atmosphere. Accordingly, the samples were marked with three numbers (A.B.C), where the first number A, indicates how long time periods the samples have been exposed, starts with none, first and second round in the marine atmosphere. The second number B, indicates which repassivation products was being treated with or without, exception of the reference samples. The last number C, says there are three parallel samples for each experiment. All samples were damaged by a grinder, except two reference samples that were used further on ASTM G61-86, and seven repassivation products were used on the samples, with three parallel samples for each experiment i.e. 57 samples in total.

Samples 1.1.1-1.1.3 and 2.1.1-3.8.3 were damaged by a rotary steel brush, equipped on a grinder with hard braided threads to break down the samples passivation layer, and samples 1.2.1-1.3.3 were damaged by nothing. Afterwards, samples 2.1.1-3.8.3 were exposed for the marine atmosphere and treated with repassivation products. Finally, samples 3.1.1-3.8.3 were exposed a second round for the marine atmosphere and again treated with the same repassivation products. Table 4 shows an overview matrix that was followed for the main experiments. There is also Table 5 that shows which pickling- and repassivation products used for the samples. Finally, it was performed chemical analysis for several areas, deciding the chemical composition.

TABLE 4: OVERVIEW OF EXPOSED ENVIRONMENTS ON THE SAMPLES.

Exposed for	Nothing	Marine atmosphere	
		1 round (5days)	2 rounds (total of 10 days)
Samples:			
1.1.1, 1.1.2, 1.1.3	X		
1.2.1, 1.2.2, 1.2.3	X		
1.3.1, 1.3.2, 1.3.3	X		
2.1.1, 2.1.2, 2.1.3		X	
2.2.1, 2.2.2, 2.2.3		X	
2.3.1, 2.3.2, 2.3.3		X	
2.4.1, 2.4.2, 2.4.3		X	
2.5.1, 2.5.2, 2.5.3		X	
2.6.1, 2.6.2, 2.6.3		X	
2.7.1, 2.7.2, 2.7.3		X	
2.8.1, 2.8.2, 2.8.3		X	
3.1.1, 3.1.2, 3.1.3			X
3.2.1, 3.2.2, 3.2.3			X
3.3.1, 3.3.2, 3.3.3			X
3.4.1, 3.4.2, 3.4.3			X
3.5.1, 3.5.2, 3.5.3			X
3.6.1, 3.6.2, 3.6.3			X
3.7.1, 3.7.2, 3.7.3			X
3.8.1, 3.8.2, 3.8.3			X

TABLE 5: OVERVIEW OF PICKLING OR/AND REPASSIVATION PRODUCTS USED ON THE SAMPLES.

Products	None	Valhall			Corrogel Offshore	Avesta (cleaner, pickling, passivati-on)	Avesta (cleaner, passivatio-n)	Innotek Beise spray 2020
		Green -Gel	Ultra -Gel	Clean -Gel				
Samples:								
1.1.1,2,3 1.2.1,2,3 1.3.1,2,3 2.1.1,2,3 3.1.1,2,3	X							
2.2.1,2,3 3.2.1,2,3		X						
2.3.1,2,3 3.3.1,2,3			X					
2.4.1,2,3 3.4.1,2,3				X				
2.5.1,2,3 3.5.1,2,3					X			
2.6.1,2,3 3.6.1,2,3						X		
2.7.1,2,3 3.7.1,2,3							X	
2.8.1,2,3 3.8.1,2,3								X

3.1 Background of the thesis

There are significant challenges with external pitting- and crevice corrosion of 316L in form of piping in the oilfield. These are: presence of marine atmosphere containing chlorides, the temperature and humidity. These sort of problems has cost a lot of money, replacing and maintaining. There has been clear indications of these problems over the past decade and could be related to manufacture's new technique of minimizing the alloy content. According to ASTM specifications, Molybdenum should stay between 2-3%. Molybdenum provide great resistance to localized corrosion. Another indication could be changing content of blasting operation from silica sand to iron and copper contamination slag.[3]

In this thesis the pitting and crevice corrosion resistance of 316L in marine atmosphere will be investigated and assessed. Various passivation and pickling products will be tested, evaluated and compared on corroded 316L plates, to see whether there are products that actually have any remarkable effect on corrosion resistance. If it turns out that a product can provide a good effect, it will be a big win for AkerBP, by reducing the paint programs and reduce costs. There will be performed electrochemical testing according to ASTM standard G61-86, by comparing the pitting- and repassivation potential. The chemical composition will also be investigated with a literature study focusing on the corrosion properties of 316L mainly in a marine/offshore atmosphere.

3.2 Material Certificate

Material tested are prime cold rolled stainless steel sheet of grad UNS S31603/ W 1.4404. The material was delivered as two plates with dimension 1.2mm x 1250.0mm x 2500.0mm produced in Taiwan. The material certification gives information about material mechanism properties and chemical composition in weight %, and can be found in appendix A. Quality assurance were managed by Jian Yi Guo department and shown in Table 6 and Table 7.

TABLE 6: MECHANISM PROPERTIES.

	Tensile Strength (MPa)	Yield Strength (0.2% offset) (MPa)	Elongation (%)	Hardness Rockwell B
Measured value	599	306	55	79
Minimum value	517	220	50	79

TABLE 7: CHEMICAL COMPOSITION.

	Cr%	Ni%	C%	Mn%	Si%	P%	S%	N%	Mo%
Measured value	16.81	10.10	0.022	1.03	0.65	0.034	0.002	0.012	2.01
Minimum value	16	10	-	-	-	-	-	-	2.0
Maximum demand	18	14	0.03	2.0	1.0	0.045	0.030	0.10	3.0

3.3 Machining and performance

Cutting of the samples was performed with a plate scissor, due to plate thickness. On the table a hydraulic piston holding the plate when cutting and a guillotine to which divided the plates was used. The plate scissor was set to correct dimensions, measured with digitally caliper before cutting. The plate scissor is shown in the figure below.



FIGURE 9: THE PLATE SCISSOR.

For the pre-experiments, a sandblaster, sanding belt and wire brush were used. Also, a rotary steel brush equipped on high-speed air compressor with soft threads, battery operated drill machine with soft threads, or grinder with hard braided threads.



FIGURE 10: LEFT: SANDING BELT, MIDDLE: SANDBLASTER AND RIGHT: WIRE BRUSH.



FIGURE 11: LEFT: HIGH-SPEED AIR COMPRESSOR, MIDDLE GRINDER AND RIGHT: BATTERY OPERATED DRILL.



FIGURE 12: ROTARY STEEL BRUSH, LEFT: HARD- AND RIGHT: SOFT THREADS.

3.4 Pre samples for generate corrosion

Pre-experiments were performed to achieve general corrosion over the whole surface. Different kind of techniques were used to break down the passivation layer of samples and afterward placed in a bucket of seawater, or outside exposed for simulated marine atmosphere to generate general corrosion. A stopwatch or timer was used to take the time for each process. Sample 0.1, 0.2, 0.3, 0.4 and 0.5 were cut with the same length and width, shown in the figure below.



FIGURE 13: SAMPLE 0.1-0.5.

Sample 0.1 was exposed for sanding belt, shown in Figure 10, for 2min at each side. Afterwards was sample 0.2 damage by a steel brush for 3min at each side, shown in figure 10. Next sample 0.3 was exposed for sandblast, also shown in Figure 10 for 1min at each side. Both samples 0.4 and 0.5 were damaged by a rotary steel brush with soft threads for 2min at each side, but sample 0.4 was equipped with a battery operated drill and sample 0.5 with a high-speed air compressor. Every sample was then placed in a bucket with seawater for 2 weeks. The seawater used for the first week was collected in Hafrsfjord and afterwards replaced with seawater gathered from the North Sea, but the bacteria were filtered. The figure below displays the samples inside the bucket.

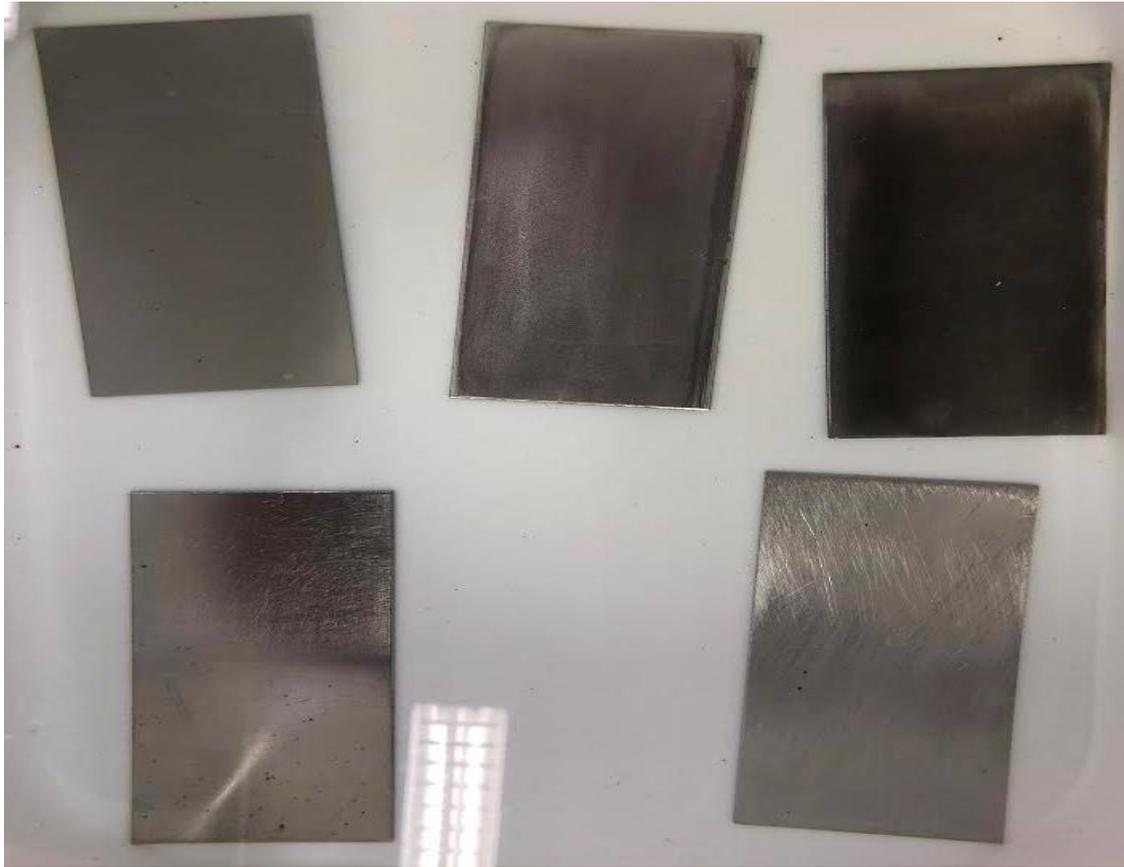


FIGURE 14: TOP LEFT: 0.3, TOP MIDDLE: 0.5, TOP RIGHT: 0.4, BOTTOM LEFT: 0.2 AND BOTTOM RIGHT: 0.1.

Afterwards sample 0.5 was placed in the simulated marine atmosphere for 2 weeks. The simulated marine atmosphere was 100 meter away from the coast, placed on the second floor outside on a balcony facing the coast, but protected against the rain. The sample was sprayed with seawater three times each day, on both sides, where the seawater was gathered from the coast. The figure below illustrates this simulation.

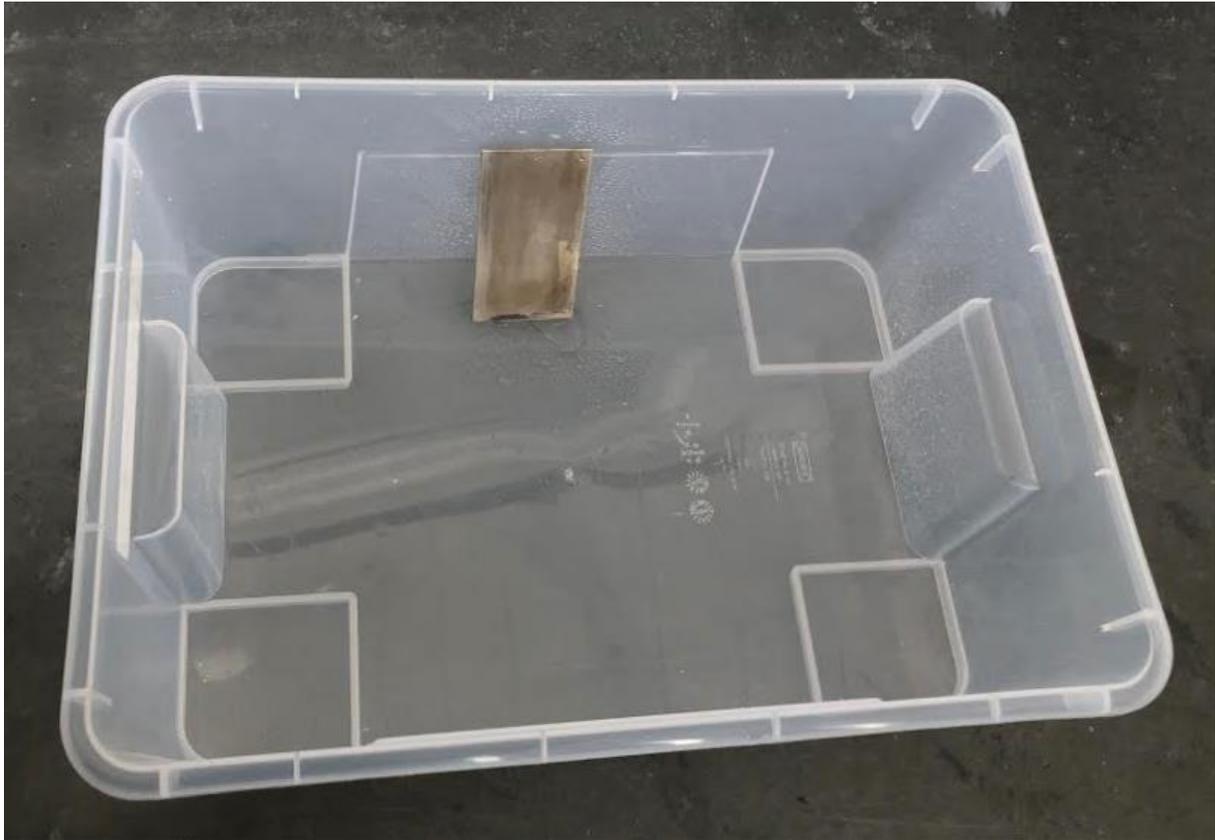


FIGURE 15: SAMPLE 0.5 EXPOSED FOR MARINE ATMOSPHERE.

Sample 0.6 was exposed for rotary steel brush, with hard braided threads, equipped on a grinder for 2min at each side. Then it was exposed for marine atmosphere for 3 days with the same procedure written above. Sample 0.6 and 1.1.1-3.8.3 were all cut in the same dimension 9cm x 9cm, shown below.



FIGURE 16: SAMPLE 0.6 AND 1.1.1-3.8.3 BEFORE ANY PREPARATIONS.

3.5 Specimen Preparation for generate corrosion

After the pre samples tested were finished and studied, the actual tests could begin. Samples 1.1.1-1.1.3 and 2.1.1-3.8.3 were all exposed for rotary steel brush with hard braided threads, equipped on a grinder for 2min at both sides. Afterwards samples 2.1.1-3.8.3 were exposed for the first round of marine atmosphere with the same procedure written above. Next they were treated with different repassivation products, described in subchapter: “Repassivation” underneath chapter 3, material and methods. After that, samples 3.1.1-3.8.3 were exposed, for the second round, of marine atmosphere and treated with different repassivation products. The figure below shows some of the samples exposed for the marine atmosphere.

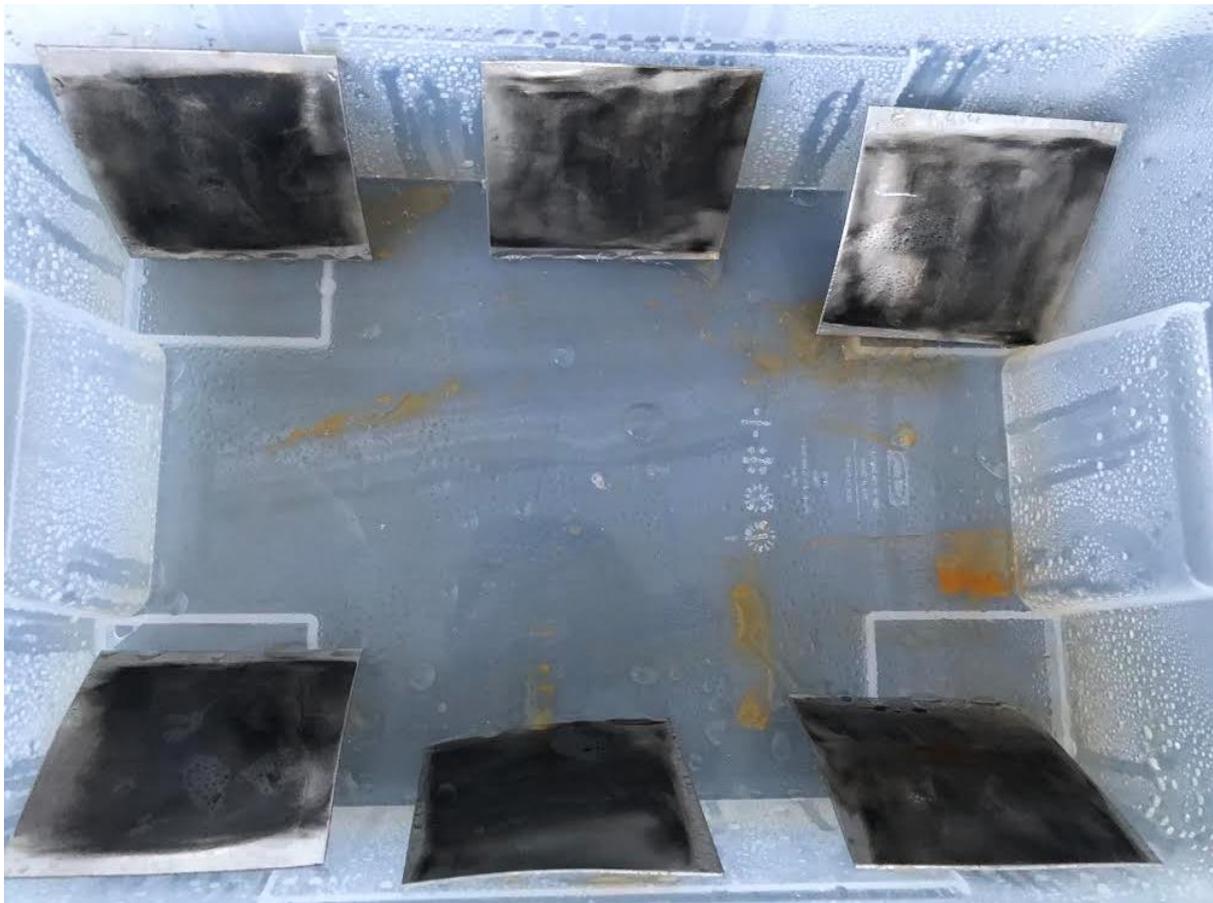


FIGURE 17: SOME SAMPLES EXPOSED FOR MARINE ATMOSPHERE.

3.6 Repassivation

Most of the samples were treated with different repassivation products, which can be found in Table 5 and were performed with supplier’s recommended procedures. Valhall GreenGel, UltraGel and CleanGel samples were dipped down as it covered the entire surface and kept on for 24 hours in room temperature, then washed off with water.

Before using Corrogel Offshore product, the container had to be shaken before use. Afterwards the samples should be brushed on and washed off with water, after 30min in room temperature. This step was done one more time, leaving the repassivation product on for 3 hours, then washed off.

Avesta products were performed in 3 steps on the samples: Cleaner, pickling and passivation. The cleaner product was applied with a brush on the samples, and left to work for 30min in a temperature of 10 degrees, then washed off. The pickling container had to be shaken before use and was applied with an acid-resistant brush. The solution was removed after 90 min and cleaned with water. Eventually the samples were treated with passivation product and removed with water after 20min. All of the waste water were treated before emission.

The last product, Innotek was applied with an acid-resistant brush on the samples. This was performed in a temperature of 10 degrees and the acid was removed after 3 hours with water. The waste water was also treated before emission.

The table below shows what the products contain. According to HOCNF(Harmonized Offshore Chemical Notification Format), products categorized under yellow and green, is normally granted for emission without any specified terms. [39]

TABLE 8: OVERVIEW OF WHAT THE PRODUCTS CONTAIN AND ENVIRONMENTALLY FRIENDLY.

Product	Hazardous ingredients	Contain	HOCNF
Valhall GreenGel	Inhibitor Citric acid Colour Thickener	<2% 6-12% <0.01 <2%	Green
Valhall UltraGel	Inhibitor Phosphoric acid Citric acid Colour Thickener	<2% <30% <15% <0.01 <2%	Yellow
Valhall CleanGel	Inhibitor Phosphoric acid Citric acid Colour Thickener	<2% <5% <30% <0.01 <2%	Yellow
Offshore CorroGel	Phosphoric acid	10-24%	Yellow
Avesta Cleaner 401	Phosphoric acid Dodecylpoly (ethylene glycol ether) Heksa fluosilici acid	12.5-25% 2.5-5% 0.1-2.5%	-
Avesta BlueOne Pickling Paste 130	Hydrofluoric acid Nitric acid	5-12.5% 12.5-25%	-
Avesta FinishOne Passivator 630	Hydrogen peroxide	2.5-5%	-
InnoTek Beise Sray 2020	Hydrofluoric acid Nitric acid	<7% <25%	-

3.7 ASTM G61 Test

Standard ASTM G61 – 86 (reapproved 2014) states, “Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys”. This test was performed to determine the pitting potential and repassivation potential. [40]

3.7.1 Preparation

A reference electrode, a counter electrode and a working electrode in a sodium chloride solution was used to perform the conducting Potentiodynamic polarization test. All the samples were cut in long rectangular shapes so that it could be simple to measure the

area in the solution. There was also made some trial experiments for testing and preparation. The values for Open Circuit Potential (OCP) are specified in the figure below.

Chart	Experimental Setup	Experimental Notes	Hardware Settings
Potentiostat	PCI4G750-51101	Pstat Model	Series-G 750
Control Mode	Potentiostat	Current Convention	Anodic
Control Amp Speed	Medium	I/E Stability	Norm
I/E AutoRange	<input checked="" type="checkbox"/> On	I/E Range	75 mA
Ich Auto Range	<input checked="" type="checkbox"/> On	Vch Auto Range	<input checked="" type="checkbox"/> On
Ich Range	3 V	Vch Range	30 V
Ich Filter	5 Hz	Vch Filter	5 Hz
Ich Offset Enable	<input type="checkbox"/> Off	Vch Offset Enable	<input type="checkbox"/> Off
Ich Offset (V)	<input type="text" value="0"/>	Vch Offset (V)	<input type="text" value="0"/>
Positive Feedback IR Comp	<input type="checkbox"/> Off	Positive Feedback Resistance	<input type="text" value="0"/>
I/E Range Lower Limit	7.5 nA	Ach Range	3 V
DC Calibration Date	13.9.2017	AC Calibration Date	13.9.2017
Framework Version	5,67		

FIGURE 18: HARDWARE SETTINGS FOR OCP.

Value as initial-, peak-, final potential, forward-, reverse scan, sample area and sample period were selected before the cyclic polarization test. The values selected are shown in the figure below.

Chart	Experimental Setup	Experimental Notes	Open Circuit Voltage	Hardware Settings
Initial E (V)	<input type="text" value="-1"/>	<input checked="" type="radio"/> vs. E _{ref}	<input type="radio"/> vs. E _{gc}	
Apex E (V)	<input type="text" value="1.6"/>	<input checked="" type="radio"/> vs. E _{ref}	<input type="radio"/> vs. E _{gc}	
Final E (V)	<input type="text" value="-1"/>	<input checked="" type="radio"/> vs. E _{ref}	<input type="radio"/> vs. E _{gc}	
Test Identifier	<input type="text" value="Cyclic Polarization Scan 3.6.3"/>			
Date	<input type="text" value="15.3.2018"/>			
Time	<input type="text" value="16:26:22"/>			
Forward Scan (mV/s)	<input type="text" value="0.5"/>	Reverse Scan (mV/s)	<input type="text" value="0.5"/>	
Sample Period (s)	<input type="text" value="1"/>	Apex I (mA/cm ²)	<input type="text" value="15"/>	
Sample Area (cm ²)	<input type="text" value="1"/>			
Density (g/cm ³)	<input type="text" value="7.87"/>			
Equiv. Wt	<input type="text" value="27.92"/>			
Conditioning	<input type="checkbox"/> Off	<input type="text" value="15"/> Time(s)	<input type="text" value="0"/> E(V)	
Init. Delay	<input type="checkbox"/> Off	<input type="text" value="300"/> Time(s)	<input type="text" value="0.1"/> Stab.(mV/s)	
IR Comp	<input type="checkbox"/> Off			
Equil. Time (s)	<input type="text" value="0"/>			
Open Circuit (V)	<input type="text" value="-0.11267"/>			

FIGURE 19: EXPERIMENTAL SETUP FOR CYCLIC POLARIZATION TEST.

3.7.2 Apparatus/equipment

- Working Electrode (sample)
- Reference Electrode
- Counter Electrode
- Beakers
- Gamry Potentiostat
- Thermometer
- Digital caliper
- Parafilm and airtight tape
- Sartorius weight
- Nitrogen tank
- Plastic pipes

3.7.3 Producers

The sample was set in beaker containing distilled water before placed in ultrasonic bath for 5min and placed to dry. Meanwhile preparing the sodium chloride solution, 34 g of reagent grade NaCl was measured with a Sartorius weight and afterwards dissolved in

920 mL distilled water, giving 3.56% sodium chloride solution. 900 ml of the solution was relocated into the polarization cell and measured a temperature of 21 ± 2 °C. A lid was placed with hole for each electrode and the plastic pipe connected to the nitrogen tank on top of the beaker, and used Parafilm and airtight tape to make it airtight, shown in the figure below.

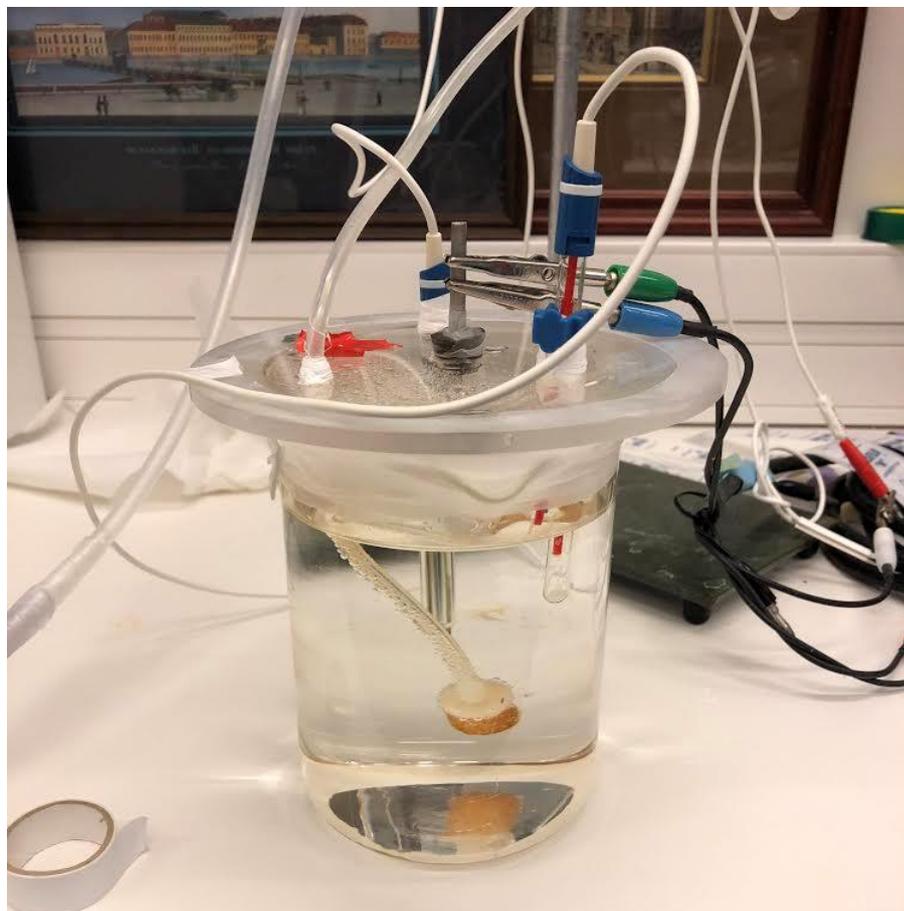


FIGURE 20: EXPERIMENT SETUP.

The working electrode and counter electrode were placed into the beaker, but the working electrode was placed above the solution level before purging nitrogen, due to risks of bubbles attached, leading to earlier pitting corrosion. Nitrogen was used to remove oxygen in the solution for 5min and afterwards the reference electrode was inserted and sealed the beaker. A digital caliper was used to measure 1cm^2 of the sample immersed in the solution. The Gamry software was started and every electrode were connected, and the open circuit potential (OCP) was run for 15min. After obtaining OCP graph, several values were added for initial-, peak- and reverse potential before initiating the cyclic polarization test. The pitting- and repassivation potential from the curve was obtained after approximately one and a half hour.

3.7.4 Deviation from Standard ASTM G61-86

As mentioned before, this test was based on ASTM standard G61-86 with a few deviations of the standard:

- **Specimen holder:** The standard recommends using a suitable holder, designed to expose 1cm^2 for electrolyte. This was performed different, but with same exposure area.
- **Grinding the sample:** The standard says that the sample should be wet grinded with 240- and 600-grit SiC paper, this was not done.
- **Removing the oxygen:** The oxygen was purged with gas for 5min instead of 60min.
- **Temperature:** The temperature used inside the solution was 21 ± 2 °C instead of 25 ± 1 °C.
- **Purification of the sample:** The sample was cleaned in ultrasonic bath with distilled water for 5min. The standard states that the sample should be cleaned in ultrasonic with detergent and water for 5min. Afterwards flushed with distilled water.
- **Potential scan rate:** It was used 0.5 mV/s instead of 0.17mV/s as potential scan rate.

3.8 Scanning Electron Microscope (SEM)

Energy dispersive spectrometer (EDS) for X-rays with predefined values in the EDAX (Standardless Element Coefficients: SEC default table) software was used to determine which elements (qualitative) and amounts (quantitative), which were presented in the samples. One sample (1cm X 1cm) was produced of each plate and cleaned with Acetone before inserted inside the chamber. Before the samples could be examined, there had to be vacuum inside the chamber, and a green chin came up on the screen when it was ready for examination. The working distance was adjusted to 10mm and acceleration voltage was set first to 15kV and 25kV afterwards. Then it had to be adjusted for focus, lens mistakes, contrast and brightness. Several areas and points were investigated to determine the elements weight percent. K-lines were selected for the elements to be determined, also L-lines and M-lines were required due to low acceleration voltages. The figure below shows the SEM and how the samples were mounted before inserted.

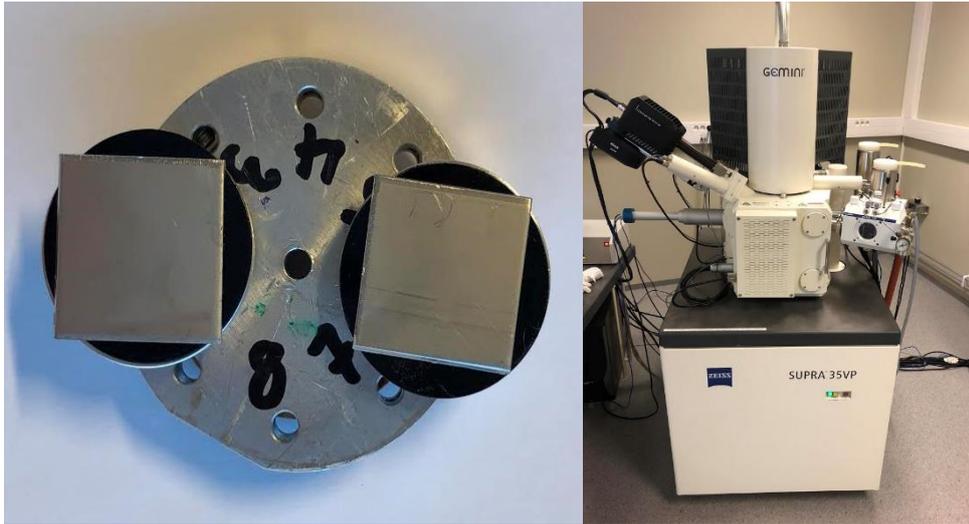


FIGURE 21: SAMPLE A AND B, AND SEM ZEISS SUPRA 35 VP.

3.9 Positive Material Identification (PMI)

PMI analyses were used to determine quantitative presented in the plates. One sample was used from each plate. PMI pistol was adjusted for stainless steel 316 and there were taken four analyses at each sample. Each analysis took 20 seconds before the results were ready. The figure below shows the PMI pistol.



FIGURE 22: PMI PISTOL.

3.10 Health, Safety and Environment (HSE)

In the workshop and at the laboratory there are several potential dangers, where personal protective equipment must be used. Safety shoes and coveralls should always be used, should be tight and flame retardant. It is also recommended to use safety goggles, gloves and hearing protection by using the plate scissor. By mixing or handling chemicals, there should always be used rubber gloves, safety goggles, and it should be mixed under drains. For some of the chemicals it is also a must to use a protective suit. For further information about used chemicals, read attachments in appendix B.

4 Results

4.1 Analysis of pre samples for generate corrosion

Poor signs of general corrosion was observed on samples 0.1, 0.2, 0.3 and 0.4, shown in the figures below, after being exposed to a damage treatment and seawater. There were some indications leading to undesirable pitting corrosion and also a little sign of discoloration a few places. The results obtained from these methods gave unpleasant results.



FIGURE 23: SAMPLE 0.1 AFTER BEEN EXPOSED FOR SANDING BELT AND SEAWATER.



FIGURE 24: SAMPLE 0.2 AFTER DAMAGED BY A STEEL BRUSH AND EXHIBITED BY SEAWATER.



FIGURE 25: SAMPLE 0.3 EXPOSED FOR SANDBLASTING AND SEAWATER.



FIGURE 26: SAMPLE 0.4 EXPOSED BY A ROTARY STEEL BRUSH WITH SOFT THREADS EQUIPPED ON A BATTERY OPERATED DRILL AND EXHIBITED BY SEAWATER.

After being exposed for rotary steel brush with high-speed and exhibited by seawater and marine atmosphere, this sample showed some indications of discoloration. There was no observation of any pitting corrosion at the surface. This example provided a little better result compared to sample 0.1-0.4, but it would have been more satisfying with a thicker and a more corrosive result.



FIGURE 27: SAMPLE 0.5 EXPOSED BY A ROTARY STEEL BRUSH WITH SOFT THREADS EQUIPPED ON A HIGH-SPEED AIR COMPRESSOR EXHIBITED BY SEAWATER AND MARINE ATMOSPHERE.

The last pre-test to generate general corrosion was achieved with a grinder, leading to the most effective method to expose the surface. The sample was exposed with high temperature and quick operation speed, and afterwards exhibited for marine atmosphere. Sample 0.6 delivered excellent results after just a few days in marine atmosphere, as shown in Figure 28. This result provided a uniform corrosion where the different repassivation products could have a lot to work with. It was hard to judge for unwanted pitting corrosion underneath, but it could be possible. This result gave the opportunity to proceed to the next step.

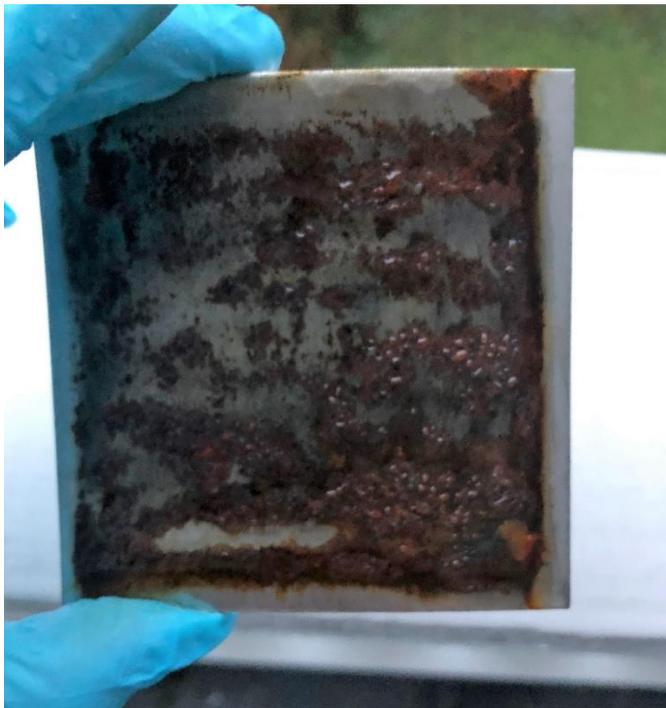


FIGURE 28: SAMPLE 0.6 EXPOSED BY GRINDER WITH ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS AND EXHIBITED FOR MARINE ATMOSPHERE.

4.2 Analysis of samples for generate corrosion and repassivation

Samples 1.1.1-1.1.3 and 2.1.1-3.8.3 were all exposed for rotary steel brush with hard braided threads equipped by a grinder and afterwards exhibited for marine atmosphere for 1 round. The figure below shows the results obtained and the rest of the results are found in appendix C. The samples have a general corrosion covering almost the whole surface, but some differences can be observed, especially at the edges.



FIGURE 29: SAMPLES EXPOSED FOR GRINDER AND MARINE ATMOSPHERE.

1.1.X samples were just damaged by the grinder without exposing for marine atmosphere, allowing us to compare for further use in subchapter 4.3 Analysis of ASTM G61-86 on 316L, shown in Figure 30. Figure 16 presents samples 1.2.X and 1.3.X as reference specimens, also used in subchapter 4.3 Analysis of ASTM G61-86 on 316L.



FIGURE 30: SAMPLE 1.1.X ONLY EXPOSED FOR GRINDER.

First time exposed for marine atmosphere repassivation

Every figure below in this subchapter, starting from the top left corner, begins with sample 2.X.1, middle 2.X.2 and 2.X.3 to the right. At the bottom from the left 3.X.1, middle 3.X.2 and 3.X.3 to the right.

Samples 2.1.X and 3.1.X were just exposed for marine atmosphere with non repassivation products and are shown in the figure below. As mentioned before, they are all exposed with the grinder and marine atmosphere, with the same amount of time.



FIGURE 31: SAMPLES 2.1.X AND 3.1.X WITH NON REPASSIVATION.

Samples 2.2.X and 3.2.X were repassivated with Valhall GreenGel for 24 hours, displayed in Figure 32 and Figure 33. In Figure 32, almost all of the corrosion was removed, but in Figure 33, there were some problems removing the gel product from the surface, leaving an uncleaned surface.



FIGURE 32: SAMPLES 2.2.X AND 3.2.X FRONTSIDE TREATED WITH VALHALL GREENGEL.

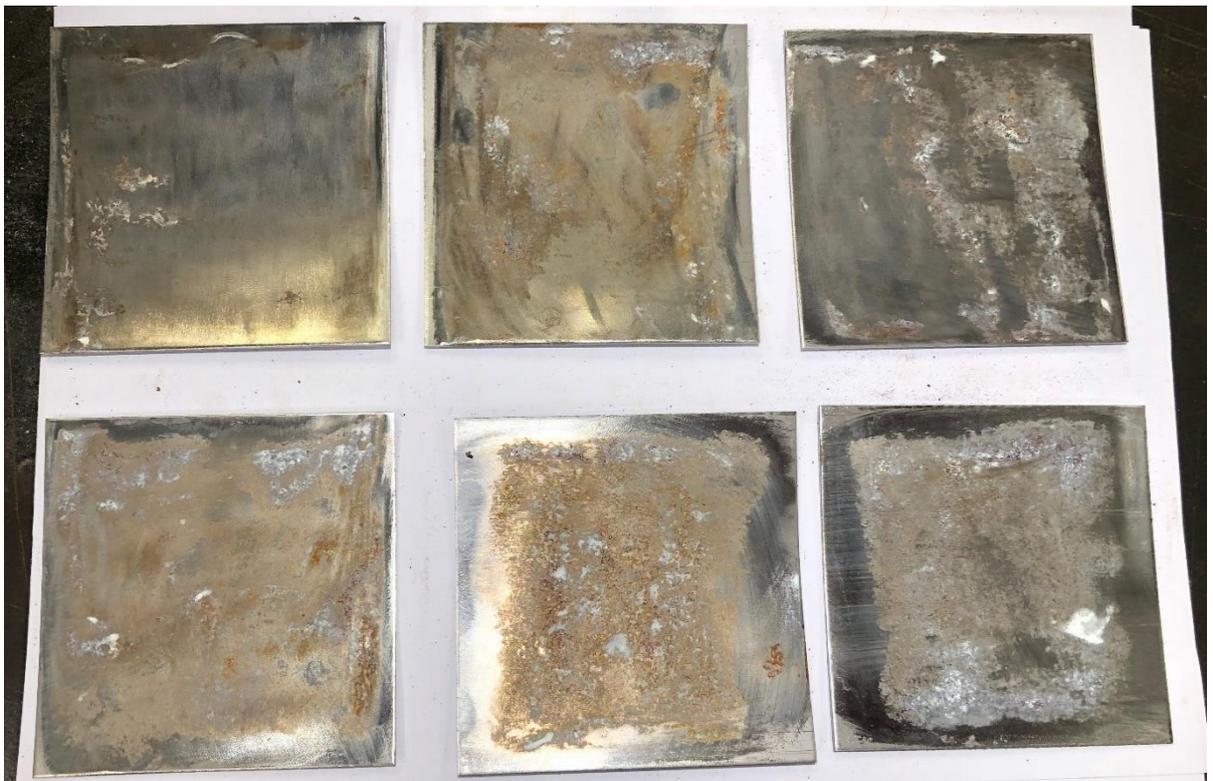


FIGURE 33: SAMPLES 2.2.X AND 3.2.X BACKSIDE TREATED WITH VALHALL GREENGEL.

Valhall UltraGel was applied for 24 hours on samples 2.3.X and 3.3.X and Valhall CleanGel on samples 2.4.X and 3.4.X , and removed all of the corrosion. It came up with extraordinary clean and blank surfaces.



FIGURE 34: SAMPLES 2.3.X AND 3.3.X FRONTSIDE TREATED WITH VALHALL ULTRAGEL.



FIGURE 35: SAMPLES 2.4.X AND 3.4.X BAKSIDE TREATED WITH VALHALL CLEANGEL.

By carrying out tests with Corrogel Offshore, the samples 2.5.X and 3.5.X came up with some mixed results. A few samples occurred with some corrosion and uncleaned surface, while other samples had it completely or almost removed. Figure 36 shows the varieties of the samples.



FIGURE 36: SAMPLES 2.5.X AND 3.5.X FRONTSIDE APPLIED WITH CORROGEL OFFSHORE.

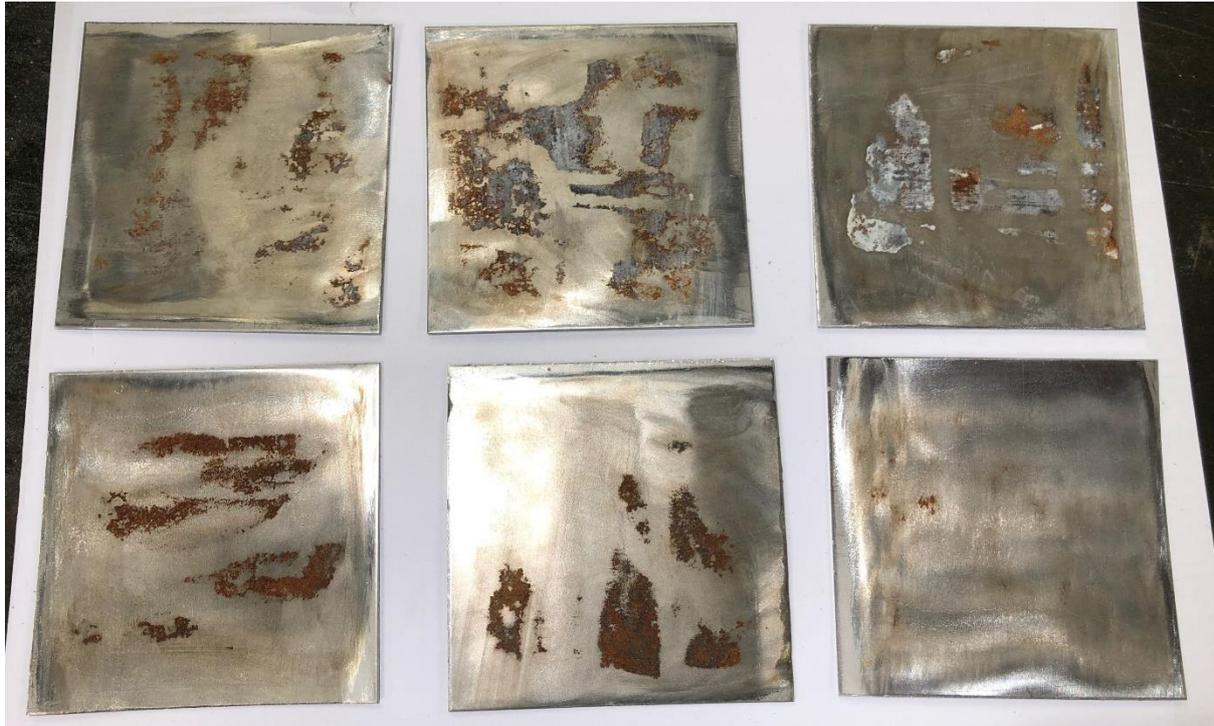


FIGURE 37: SAMPLES 2.5.X AND 3.5.X BACKSIDE APPLIED WITH CORROGEL OFFSHORE.

There were big variation between repassivation applied by Avesta with and without pickling. Samples 2.6.X and 3.6.X were exposed with Avesta cleaning, pickling and repassivation and provided a new clean and blank surface without any corrosion, and the damage from the grinder had almost disappeared. The samples treated without pickling presented unpleasant result, there were still plenty of corrosion left, the sample asses are shown below.



FIGURE 38: AVESTA WITH PICKLING.



FIGURE 39: AVESTA WITHOUT APPLIED PICKLING.

Samples 2.8.X and 3.8.X were exposed with Innotek. They performed very individually, as shown in the figure below. By looking at the figure, it is possible to see where it has taken effect and some places where it has been poorly treated.



FIGURE 40: SAMPLES 2.8.X AND 3.8.X EXPOSED WITH INNOTEK.

Second time exposed for marine atmosphere and repassivation

After samples 3.1.X were exposed a second time for marine atmosphere, it resulted to a little corroded samples. It can be seen in figure 41, a more uniform layer of general corrosion over the surface. The rest of the samples didn't show any development of general corrosion, they looked almost exactly the same, and the figure can be found in appendix D.



FIGURE 41: SAMPLES 3.1.X EXPOSED SECOND TIME FOR MARINE ATMOSPHERE.

Afterwards being exposed for marine atmosphere, samples 3.2.X-3.8.X were treated a new round with repassivation products. The improvement of samples 3.3.X, 3.4.X and 3.6.X were hard to tell a part due to the fact that the surfaces were already great, figures found in appendix E. Samples 3.2.X showed great changes after the repassivation, a little

more general corrosion was removed and the surface was cleaner without residue of gel product, shown in the figure below.



FIGURE 42: SAMPLES 3.2.X AFTER SECOND REPASSIVATION WITH VALHALL GREENGEL.

There were overserved immense recovery for samples 3.5.X, by applying repassivation product the second time. Almost everything of the general corrosion and residue of gel product was removed, leaving a smooth surface.

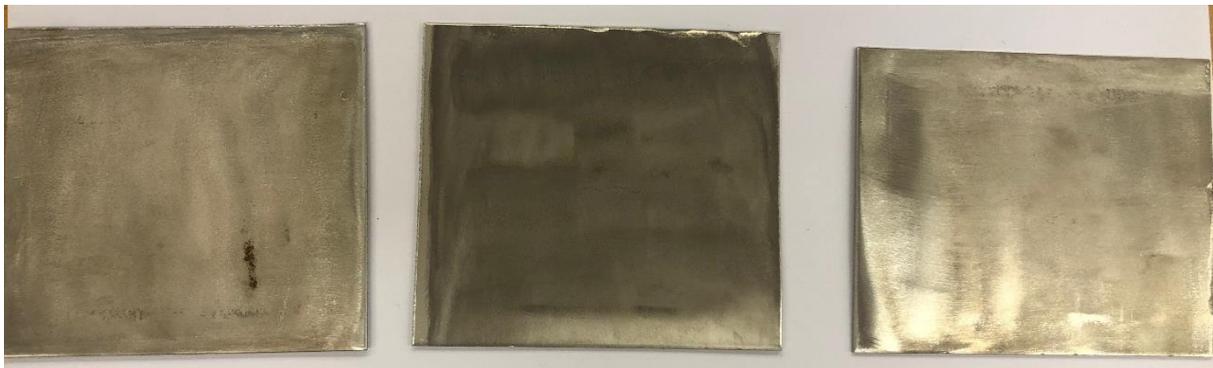


FIGURE 43: AFTER APPLYING CORROGEL OFFSHORE SECOND TIME ON SAMPLES. 3.5.X.

Upon completion of a new treatment of samples 3.7.X, there was still some general corrosion over the surface. There was found little variety in each of the samples, almost identical. It is obvious that it works better with pickling product.



FIGURE 44: SAMPLES 3.7.X AFTERWARDS EXHIBITED FOR AVESTA WITHOUT PICKLING.

In the figure below, there has been huge improvements for samples 3.8.X. Compared to earlier, Figure 40 has been drastically changed. Corrosion has been completely removed and the surface looks much smoother than before.



FIGURE 45: REPASSIVATION OF SAMPLES 3.8.X WITH INNOTEK.

4.3 Analysis of ASTM G61-86 Test on 316L

Table 9 shows an overview over the results obtained in ASTM G-61-86 to identify pitting-, repassivation-, open-circuit-, corrosion potential and if uniform corrosion occurred for 316L, with different repassivation products. It is also a post-chart of the pitting- and repassivation potential, plus a post-chart with OCP and corrosion potential, shown in Figure 46 and Figure 47. Results for these tests were analyzed, evaluated and compared, where corrosion potential are taken from the graphs and open circuit potential graphs are shown in Appendix F. Each of the samples were exposed for the same amount of time and the procedures were stored in the same Potentiodynamic polarization graphs to make it easier to be evaluated and compared. There was observed hysteresis loop closed in every sample. Fluctuation was also observed before it reached the pitting potential and could be blamed by either noise or metastable pits.

TABLE 9: RESULTS OBTAINED FROM ASTM G61-86.

Samples	Pickling or/and repassivation	Pitting potential [mV]	Repassivation potential [mV]	OCP [mV]	Corrosion potential [mV]	Uniform corrosion
1.1.X	-	217	170	-450	-540	X
2.1.X	-	132	89	-300	-560	X
3.1.X	-	85	72	-250	-660	X
1.2.X	-	104	21	-220	-330	-
1.3.X	-	109	6	-110	-200	-
2.2.X	Valhall GreenGel	197	147	-230	-360	X
3.2.X	Valhall GreenGel	184	72	-370	-440	Only 3.2.1
2.3.X	Valhall UltraGel	72	27	-210	-350	-
3.3.X	Valhall UltraGel	367	60	-150	-380	-
2.4.X	Valhall CleanGel	145	55	-260	-370	X
3.4.X	Valhall CleanGel	271	65	-210	-510	-
2.5.X	Corrogel Offshore	132	38	-260	-370	X
3.5.X	Corrogel Offshore	278	88	-140	-390	-
2.6.X	Avesta (cleaner, pickling, passivation)	97	16	-260	-350	-
3.6.X	Avesta (cleaner, pickling, passivation)	310	51	-30	-350	-
2.7.X	Avesta (cleaner, passivation)	110	61	-160	-410	X
3.7.X	Avesta (cleaner, passivation)	99	50	-120	-350	X
2.8.X	Innotek	105	43	-140	-430	-
3.8.X	Innotek	288	59	-40	-370	-

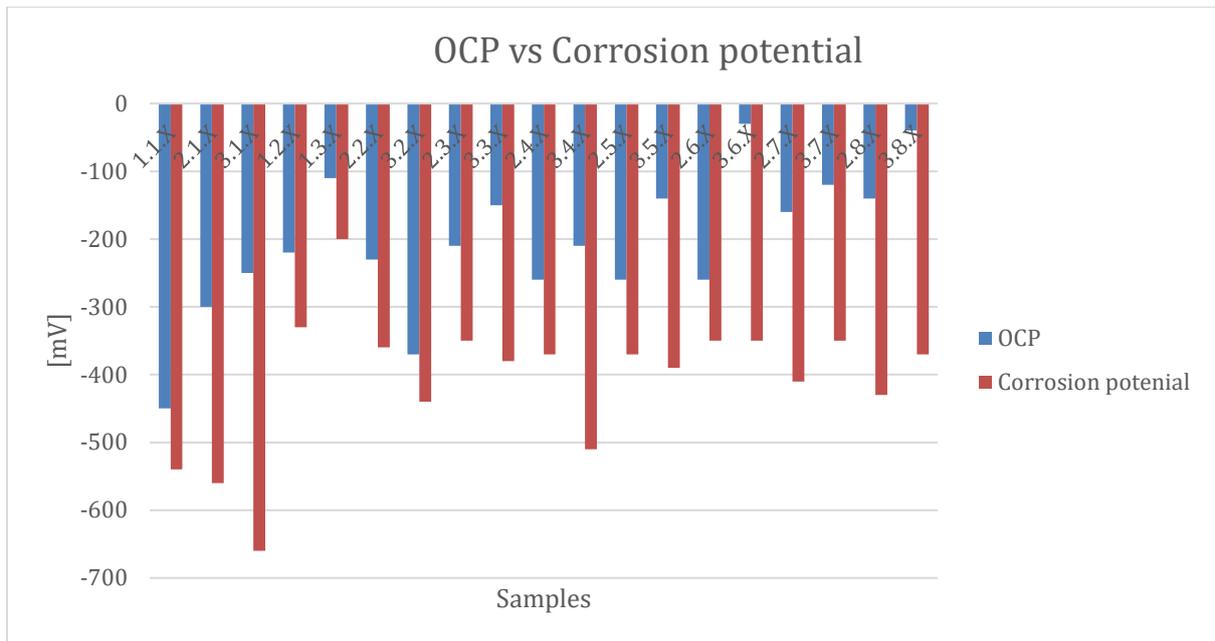


FIGURE 46: POST CHART OF OCP VS CORROSION POTENTIAL.

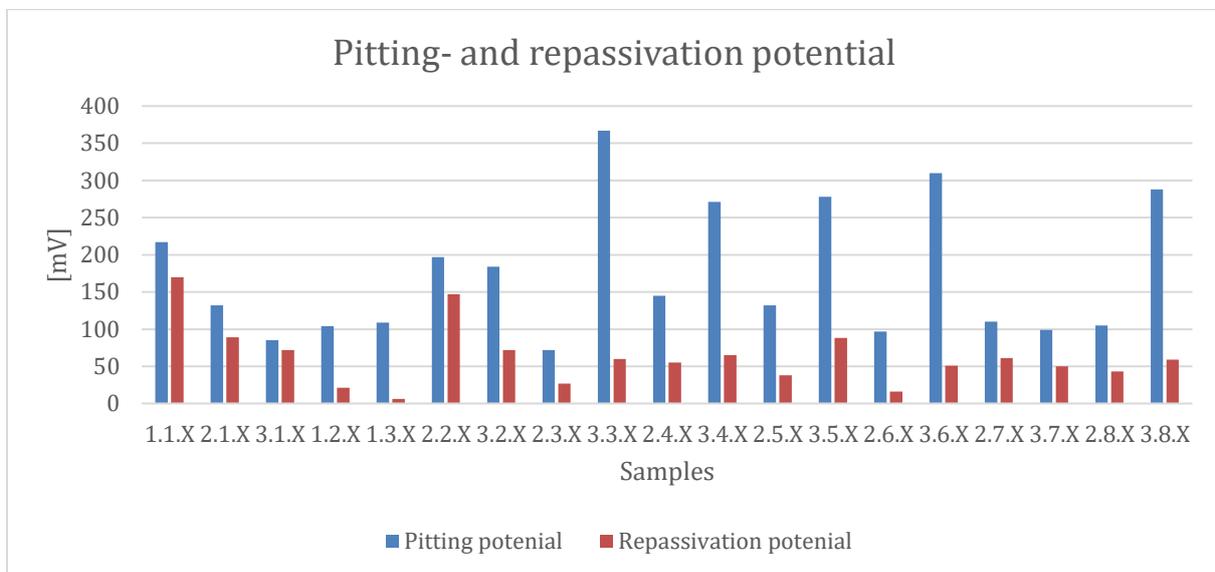


FIGURE 47: POST CHART OF PITTING- AND REPASSIVATION POTENTIAL.

Samples without treatment

In Figure 48, the polarization curves shows uniform corrosion in the transpassive regions instead of localized corrosion. The initiation and propagation of localized corrosion didn't occur before a large amount of current was applied, and gave a result of 217mV and 170mV as pitting- and repassivation potential. The curves obtained from the graphs, are very similar. However, the areas of the hysteresis loop are very low, leading to good resistant against crevice corrosion. There was no observation of crevice

corrosion, only in a pre-sample, where there was used watertight tape to measure exactly area of 1cm^2 .

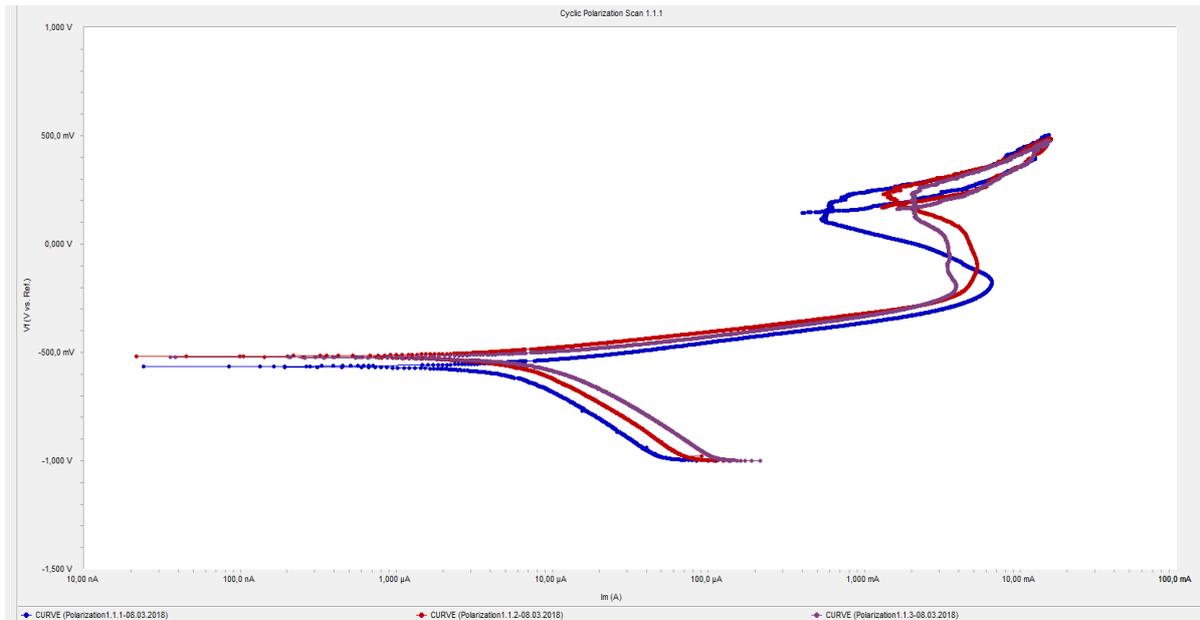


FIGURE 48: CYCLIC POLARIZATION CURVES FOR SAMPLE 1.1.X.

The polarization curves in Figure 49, also shows initiation of uniform corrosion in transpassive regions. It required higher current for initiation and propagation of localized corrosion. The graphs achieved had a little wider gap, but gave pitting- and repassivation potential as 132mV and 89mV. Sample 2.1.1 and 2.1.3 curve had higher repassivation potential than pitting potential.

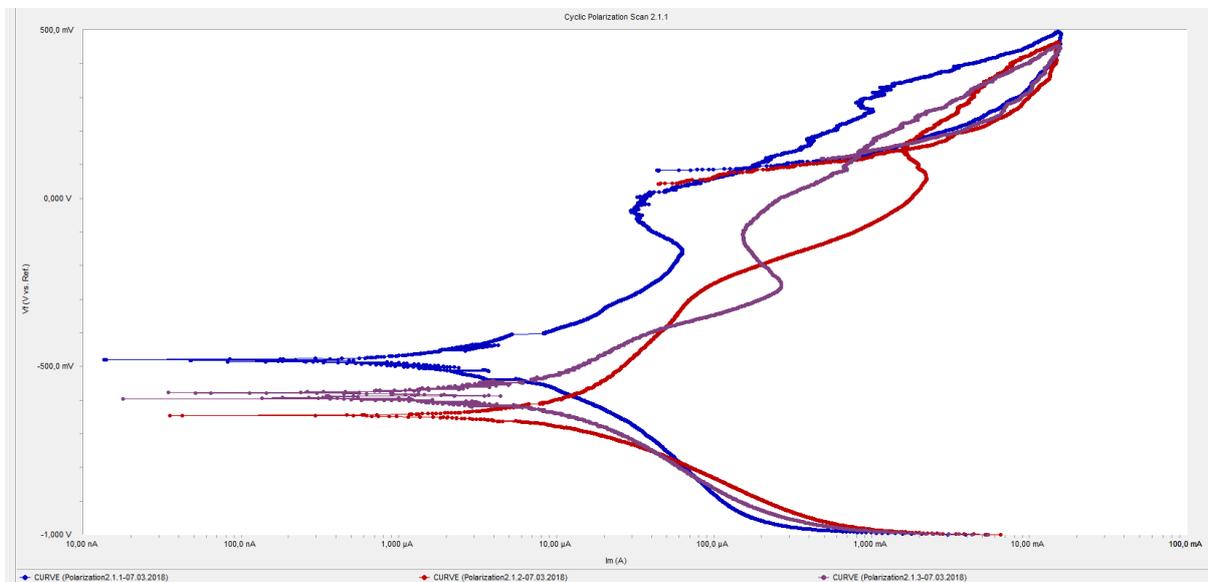


FIGURE 49: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.1.X.

The graph for polarization curves displays beginning of uniform corrosion in transpassive regions, leading initiation and propagation of localized corrosion after applying more current. The curves presents the same values and shapes, but came up with higher repassivation potential in sample 3.1.1. The pitting- and repassivation potential was 85mV and 72mV, and with small areas inside the hysteresis, giving good resistance against crevice corrosion.

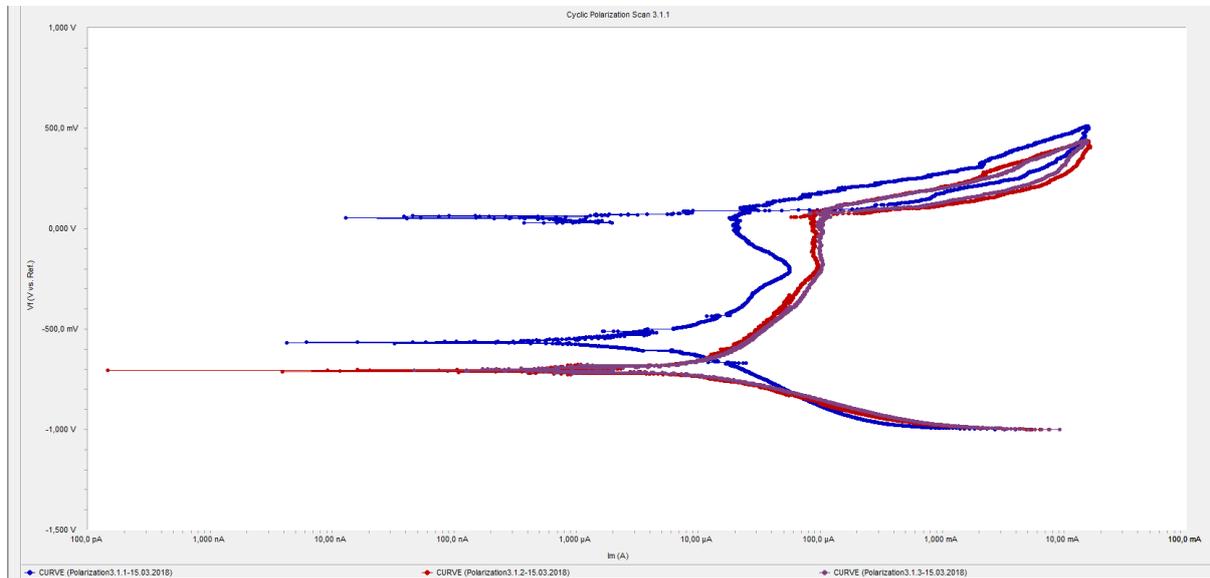


FIGURE 50: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.1.X.

Reference samples

In Figure 51, represented as reference samples, the polarization curves shows only results of initiation and propagation of localized corrosion. The curves were very similar with a little lower pitting potential in sample 1.2.3. The pitting- and repassivation potential was 104mV and 21mV.

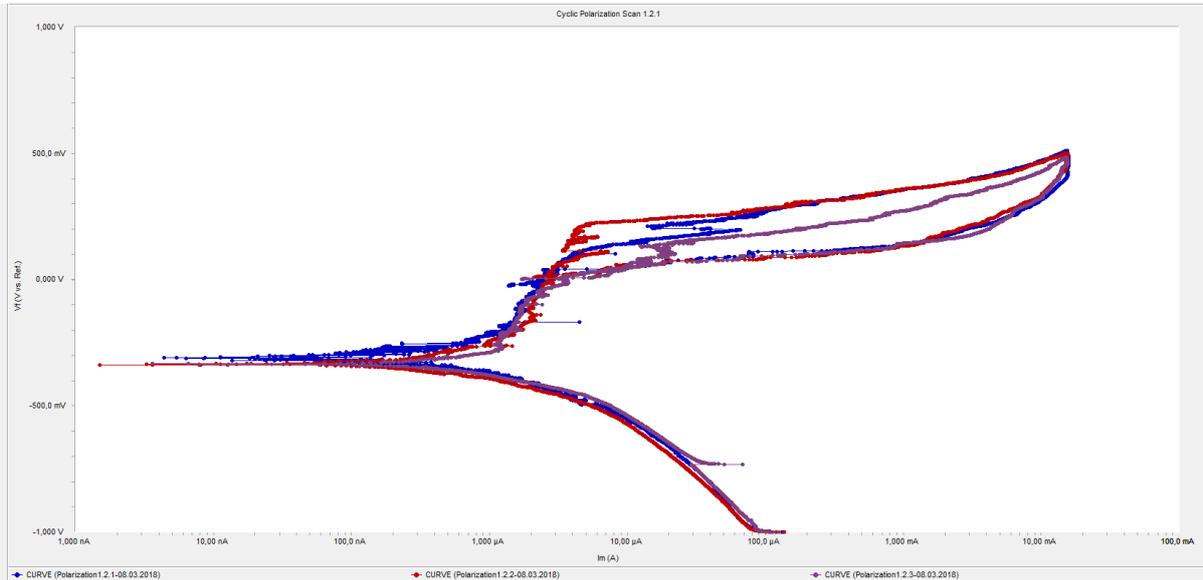


FIGURE 51: CYCLIC POLARIZATION CURVES FOR SAMPLES 1.2.X.

Samples 1.3.X are reference samples, but the tests were performed differently. These tests were done without removing the oxygen inside the solution. As shown in Figure 52, there are just indication by initiation and propagation of localized corrosion. The pitting- and repassivation potential were observed as 109mV and 6mV, almost the same values performed with nitrogen. The curves had a related like shape, but the pitting potential had little variation.

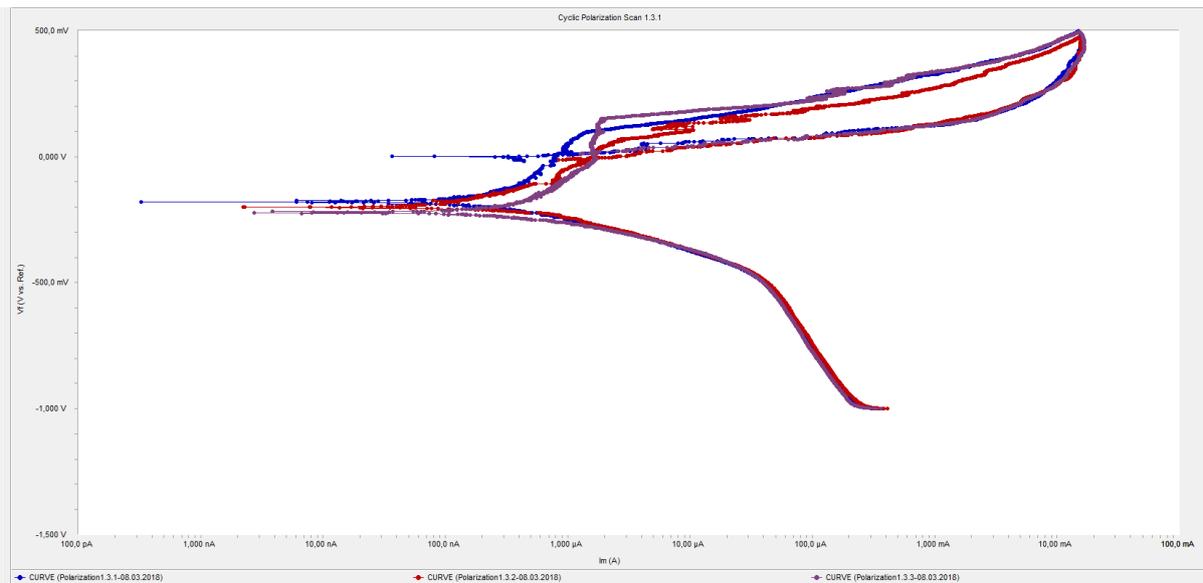


FIGURE 52: CYCLIC POLARIZATION CURVES FOR SAMPLES 1.3.X.

Samples treated with Valhall GreenGel

In Figure 53, there are clear indications of uniform corrosion in the transpassive regions. The initiation and propagation of pitting corrosion occurs after increased

current, followed by a small hysteresis loop. The pitting- and repassivation potential was found to be 197mV and 147mV, but had a little variation value for each sample.

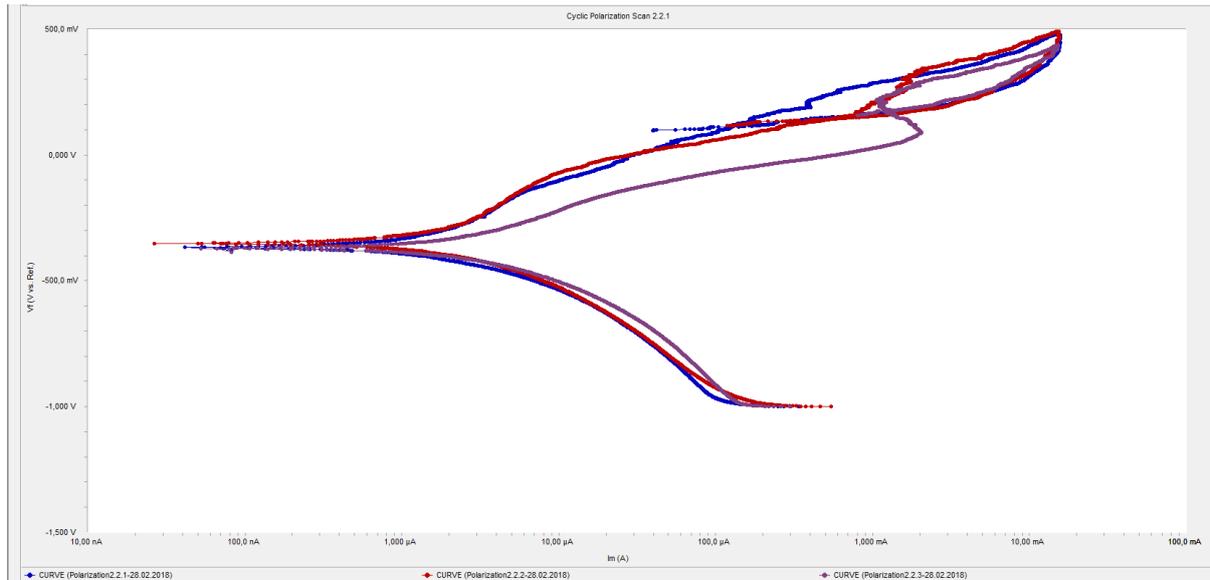


FIGURE 53: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.2.X.

In Figure 54, a lot of fluctuation in the potential can be seen before it reached the pitting potential in samples 3.2.2 and 3.2.3, with similar shape compared to sample 3.2.1. Results obtained from sample 3.2.1 gave higher repassivation potential than pitting potential. It also began with uniform corrosion and developed to initiation and propagation of localized corrosion after applied more current. However, the pitting- and repassivation potential was observed to be 184mV and 72mV.

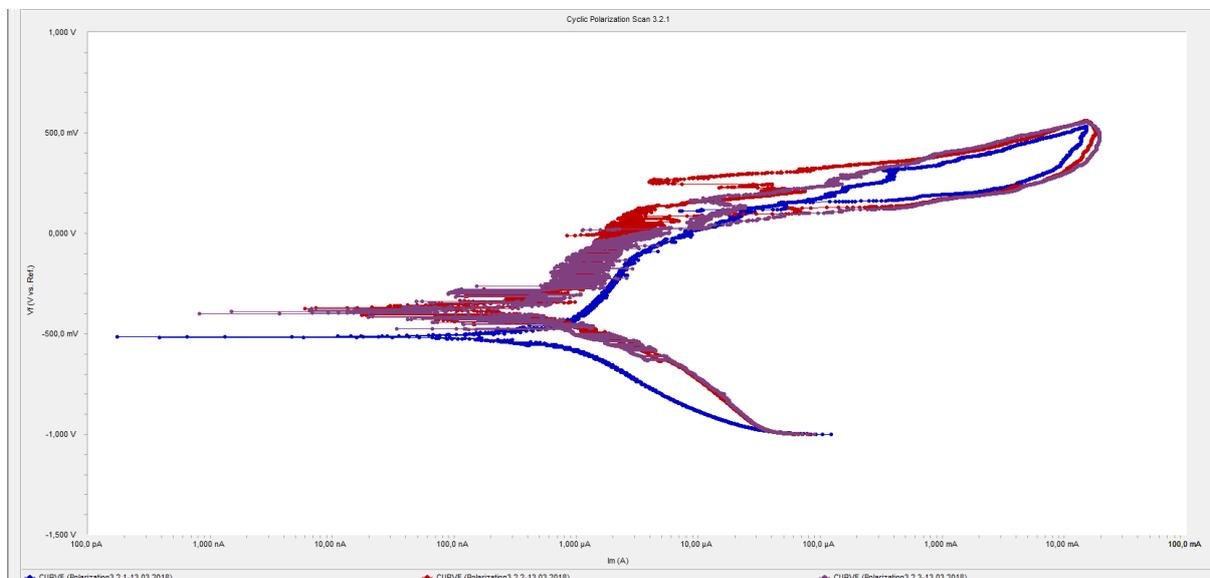


FIGURE 54: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.2.X.

Samples treated with Valhall Ultragel

The polarization curves recovered from Figure 55, shows a lot of fluctuation in the potential before pitting potential occurred. There were only indication of initiation and propagation of localized corrosion, while sample 2.3.1 resulted with lower potentials, and higher repassivation potential than pitting potential. Furthermore, the shape for sample 2.3.2 and 2.3.3 were alike and had almost the same potentials. The pitting- and repassivation potential was detected to be 72mV and 27mV.

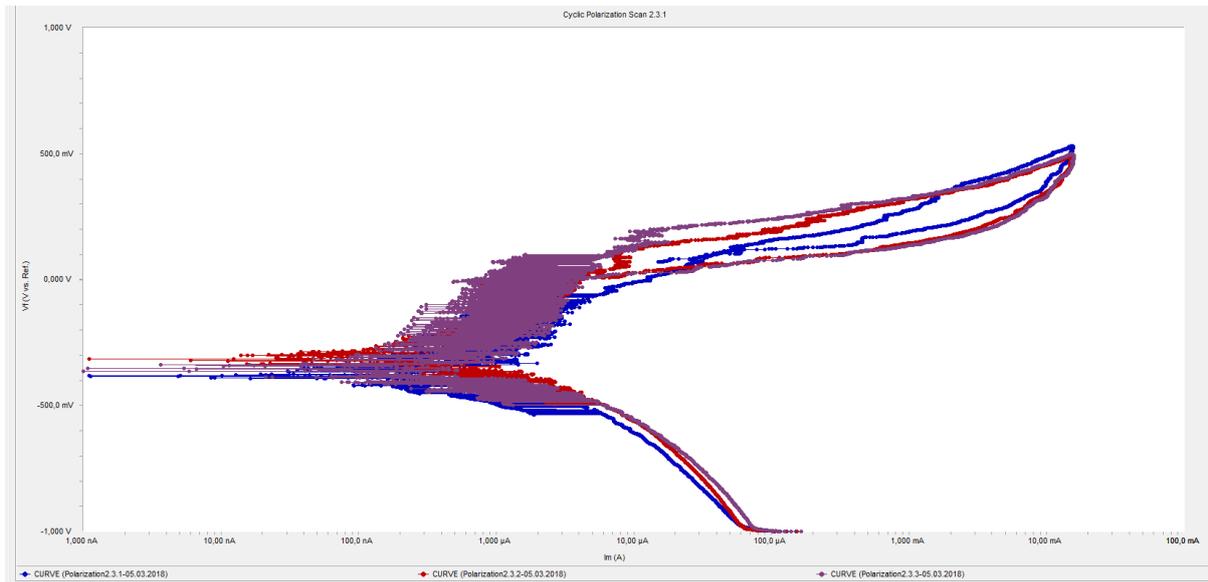


FIGURE 55: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.3.X.

In Figure 56, the graph shows indication of initiation and propagation of localized corrosion. However, the potential are unsteady before it reached the pitting potential. The pitting potential had almost the same values and found as 367mV, while the repassivation potential varied a little more, but was measured to be 60mV. That pitting potential was the highest value from the results. Additionally, the shape of the curves look almost the same.

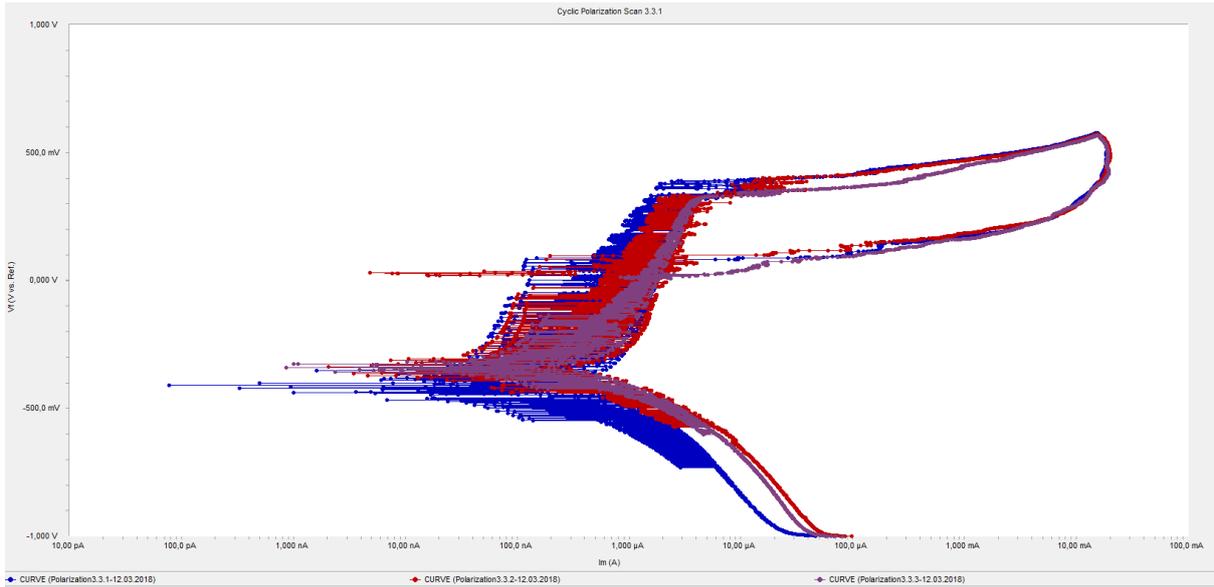


FIGURE 56: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.3.X.

Samples treated with Valhall CleanGel

The cyclic polarization curve observed in Figure 57, had very different shapes and potentials from one another. Sample 2.4.1 and 2.4.3 showed some uniform corrosion in the transpassive regions, after increasing the current it changed to pitting potential. While sample 2.4.2 displayed initiation and propagation of localized corrosion. All of the curves potential had fluctuation before the pitting potential. The pitting- and repassivation potential was observed as 145mV and 55mV.

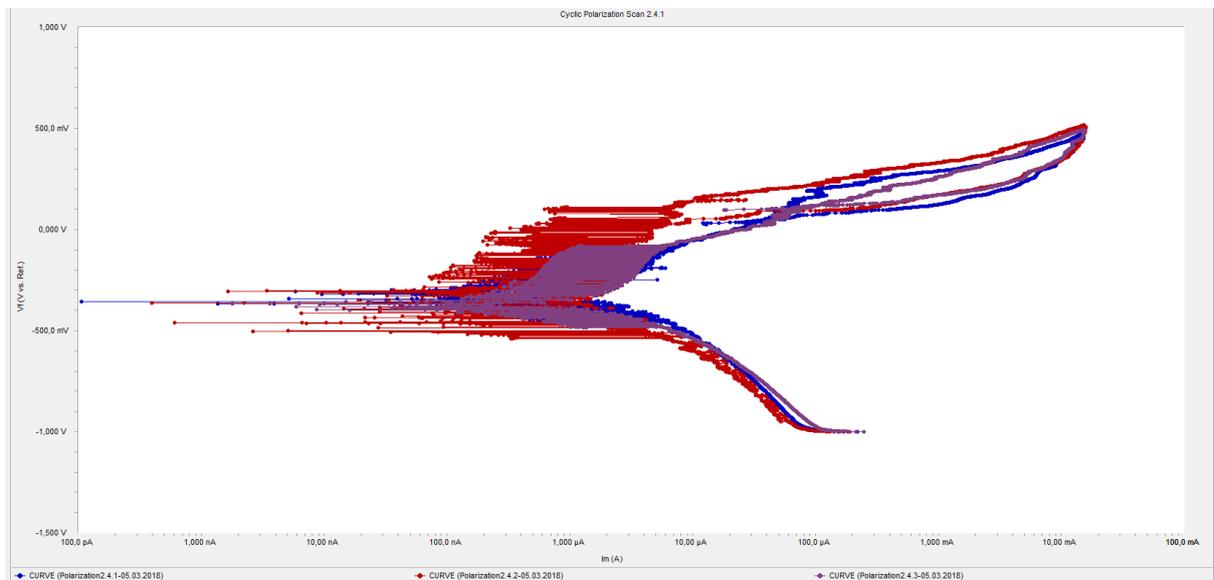


FIGURE 57: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.4.X.

In Figure 58, similar potential values and patterns in the curves can be seen. There were none uniform corrosion, just indication that initiation and propagation of localized

corrosion occurred. There was just a little sign of fluctuation before it reached the pitting potential in sample 3.4.1. The pitting- and repassivation potential was found to be 271mV and 65mV.

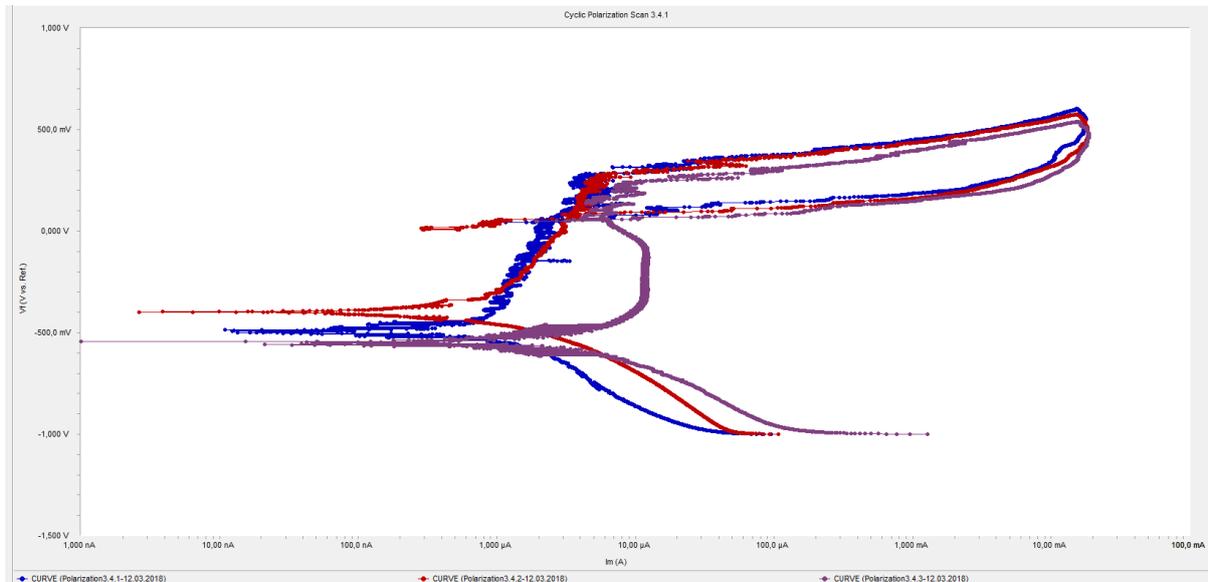


FIGURE 58: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.4.X.

Samples treated with Corrogel Offshore

There was observed a short period of uniform corrosion in the transpassive regions before exposed by initiation and propagation of localized corrosion, in Figure 59. The curves obtained from the figure behaved almost identical and contained fluctuation before it entered the pitting potential. The pitting- and repassivation potential was observed to be 132mV and 38mV.

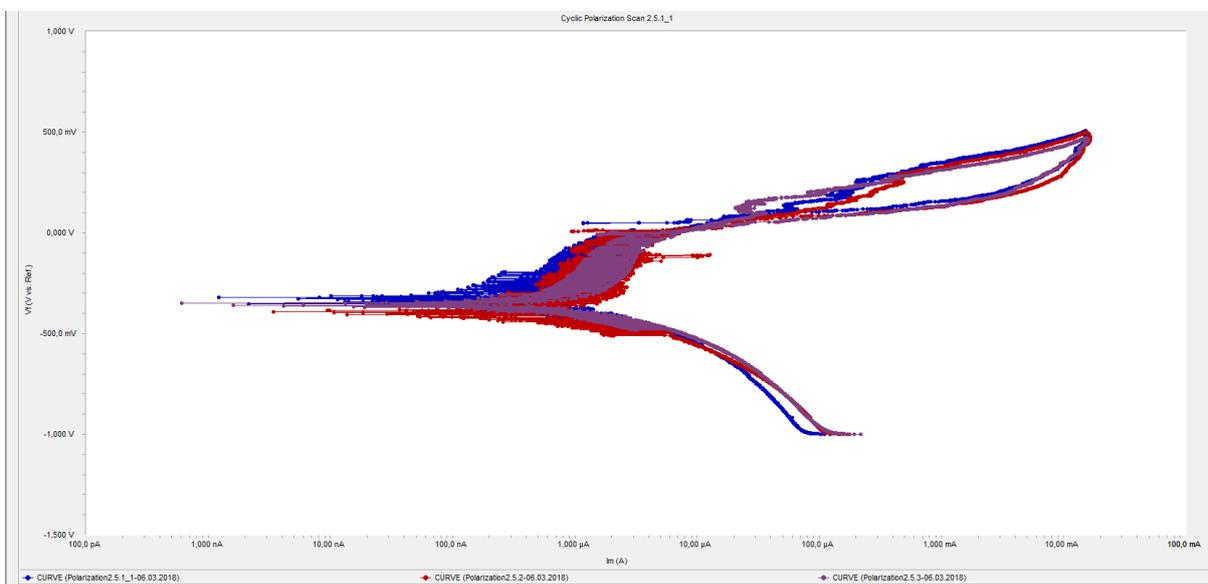


FIGURE 59: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.5.X.

In Figure 60, there were clear indication of initiation and propagation of localized corrosion with alike potential values and curves. However, there was some fluctuation with sample 3.5.1. Results obtained from the curves gave 278mV and 88mV as pitting- and repassivation potential. Additionally, the pitting potential occurred with a smaller amount of current.

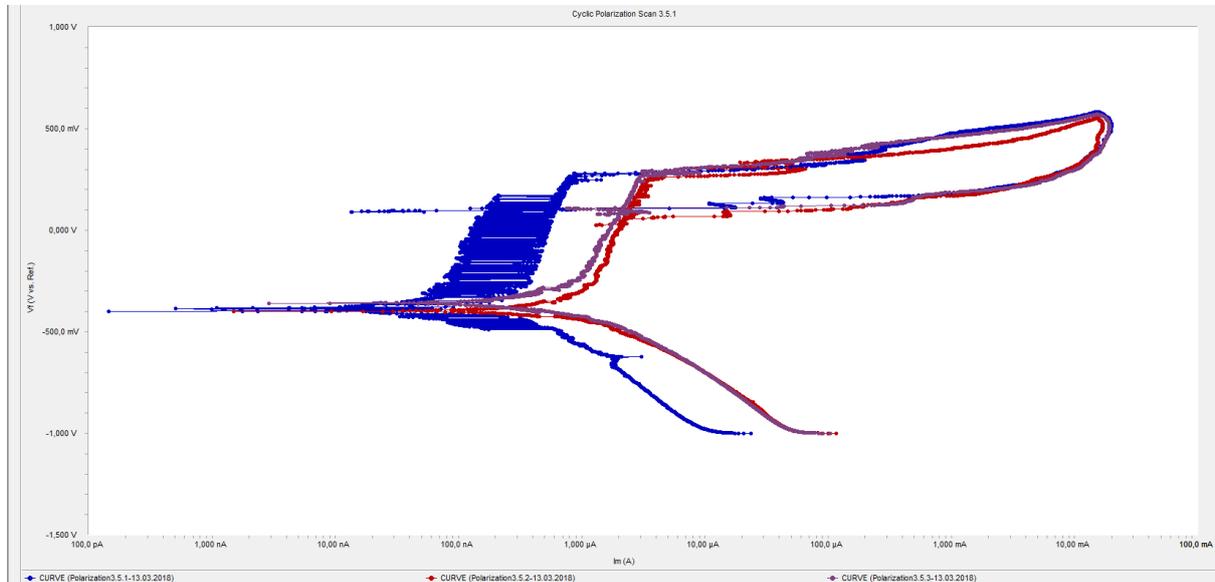


FIGURE 60: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.5.X.

Samples treated with Avesta with pickling

After analyzing Figure 61, it showed similar indication for sample 2.6.2 and 2.6.3, but different results for sample 2.6.1. Sample 2.6.1 had much lower values, and with slimmer hysteresis loop, also containing fluctuation. Entirety gave a pitting- and repassivation potential as 97mV and 16mV. Furthermore, there were only initiation and propagation of localized corrosion.

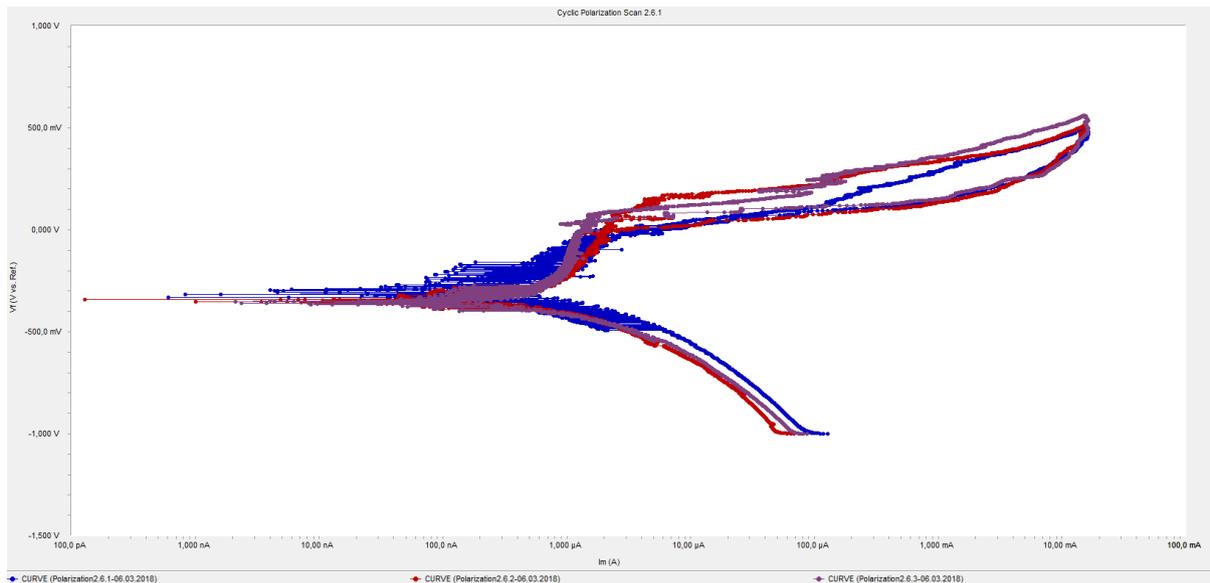


FIGURE 61: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.6.X.

In Figure 62, the cyclic polarization curve showed signs of fluctuation with the corrosion potential. The results found were very similar values and pattern, leading to a pitting- and repassivation potential as 310mV and 51mV. It was only indicated that initiation and propagation of localized corrosion occurred.

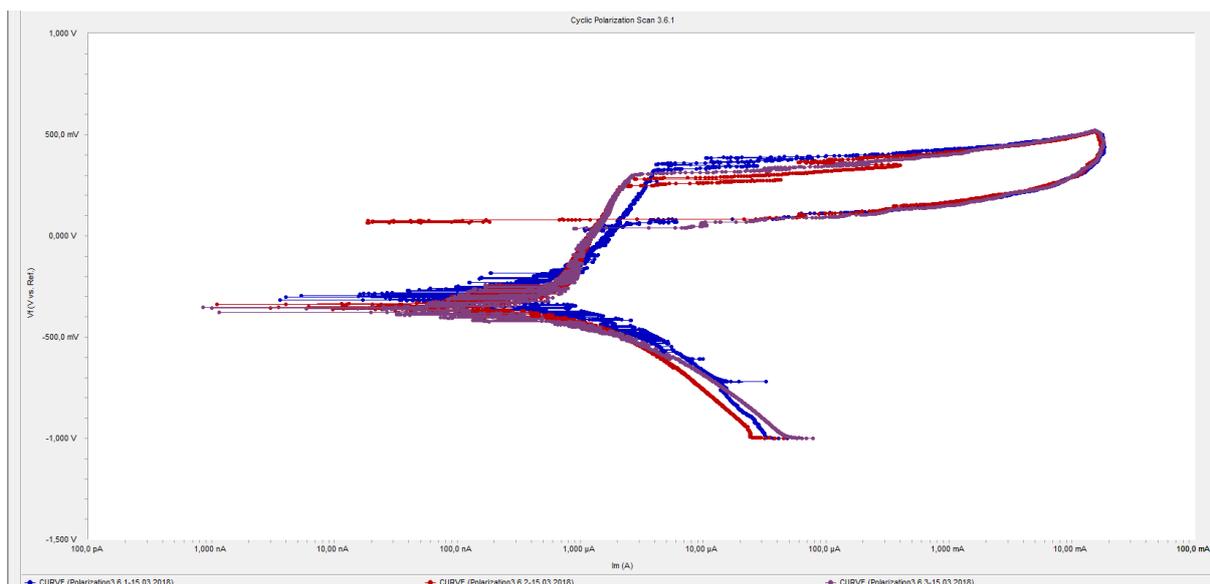


FIGURE 62: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.6.X.

Samples treated with Avesta without pickling

After studying Figure 63, huge variety was observed. Sample 2.7.1 and 2.7.2 had higher repassivation potential than pitting potential. There were formation of initiation and propagation of localized corrosion, but sample 2.7.1 was also exposed for uniform corrosion until it reached a large amount of current. There was also seen fluctuation,

especially in sample 2.7.2. The pitting- and repassivation potential were found as 110mV and 61mV.

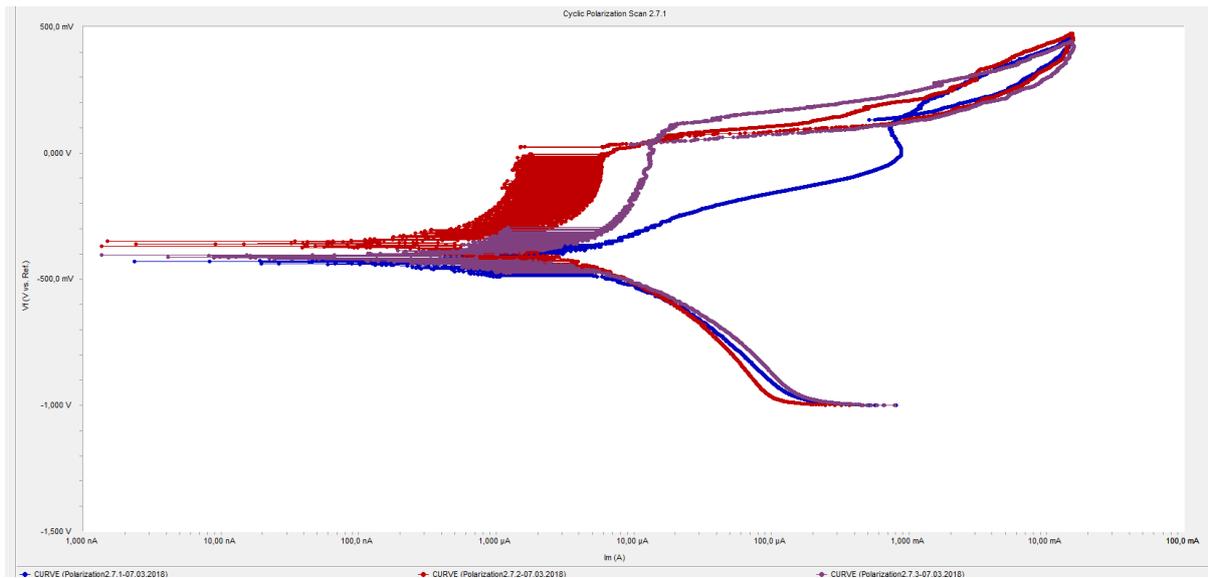


FIGURE 63: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.7.X.

Figure 64 shows the cyclic polarization curves with a few differences. There were observed fluctuation in every sample until it reached uniform corrosion or pitting potential. Samples 3.7.3 obtained higher repassivation- than pitting potential and also uniform corrosion after increased current, leading to initiation and propagation of localized corrosion. The pitting- and repassivation potential was observed to be at 99mV and 50mV.

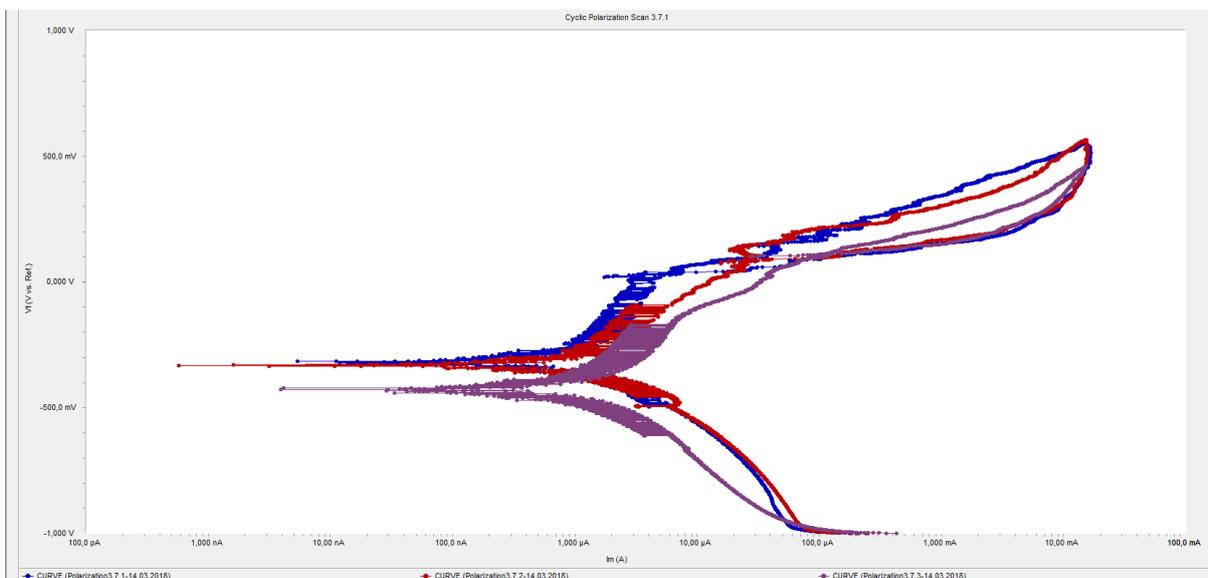


FIGURE 64: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.7.X.

Samples treated with Innotek

In Figure 65, the indication shown is that initiation and propagation of localized corrosion occurred. Here, the curves are very homogeneous, exception of repassivation values. The curves had low amount of fluctuation. Furthermore, the pitting- and repassivation potential was found to be 105mV and 43mV.

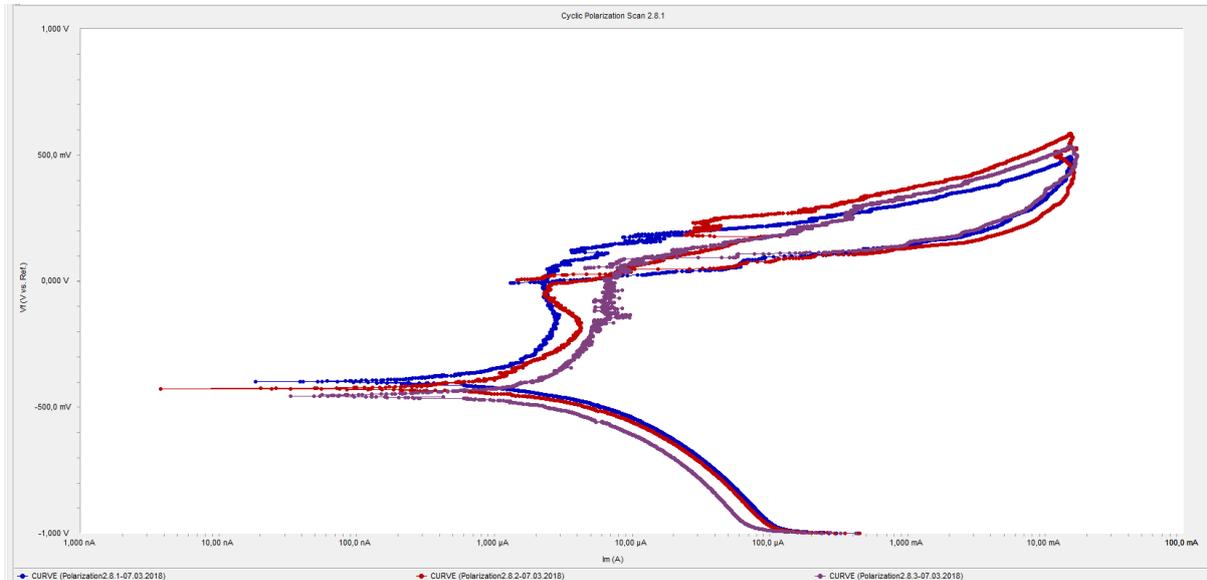


FIGURE 65: CYCLIC POLARIZATION CURVES FOR SAMPLES 2.8.X.

The pitting- and repassivation was found to be at 288mV and 59mV, obtained in Figure 66. Sample 3.8.2 and 3.8.3 consist of fluctuation before it reached the pitting potential. The pitting potential had almost similar value, while the repassivation potential varied greatly. There were just indication of initiation and propagation of localized corrosion.

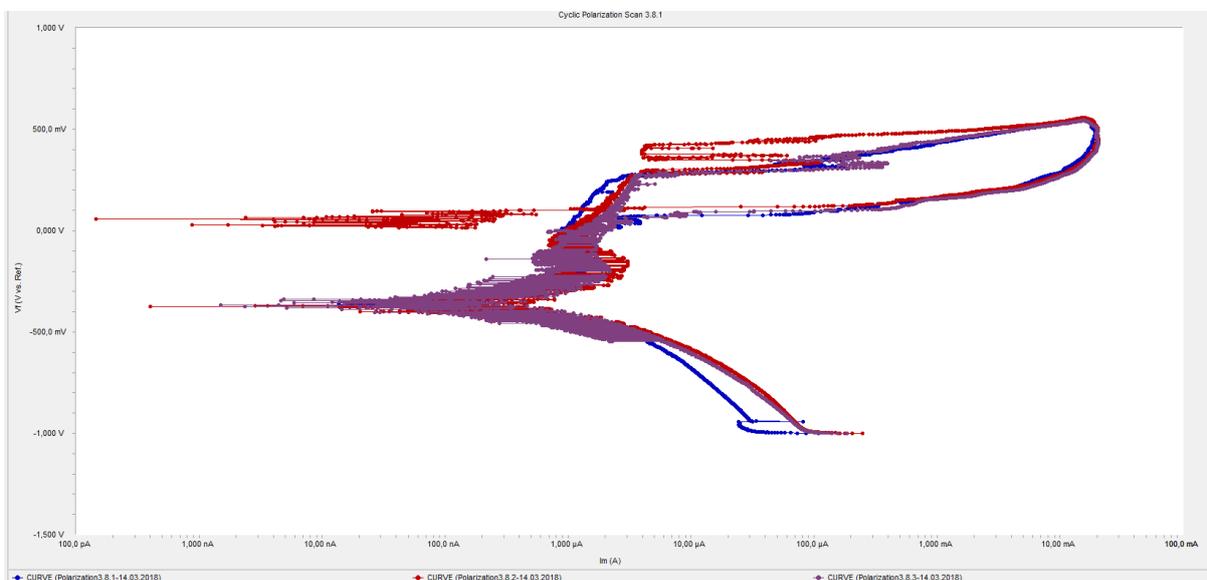


FIGURE 66: CYCLIC POLARIZATION CURVES FOR SAMPLES 3.8.X.

4.4 Analysis of Scanning Electron Microscope

Point- and area- analyzes were performed on both plates to determine the chemical composition. The different elements were identified by looking at the energy of the characteristic X-rays, shown in the figure below. The analysis program was used to identify these, but had to verify the results, by checking that the energy peaks on the spectrum actually matched. The results from the analysis and the certificate are found in Table 10. From Table 10, there are small different values, except for carbon and nitrogen. Chromium was found to be around 1Wt% higher, while molybdenum was measured around 0.5Wt% less than the certificate.

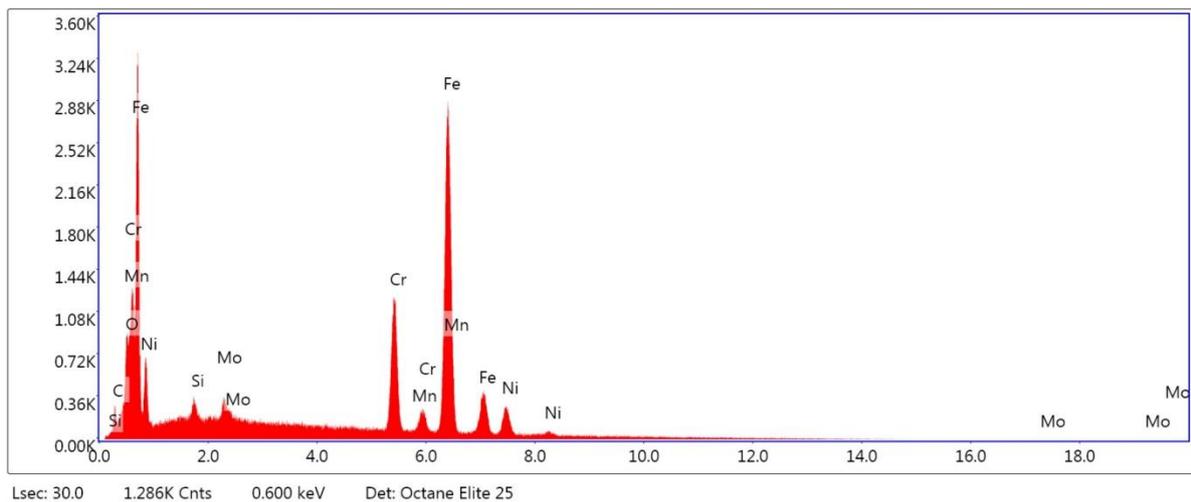


FIGURE 67: EDS-ANALYSIS FROM ONE SAMPLE.

TABLE 10: CHEMICAL COMPOSITION FOR SAMPLE 1, SAMPLE 2 AND THE CERTIFICATE.

Sample	1	1	2	2	Certificate
Acceleration voltage	15kV	25kV	15kV	25kV	-
Elements	Wt%	Wt%	Wt%	Wt%	Wt%
N K	-	0,33	-	0,11	0,012
C K	1,20	1,86	0,74	1,51	0,022
O K	1,15	-	0,93	-	-
Mn L	0,71	1,13	0,89	1,08	1,03
Si K	0,50	0,40	0,54	0,55	0,65
Mo L	1,45	1,41	1,50	1,43	2,01
Cr K	17,68	18,01	17,57	18,08	16,81
Fe K	68,50	67,83	68,38	68,02	-
Ni K	9,41	9,03	9,35	9,17	10,10
P K	-	-	-	0,04	0,034
S					0,002
Total	100,57	100	99,89	99,99	-

The purpose of investigating the plate's chemical composition was to compare them with the certificate and look for deviation, especially for chromium and molybdenum.

4.5 Analysis of PMI

The chemical composition was also obtained with PMI analysis. Results from PMI analysis are shown in Table 11. The results shows very small variety compared to the certificate.

TABLE 11: CHEMICAL COMPOSITION PERFORMED WITH PMI FOR SAMPLE 1, SAMPLE 2 AND THE CERTIFICATE.

Sample	1	2	Certificate
Elements	Wt%	Wt%	Wt%
Cr	16,91	17,05	16,81
Cu	0,41	0,39	-
Fe	69,33	69,25	-
Mn	1,05	0,94	1,03
Mo	2,02	2,00	2,01
Ni	10,28	10,12	10,10

5 Discussion

The main objective of the thesis was to investigate what effect of the repassivation product has on corrosion resistance property of 316L in marine atmosphere. Another interest was to investigate the chemical composition and compare it with the certificate. It was therefore chosen to perform a method to achieve general corrosion. Exposed with marine atmosphere, visual inspection before and after repassivation, electrochemical test and chemical composition. The Electrochemical test was performed according to ASTM G61-86, and several trial experiments was performed before starting the experiment on the real samples. Three parallel tests were performed for the visual inspection and the electrochemical test for each combined experiment.

Chemical composition was performed with SEM- and PMI-analyzation, and the results matched well, according to the certificate. According to the theory, chapter 2.13.3, molybdenum K-shell characteristic X-rays won't appear before 25kV spectrum, but came up with less wt% after adjusting the acceleration voltage from 25kV to 15kV. Generally, several energy peaks on the spectrum, gives more accuracy, because of less uncertainty of noise in the spectrum. This gives some suspicion of low content of molybdenum, due to lower content with 25kV spectrum, and it could be measured with a more accurate method as wavelength dispersive spectrometer (WDS). However, the results obtained from PMI supports that the chemical composition certificate is correct.

There was not much evidence in the literature to break down the passive layer and achieve general corrosion, and was performed with experience from the field. Rotary steel brush with hard braided threads equipped by a grinder provided high speed, led to high temperature and broke down the passive layer. It was done manually, which led to uncertainty around where the samples was damaged, even though it was exposed for the same amount of time. It was exposed for marine atmosphere instead of seawater, due to similar issues as in the problem. The simulated marine atmosphere was performed similarly as mentioned in chapter 2.9, where seawater was sprayed on the metal surface and cyclic drying, and the results are shown in Figure 29 and appendix C. The temperature varied from day to day, but all the samples were placed in the same place, sheltered from rainy weather.

According to theory, chapter 2.10, passivation process is a chemical treatment that gives greater corrosion resistance, smooth and clean surface, and extends the life of steel. Pickling removes impurities from the surface after being exposed like for example a grinder, and the corrosion properties can be restored, according to chapter 2.11.

It was observed that corrosion was completely removed and a clean and blank surface treated with Avesta with pickling, Valhall CleanGel and Valhall UltraGel after the first time with repassivation. Valhall GreenGel and CorroGel Offshore had some problems with corrosion, removed the gel product from the surface and left behind an unclean surface, but showed great improvement after second time with repassivation. Avesta without pickling performed poorly after two times with repassivation, while Innotek had great improvement after the second time with repassivation. However, Valhall products had to be applied with dipping. This makes it difficult to carry out offshore, while the other products are applied with a brush. This was also done manually and can lead to variety. Also Valhall products have much longer treatment time, but have only one process compared to Avesta and CorroGel Offshore. According to HOCNF, products as Valhall and CorroGel Offshore are categorized under yellow and green and is normally granted emission without any specified terms. [39]

Based on the visual inspection, Valhall UltraGel and Valhall CleanGel performed better than Valhall GreenGel due to the environmentally friendly degree, as expected. Also, it came up with a greater result than CorroGel Offshore. That may come from the treatment time. However, CorroGel Offshore is more convenient offshore by applying it with a brush. Avesta with pickling performed much better than without pickling, as expected. Additionally, Avesta with pickling gave a clean and blank surface first and second round, compared to Innotek. However, both of them are not environmentally friendly, leading to treat the emissions, but good with waste water treatment systems. Innotek's results varied from the first round. The reason for this variation could be because the product didn't cover the whole surface during the treatment procedure.

The pitting tests were based on ASTM standard G61-86 with a few adjustments described in subchapter 3.6.4. This test was performed to support results from visual inspection. It was recommended to use a specimen holder to expose 1cm^2 for electrolyte, this was performed different with the same area due to uncertainties with the holder. The specimen holder could lead to crevice corrosion if it is not sealed. The

standard also says that grind paper should be used, but would result in damaging the general corrosion and repassivation product. The oxygen was purged with nitrogen for 5min instead of 60min and the temperature used for the solution was 21 ± 2 °C instead of 25 ± 1 °C because the heat element could affect the electrodes and the software, and lead to uncertain values. The standard also states that the sample needs to be cleaned with distilled water and detergent in ultrasonic bath for 5min, but was cleaned with only distilled water because it may interface with the repassivation product. It was performed 57 tests and it was used 0.5mV/s as potential scan rate instead of 0.17mV/s to save time.

Corrosion potential, or open circuit potential was determined and used for ranking the samples corrosion resistance, where higher potential means more noble. However, this is not a reliable method because it only indicates the startpoint of the cyclic polarization curve, which is used to determine the pitting- and repassivation potential. Additionally, the open circuit potential was ran for only 15min and could need more time to stabilize itself and become steady. The values are found in Table 9 and graphs in appendix F. There are almost no patterns to observe from corrosion- and open circuit potential.

The results from the cyclic polarization tests are represented in Table 9. After analyzing the Potentiodynamic experiments, there are two features to look after: the pitting potential (E_{pitt}) and the repassivation potential (E_{re}). The pitting potential takes place when pitting corrosion begins, by increasing potential. The repassivation potential takes place after the hysteresis loop is completed, after a performed reverse scan. When the reverse scan crosses the forward scan at the potential graph, repassivation occurs. This kind of experiment produces analytical data to pitting-, crevice corrosion and passivation behavior.[14, 33] Ideally, the difference between the pitting potential (E_{pitt}) and the repassivation potential (E_{re}) should be as low as possible to give great pitting resistance. [34] Samples 2.2.1-2.8.3 on one side wasn't passivated before performing G61-86 and gave a major deviation, this could be one of the reasons for general corrosion, without a passive layer. This test is used for localized corrosion attack and if the passive layer is not present, it will lead to general corrosion, which gives an invalid result. Another reason could be that after being exposed by the grinder or cut with the plate scissor, the surface could become sharp or defect. The results are shown in the table and post chart below, where samples with general corrosion are assumed as

invalid results, because they didn't have a uniform passive layer. It is a clear indication that the samples treated with passivation products have higher corrosion resistance than without, although they have been exposed by a grinder. However, there were small differences observed in the repassivation potential. Samples treated the second time with repassivation products as Valhall UltraGel, Valhall CleanGel, Microsit, Avesta with pickling and Innotek came up with a much higher pitting potential, compared to the others. Valhall UltraGel obtained almost four times greater pitting potential than the reference samples, which was not exposed with a grinder.

TABLE 12: VALID RESULTS FROM G61-86.

Samples	Pickling or/and repassivation	Pitting potential [mV]	Repassivation potential [mV]
1.2.X	-	100	20
1.3.X	-	110	10
3.2.X	Valhall GreenGel	160	50
2.3.X	Valhall UltraGel	70	30
3.3.X	Valhall UltraGel	370	60
3.4.X	Valhall CleanGel	270	70
3.5.X	Corrogel Offshore	280	90
2.6.X	Avesta (cleaner, pickling, passivation)	100	20
3.6.X	Avesta (cleaner, pickling, passivation)	310	50
2.8.X	Innotek	110	40
3.8.X	Innotek	290	60

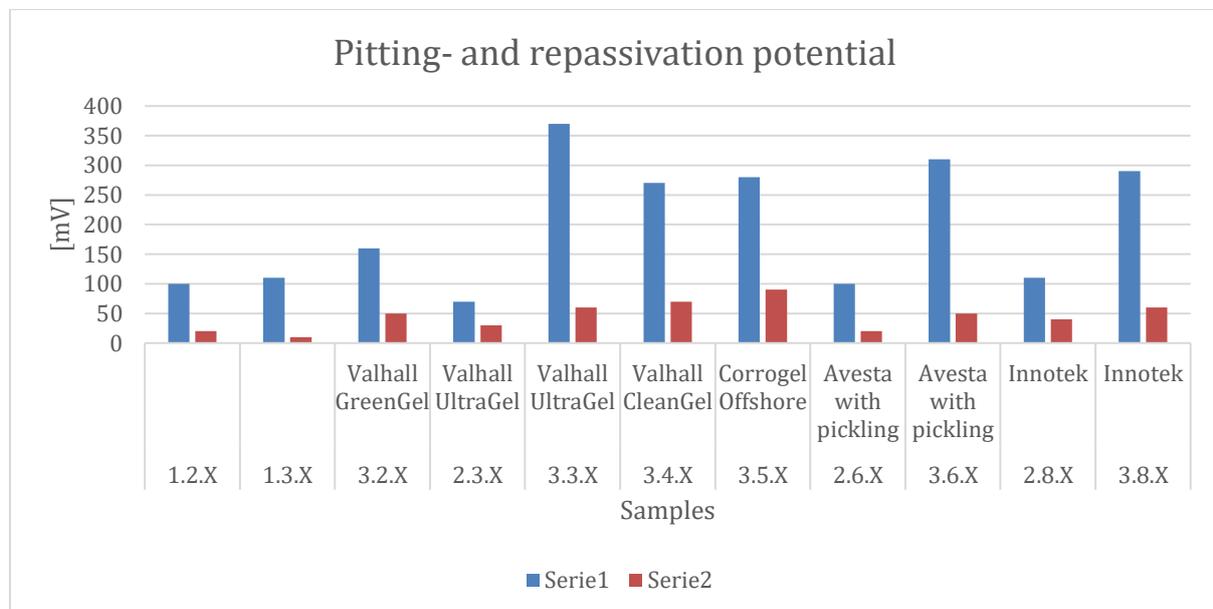


FIGURE 68: RESULTS OF PITTING- AND REPASSIVATION POTENTIAL WITHOUT INVALID RESULTS.

6 Conclusion and Recommendations

The conclusion will here be shown pointwise based on the results obtained.

- Rotary steel brush with hard braided threads equipped by a grinder, led to high temperature and provided a good method to break down the passive layer and achieve general corrosion after being exposed for simulated marine atmosphere.
- Repassivation products gives a better passive layer than a naturally developed passive layer on 316L. According to the visual inspection and ASTM G61-86 test, Valhall UltraGel obtained the best score as the environmentally friendly and Avesta with pickling, achieved the best result, used with a wastewater treatment system. The pitting potential achieved with Valhall UltraGel and Avesta with pickling were three - four times higher than the reference samples of 316L.
- Chemical composition based on characteristic X-rays were found out to fit with the certificate.

Recommendations and suggestions for further work for this subject are mentioned below:

- It could be interesting to compare with other passivation products. However, it is recommended to optimize it for offshore use, considering the environmental and user friendliness.
- Find a better method to achieve general corrosion without damaging the surface, just break down the passive layer. Also, use gel products on pipes that have been in operation.
- It is suggested to compare with another material, for example 317L, which has higher molybdenum contents, which improve the corrosion resistance in oxidizing environments and increases the pitting potential.
- Investigate the molybdenum contents with a more accurate method as wavelength dispersive spectrometer (WDS).

References

- [1] C. Reardon Arthur, *Coping with Corrosion*, 2nd Edition ed. ASM International, 2011, pp. 1-1.
- [2] J. R. Davis, *Corrosion of Weldments*. Materials Park: Materials Park, US: A S M International, 2006.
- [3] M. S.-T. Akinyemi Okeremi, "External Pitting and Crevice Corrosion of 316L Stainless Steel Instrument Tubing in Marine Environments and Proposed Solution," (in english), p. 11, 2008.
- [4] V. Kain, *Corrosion-resistant materials*. 2012, pp. 507-547.
- [5] K. R. Trethewey, *Corrosion for science and engineering*, 2nd ed. ed. London: Longman, 1995.
- [6] V. Cicek, *Corrosion chemistry*, B. Al-Numan, ed., Hoboken, N.J. : Salem, Mass.: Wiley ; Scrivener, 2011. [Online]. Available.
- [7] V. S. Sastri, *Green corrosion inhibitors : theory and practice*, Hoboken, N.J.: Wiley, 2011. [Online]. Available.
- [8] S. S. Y Sahan, E Silviana, Chairul and Wisrayetti, "Performance of the electrical generator cell by the ferrous alloys of printed circuit board scrap and Iron Metal 1020," p. 8, 2017.
- [9] Z. Ahmad, *Principles of corrosion engineering and corrosion control*, E. Institution of Chemical, ed., 1st ed. ed. Amsterdam ; Boston, Mass.: Elsevier/BH, 2006. [Online]. Available.
- [10] M. Tullmin, "Metals."
- [11] P. A. Schweitzer, *Corrosion engineering handbook (Corrosion technology)*. New York: Marcel Dekker, 1996.
- [12] N. Perez, *Electrochemistry and corrosion science*. Boston: Kluwer Academic, 2004.
- [13] A. Bahadori, *Corrosion and materials selection : a guide for petroleum and chemical industries*: John Wiley & Sons, 2014. [Online]. Available.
- [14] C. American Society for Metals Handbook, *Metals handbook : 13 : Corrosion*, 9th ed. ed. Metals Park, Ohio: American Society for Metals, 1987.
- [15] A. J. Sedriks, *Corrosion of stainless steels*, 2nd ed. ed. (Corrosion monograph series). New York: Wiley, 1996.
- [16] J. K. Wessel, *Handbook of advanced materials : enabling new designs*, J. K. Wessel, ed., Hoboken, NJ: WileyInterscience, 2004. [Online]. Available.
- [17] H. S. Khatak and B. Raj, *Corrosion of austenitic stainless steels : mechanism, mitigation and monitoring*. Cambridge: Woodhead Publ., 2002.
- [18] D. D. Kopeliovich. (2015). *Pitting Corrosion*. Available: http://www.substech.com/dokuwiki/doku.php?id=pitting_corrosion
- [19] V. Burt, *Crevice Corrosion*, 2nd Edition ed. ASM International, 2015, pp. 1-1.
- [20] S. Geng, J. Sun, and L. Guo, "Effect of sandblasting and subsequent acid pickling and passivation on the microstructure and corrosion behavior of 316L stainless steel," *Mater. Des.*, vol. 88, pp. 1-7, 2015.
- [21] A. D. Mercer, *Corrosion in seawater systems (Ellis Horwood series in corrosion and its prevention)*. New York: Ellis Horwood, 1990.
- [22] AZoM. (2004). *Stainless Steel - Grade 316L - Properties , Fabrication and Applications (UNS S31603)*. Available: <https://www.azom.com/article.aspx?ArticleID=2382>
- [23] P. S. P. Inc, "Alloy 316/316L specifications: UNS S31600/S31603," ed: U.S.A, 2014, p. 2.
- [24] J. G. Speight, *Oil and gas corrosion prevention : from surface facilities to refineries*: Gulf Publishing Company, 2014. [Online]. Available.

- [25] L. Bertolini, *Corrosion of Steel in Concrete: Prevention, Diagnosis, Repair*, 2nd ed ed. Weinheim: Weinheim : John Wiley & Sons, Incorporated, 2013.
- [26] W. Lv, C. Pan, W. Su, Z. Wang, S. Liu, and C. Wang, "Atmospheric corrosion mechanism of 316 stainless steel in simulated marine atmosphere," *Corrosion Engineering, Science and Technology*, vol. 51, no. 3, pp. 155-162, 2016.
- [27] E. inox. *Pickling and passivating stainless steel*. Available: [http://www.worldstainless.org/Files/issf/non-image-files/PDF/Euro Inox/Passivating Pickling EN.pdf](http://www.worldstainless.org/Files/issf/non-image-files/PDF/Euro%20Inox/Passivating%20Pickling%20EN.pdf)
- [28] D. M. F. Inc. *Stainless Steel Passivation*. Available: <https://www.delstar.com/stainless-steel-passivation>
- [29] T. note. (2016). *Pickling and passivation*. Available: <https://www.nickelinstitute.org/~media/Files/TechnicalLiterature/ACA%20TN%20Aug%2016%20-%20Pickling%20%20Passivation.ashx>
- [30] D. M. F. Inc. *Passivation*. Available: <https://www.delstar.com/passivating>
- [31] L. F. Li, M. Daerden, P. Caenen, and J. P. Celis, *Effect of HCl on Pickling of 304 Stainless Steel in Iron Chloride-Based Electrolytes*. 2006, pp. 579-584.
- [32] A. Bornmyr. (2009). *Pickling Handbook surface treatment of stainless steels*. Available: http://www.misterstainless.com/assets/pickling_handbook.pdf
- [33] MEE. (2014). *Electrochemical Corrosion Testing*. Available: <https://www.mee-inc.com/hamm/electrochemical-corrosion-testing/>
- [34] Z. S.-S. M. Janik-Czachor, "The analysis of electrochemical methods for the determination of characteristic potentials of pitting corrosion," vol. 11, no. 12, pp. 901-914, 1971.
- [35] J. Hjelen, *Scanning elektron-mikroskopi*. Trondheim: SINTEF, 1989.
- [36] M. S. Shackley, *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*. Springer New York: New York, NY, 2011.
- [37] BRUKER. (2018). *Handheld XRF: How it works*. Available: <https://www.bruker.com/products/x-ray-diffraction-and-elemental-analysis/handheld-xrf/how-xrf-works.html>
- [38] BRUKER. (2018). *OES (Optical Emission Spectrometry) vs XRF for Positive Materials Identification (PMI) and Alloy Analysis*. Available: <https://www.bruker.com/products/x-ray-diffraction-and-elemental-analysis/handheld-xrf/applications/pmi/oes-vs-xrf-for-pmi.html>
- [39] Petoro. (2012). *Driftsstanser ga*
økt CO2-utslipp i 2012. Available: <https://www.petoro.no/petoro-aarsrapport/2012/hms/miljo/utslipp-til-kjemikalier>
- [40] *Standard test method for conducting cyclic potentiodynamic polarization measurements for localized corrosion susceptibility of Iron-, Nickel-, or Cobalt-based alloys* (ASTM designation). West Conshohocken, Pa: ASTM International, 2014.



The safety data sheet is in accordance with Commission Regulation (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

SECTION 1: Identification of the substance/mixture and of the company/undertaking

Date issued	18.05.2016
Revision date	20.09.2016

1.1. Product identifier

Product name	Valhall GreenGel
--------------	------------------

1.2. Relevant identified uses of the substance or mixture and uses advised against

Function	Surface cleaning of oxidized (rust), salts, limestone algae etc.
Product group	Cleaning agent
Uses advised against	Corrodes galvanized and zinc metallized metal and surfaces treated with zincethylsilicate.
The chemical can be used by the general public	Yes

1.3. Details of the supplier of the safety data sheet

Company name	Valhall NGP as
Postal address	Leirvikåsen 45
Postcode	5179
City	Godvik
Country	Norway
Tel	+47 56126100
E-mail	post@valhallngp.no
Website	http://www.valhallngp.no
Enterprise no.	916488890MVA

1.4. Emergency telephone number

Emergency telephone	Norwegian Poisoning Alarm Telephone: 22 59 13 00 Ambulance: 113
---------------------	--------------------------------------------------------------------

SECTION 2: Hazards identification

2.1. Classification of substance or mixture

Classification according to 67/548/EEC or 1999/45/EC	C R36
Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]	Eye Irrit. 2; H319

2.2. Label elements

Hazard Pictograms (CLP)



Signal word	Warning
Hazard statements	H319 Causes serious eye irritation.
Precautionary statements	P264 Wash thoroughly after handling. P280 Wear protective gloves / protective clothing / eye protection / face protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+P313 If eye irritation persists: Get medical advice / attention.

2.3. Other hazards

PBT / vPvB	No PBT/vPvB
------------	-------------

SECTION 3: Composition/information on ingredients

3.2. Mixtures

Substance	Identification	Classification	Contents
Citric Acid	CAS no.: 5949-29-1 EC no.: 201-069-1 Registration number: 01-2119457026-42-xxxx	R36 Xi H319 Eye Irrit. 2	8 - 12 %
Inhibitor		Classification notes: Shall not be classified	< 2 %
Thickener		Classification notes: Shall not be classified	< 2 %
Colouring		Classification notes: Shall not be classified	< 0,01 %

SECTION 4: First aid measures

4.1. Description of first aid measures

General	Call 113 and provide the information in the MSDS if pain should occur. For emergency phone see also section 1.4
Inhalation	By ordinary handling develops no gases
Skin contact	Wash with plenty of soap and water.
Eye contact	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Ingestion	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.

4.2. Most important symptoms and effects, both acute and delayed

Delayed symptoms and effects	Skin will be reddened by exposure over time. Eyes will sting sharp depending on the amounts of products that are in the eyes.
------------------------------	-------------------------------------------------------------------------------------------------------------------------------

4.3. Indication of any immediate medical attention and special treatment needed

Medical treatment	Ordinary symptomatic treatment.
-------------------	---------------------------------

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media	As appropriate for the surrounding fire.
------------------------------	------------------------------------------

5.2. Special hazards arising from the substance or mixture

Fire and explosion hazards	The product is not flammable.
Hazardous combustion products	Phosphorus oxides (POx)

5.3. Advice for firefighters

Personal protective equipment	Use personal protective equipment as required.
-------------------------------	------------------------------------------------

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures	Flush with water
Personal protection measures	Wear protective gloves / protective clothing / eye protection / face protection.

6.2. Environmental precautions

Environmental precautionary measures	The product is non-toxic and biodegradable. By concentrated spills will dilution and use of base as lye neutralizing product.
--------------------------------------	-------------------------------------------------------------------------------------------------------------------------------

6.3. Methods and material for containment and cleaning up

Cleaning method	Flush with water
-----------------	------------------

6.4. Reference to other sections

Other instructions	Look at section 8 and 13
--------------------	--------------------------

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Protective Safety Measures

Protective Safety Measures	Do not eat, drink or smoke while working.
----------------------------	-------------------------------------------

7.2. Conditions for safe storage, including any incompatibilities

7.3. Specific end use(s)

Specific use(s)	Look at section 1.2
-----------------	---------------------

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.2. Exposure controls

Limitation of exposure on workplace	It must be used personal protective equipment. In cooperation with the supplier selected this according to the CEN standards.
-------------------------------------	-------------------------------------------------------------------------------------------------------------------------------

Safety signs



Respiratory protection

Respiratory protection	In case of inadequate ventilation wear respiratory protection.
Respiratory protection, general	Partial or full mask with dust filter in enclosed spaces.

Hand protection

Hand protection	PVC/Rubber/Latex
-----------------	------------------

Eye / face protection

Eye protection	Goggles, Mask
----------------	---------------

Skin protection

Skin protection (except hands)	Full personal protective clothing.
--------------------------------	------------------------------------

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	Gel like liquid
Colour	Orange
Odour	Weak
pH (aqueous solution)	Value: < 2 Method of testing: pH meter

Revision date 20.09.2016

	Test temperature: = 20
Freezing point	Value: < 2 °C
Specific gravity	Value: ~ 1143,18 kg/m ³
	Test temperature: 20 °C
Solubility in water	Complete
Viscosity	Value: ~ 7000 mpa

9.2. Other information

SECTION 10: Stability and reactivity

10.1. Reactivity

10.2. Chemical stability

10.3. Possibility of hazardous reactions

10.4. Conditions to avoid

Conditions to avoid Keep cool. Protect from sunlight.

10.5. Incompatible materials

10.6. Hazardous decomposition products

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Other information regarding health hazards

General The amount of product exposed to the skin is equivalent to degree of irritation and possible damage.

Potential acute effects

Inhalation May cause respiratory irritation

Eye contact Causes serious eye irritation

Ingestion Irritating to mucous membranes in mouth and throat

SECTION 12: Ecological information

12.1. Toxicity

Ecotoxicity Not classified as dangerous for the environment

12.2. Persistence and degradability

Persistence and degradability description Fully biodegradable

12.3. Bioaccumulative potential

Bioaccumulative potential Completely

12.4. Mobility in soil

Mobility Easily soluble in water

12.5. Results of PBT and vPvB assessment

PBT assessment results Contains no PBT substances

vPvB evaluation results Contains no vPvB substances

12.6. Other adverse effects

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Product classified as hazardous waste No

Packaging classified as hazardous No

waste	
EWC waste code	EWC: 16 50 73 EWC: 12 03 01 aqueous washing liquids

SECTION 14: Transport information

14.1. UN number

14.2. UN proper shipping name

14.3. Transport hazard class(es)

Comments	The product is not covered by international regulation on the transport of dangerous goods (IMDG, IATA, ICAO or ADR/RID).
----------	---------------------------------------------------------------------------------------------------------------------------

14.4. Packing group

14.5. Environmental hazards

14.6. Special precautions for user

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

References (laws/regulations)	Regulation on classification and labeling of hazardous chemicals, 16.07.2002 No. 1139 CLP Regulations, 16.06.2012. REACH regulation Annex II. Transportforskriften FOR 01.04.2009 No. 384.
-------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

15.2. Chemical safety assessment

SECTION 16: Other information

Hazard symbol



Irritant	
Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]	Eye Irrit. 2; H319;
List of relevant R-phrases (under headings 2 and 3).	R36 Irritating to eyes.
List of relevant H-phrases (Section 2 and 3).	H319 Causes serious eye irritation.
Information which has been added, deleted or revised	Changed description of colour Changed from H314 to H319 Added information in 3.2 for classification Corrected amount of citric acid.
Revision responsible	Raymond Engelsen
Last update date	20.09.2016
Version	4
Responsible for safety data sheet	Valhall NGP as

Revision date 20.09.2016

	SAFETY DATA SHEET Valhall Clean UltraGel	
-----------------------------------------------------------------------------------	-----------------------------------------------------------	-------------------------------------------------------------------------------------

The safety data sheet is in accordance with Commission Regulation (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

SECTION 1: Identification of the substance/mixture and of the company/undertaking

Date issued	01.02.2016
Revision date	20.09.2016

1.1. Product identifier

Product name	Valhall Clean UltraGel
--------------	------------------------

1.2. Relevant identified uses of the substance or mixture and uses advised against

Function	Surface cleaning of oxidized (rust), salts, limestone algae etc.
Product group	Cleaning agent
Uses advised against	Galvanized and metallized metal
The chemical can be used by the general public	Yes

1.3. Details of the supplier of the safety data sheet

Company name	Valhall NGP as
Postal address	Leirvikåsen 45
Postcode	5179
City	Godvik
Country	Norway
Tel	+47 56126100
E-mail	post@valhallngp.no
Website	http://www.valhallngp.no
Enterprise no.	916488890MVA

1.4. Emergency telephone number

Emergency telephone	Norwegian Poisoning Alarm Telephone:22 59 13 00 Ambulance:113
---------------------	------------------------------------------------------------------

SECTION 2: Hazards identification

2.1. Classification of substance or mixture

Classification according to 67/548/EEC or 1999/45/EC	C R34
Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]	Skin Corr 1C; H314

2.2. Label elements

Hazard Pictograms (CLP)



Revision date 20.09.2016

Signal word	Warning
Hazard statements	H314 Causes severe skin burns and eye damage.
Precautionary statements	P264 Wash thoroughly after handling. P280 Wear protective gloves / protective clothing / eye protection / face protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+P313 If eye irritation persists: Get medical advice / attention.

2.3. Other hazards

PBT / vPvB	No PBT/vPvB
------------	-------------

SECTION 3: Composition/information on ingredients

3.2. Mixtures

Substance	Identification	Classification	Contents
Citric Acid	CAS no.: 5949-29-1	R36	< 15 %
	EC no.: 201-069-1	Xi	
	Registration number: 01-2119457026-42-xxxx	H319 Eye Irrit. 2	
Phosphoric Acid	CAS no.: 7664-38-2 EC no.: 231-633-2	Skin Corr 1B	< 30 %
Inhibitor			< 2 %
		Classification notes: Shall not be classified	
Thickener			< 2 %
		Classification notes: Shall not be classified	
Colouring			< 0,001 %
		Classification notes: Shall not be classified	

SECTION 4: First aid measures

4.1. Description of first aid measures

General	Call 113 and provide the information in the MSDS if pain should occur. For emergency phone see also section 1.4
Inhalation	By ordinary handling develops no gases
Skin contact	Wash with plenty of soap and water.
Eye contact	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Ingestion	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.

4.2. Most important symptoms and effects, both acute and delayed

Delayed symptoms and effects	Skin will be reddened by exposure over time. Eyes will sting sharp depending on the amounts of products that are in the eyes.
------------------------------	-------------------------------------------------------------------------------------------------------------------------------

4.3. Indication of any immediate medical attention and special treatment needed

Medical treatment	Ordinary symptomatic treatment.
-------------------	---------------------------------

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media	As appropriate for the surrounding fire.
------------------------------	------------------------------------------

5.2. Special hazards arising from the substance or mixture

Fire and explosion hazards	The product is not flammable.
Hazardous combustion products	Phosphorus oxides (POx)

5.3. Advice for firefighters

Revision date 20.09.2016

Personal protective equipment Use personal protective equipment as required.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures Flush with water
 Personal protection measures Wear protective gloves / protective clothing / eye protection / face protection.

6.2. Environmental precautions

Environmental precautionary measures The product is non-toxic and biodegradable. By concentrated spills will dilution and use of base as lye neutralizing product.

6.3. Methods and material for containment and cleaning up

Cleaning method Flush with water

6.4. Reference to other sections

Other instructions Look at section 8 and 13

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Protective Safety Measures

Protective Safety Measures Do not eat, drink or smoke while working.

7.2. Conditions for safe storage, including any incompatibilities

7.3. Specific end use(s)

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.2. Exposure controls

Limitation of exposure on workplace It must be used personal protective equipment. In cooperation with the supplier selected this according to the CEN standards.

Safety signs



Respiratory protection

Respiratory protection In case of inadequate ventilation wear respiratory protection.

Respiratory protection, general Partial or full mask with dust filter in enclosed spaces.

Hand protection

Hand protection PVC/Rubber/Latex

Eye / face protection

Eye protection Goggles, Mask

Skin protection

Skin protection (except hands) Full personal protective clothing.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state Gel like liquid

Colour Peach

Odour Weak

pH (aqueous solution) **Value:** > 2

Revision date 20.09.2016

Freezing point	Value: < 2 °C
Specific gravity	Value: ~ 1216,44 kg/m ³ Test temperature: 20 °C
Solubility in water	Complete
Viscosity	Value: ~ 6000 mpa

9.2. Other information

SECTION 10: Stability and reactivity

10.1. Reactivity

10.2. Chemical stability

10.3. Possibility of hazardous reactions

10.4. Conditions to avoid

Conditions to avoid Keep cool. Protect from sunlight.

10.5. Incompatible materials

10.6. Hazardous decomposition products

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Other information regarding health hazards

General	The amount of product exposed to the skin is equivalent to degree of irritation and possible damage.
---------	------------------------------------------------------------------------------------------------------

Potential acute effects

Inhalation	May cause respiratory irritation
Skin contact	Corrosive
Eye contact	Causes serious eye irritation
Ingestion	Irritating to mucous membranes in mouth and throat

SECTION 12: Ecological information

12.1. Toxicity

Ecotoxicity Not classified as dangerous for the environment

12.2. Persistence and degradability

Persistence and degradability description	Fully biodegradable
-------------------------------------------	---------------------

12.3. Bioaccumulative potential

Bioaccumulative potential Completely

12.4. Mobility in soil

Mobility	Easily soluble in water
----------	-------------------------

12.5. Results of PBT and vPvB assessment

PBT assessment results	Contains no PBT substances
vPvB evaluation results	Contains no vPvB substances

12.6. Other adverse effects

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Product classified as hazardous waste	No
Packaging classified as hazardous	No

Revision date 20.09.2016

waste	
EWC waste code	EWC: 16 50 73 EWC: 12 03 01 aqueous washing liquids

SECTION 14: Transport information

14.1. UN number

ADR / RID / ADN	1805
RID	1805
IMDG	1805
ICAO/IATA	1805

14.2. UN proper shipping name

ADR	PHOSPHORIC ACID, SOLUTION
RID	PHOSPHORIC ACID, SOLUTION
IMDG	PHOSPHORIC ACID SOLUTION
ICAO/IATA	PHOSPHORIC ACID, SOLUTION

14.3. Transport hazard class(es)

ADR / RID / ADN	8
RID	8
IMDG	8
ICAO/IATA	8

14.4. Packing group

ADR	III
RID	III
IMDG	III
ICAO/IATA	III

14.5. Environmental hazards

14.6. Special precautions for user

EmS	F-A, S-B
-----	----------

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

ADR / RID - Other information

Hazard no.	80
------------	----

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

References (laws/regulations)	Regulation on classification and labeling of hazardous chemicals, 16.07.2002 No. 1139 CLP Regulations, 16.06.2012. REACH regulation Annex II. Transportforskriften FOR 01.04.2009 No. 384.
-------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

15.2. Chemical safety assessment

SECTION 16: Other information

Hazard symbol



Irritant

Classification according to Regulation (EC) No 1272/2008 Skin Corr 1C; H314;

[CLP/GHS]

List of relevant R-phrases (under headings 2 and 3).

R36 Irritating to eyes.

R34 Causes burns.

List of relevant H-phrases (Section 2 and 3).

H314 Causes severe skin burns and eye damage.

H319 Causes serious eye irritation.

Version

1

Responsible for safety data sheet

Valhall NGP as

Freezing point	Value: < 2 °C
Specific gravity	Value: ~ 1216,44 kg/m ³ Test temperature: 20 °C
Solubility in water	Complete
Viscosity	Value: ~ 6000 mpa

9.2. Other information

SECTION 10: Stability and reactivity

10.1. Reactivity

10.2. Chemical stability

10.3. Possibility of hazardous reactions

10.4. Conditions to avoid

Conditions to avoid Keep cool. Protect from sunlight.

10.5. Incompatible materials

10.6. Hazardous decomposition products

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Other information regarding health hazards

General	The amount of product exposed to the skin is equivalent to degree of irritation and possible damage.
---------	------------------------------------------------------------------------------------------------------

Potential acute effects

Inhalation	May cause respiratory irritation
Skin contact	Corrosive
Eye contact	Causes serious eye irritation
Ingestion	Irritating to mucous membranes in mouth and throat

SECTION 12: Ecological information

12.1. Toxicity

Ecotoxicity Not classified as dangerous for the environment

12.2. Persistence and degradability

Persistence and degradability description	Fully biodegradable
-------------------------------------------	---------------------

12.3. Bioaccumulative potential

Bioaccumulative potential Completely

12.4. Mobility in soil

Mobility	Easily soluble in water
----------	-------------------------

12.5. Results of PBT and vPvB assessment

PBT assessment results	Contains no PBT substances
vPvB evaluation results	Contains no vPvB substances

12.6. Other adverse effects

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Product classified as hazardous waste	No
Packaging classified as hazardous	No

Revision date 20.09.2016

	SAFETY DATA SHEET Valhall CleanGel	
-----------------------------------------------------------------------------------	-----------------------------------------------------	-------------------------------------------------------------------------------------

The safety data sheet is in accordance with Commission Regulation (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

SECTION 1: Identification of the substance/mixture and of the company/undertaking

Date issued	21.01.2016
Revision date	07.10.2016

1.1. Product identifier

Product name	Valhall CleanGel
--------------	------------------

1.2. Relevant identified uses of the substance or mixture and uses advised against

Function	Surface cleaning of oxidized (rust), salts, limestone algae etc.
Product group	Cleaning agent
Uses advised against	Corrodes galvanized and zinc metallized metal and surfaces treated with zincethylsilicate
The chemical can be used by the general public	Yes

1.3. Details of the supplier of the safety data sheet

Company name	Valhall NGP as
Postal address	Leirvikåsen 45
Postcode	5179
City	Godvik
Country	Norway
Tel	+47 56126100
E-mail	post@valhallngp.no
Website	http://www.valhallngp.no
Enterprise no.	916488890MVA

1.4. Emergency telephone number

Emergency telephone	Norwegian Poisoning Alarm Telephone:22 59 13 00 Ambulance:113
---------------------	------------------------------------------------------------------

SECTION 2: Hazards identification

2.1. Classification of substance or mixture

Classification according to 67/548/EEC or 1999/45/EC	R36 Xi
Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]	Eye Irrit. 2; H319

2.2. Label elements

Hazard Pictograms (CLP)



Revision date 07.10.2016

Signal word	Warning
Hazard statements	H319 Causes serious eye irritation.
Precautionary statements	P264 Wash thoroughly after handling. P280 Wear protective gloves / protective clothing / eye protection / face protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+P313 If eye irritation persists: Get medical advice / attention.

2.3. Other hazards

PBT / vPvB	No PBT/vPvB
------------	-------------

SECTION 3: Composition/information on ingredients

3.2. Mixtures

Substance	Identification	Classification	Contents
Citric Acid	CAS no.: 5949-29-1 EC no.: 201-069-1 Registration number: 01-2119457026-42-xxxx	R36 Xi H319 Eye Irrit. 2	< 30 %
Phosphoric Acid	CAS no.: 7664-38-2 EC no.: 231-633-2	Skin Corr 1B	< 5 %
Inhibitor			< 2 %
		Classification notes: Shall not be classified	
Thickener			< 2 %
		Classification notes: Shall not be classified	
Colouring			< 0,01 %
		Classification notes: Shall not be classified	

SECTION 4: First aid measures

4.1. Description of first aid measures

General	Call 113 and provide the information in the MSDS if pain should occur. For emergency phone see also section 1.4
Inhalation	By ordinary handling develops no gases
Skin contact	Wash with plenty of soap and water.
Eye contact	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Ingestion	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.

4.2. Most important symptoms and effects, both acute and delayed

Delayed symptoms and effects	Skin will be reddened by exposure over time. Eyes will sting sharp depending on the amounts of products that are in the eyes.
------------------------------	-------------------------------------------------------------------------------------------------------------------------------

4.3. Indication of any immediate medical attention and special treatment needed

Medical treatment	Ordinary symptomatic treatment.
-------------------	---------------------------------

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media	As appropriate for the surrounding fire.
------------------------------	------------------------------------------

5.2. Special hazards arising from the substance or mixture

Fire and explosion hazards	The product is not flammable.
Hazardous combustion products	Phosphorus oxides (POx)

5.3. Advice for firefighters

Revision date 07.10.2016

Personal protective equipment Use personal protective equipment as required.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures Flush with water
 Personal protection measures Wear protective gloves / protective clothing / eye protection / face protection.

6.2. Environmental precautions

Environmental precautionary measures The product is non-toxic and biodegradable. By concentrated spills will dilution and use of base as lye neutralizing product.

6.3. Methods and material for containment and cleaning up

Cleaning method Flush with water

6.4. Reference to other sections

Other instructions Look at section 8 and 13

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Protective Safety Measures

Protective Safety Measures Do not eat, drink or smoke while working.

7.2. Conditions for safe storage, including any incompatibilities

7.3. Specific end use(s)

Specific use(s) Look at section 1.2

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.2. Exposure controls

Limitation of exposure on workplace It must be used personal protective equipment. In cooperation with the supplier selected this according to the CEN standards.

Safety signs



Respiratory protection

Respiratory protection In case of inadequate ventilation wear respiratory protection.

Respiratory protection, general Partial or full mask with dust filter in enclosed spaces.

Hand protection

Hand protection PVC/Rubber/Latex

Eye / face protection

Eye protection Goggles, Mask

Skin protection

Skin protection (except hands) Full personal protective clothing.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state Gel like liquid

Colour Yellow

Odour Weak

Revision date 07.10.2016

pH (aqueous solution)	Value: < 2 Method of testing: pH meter Test temperature: 20 °C
Freezing point	Value: < -2 °C
Specific gravity	Value: ~ 1177,033 kg/m ³ Test temperature: 20 °C
Solubility in water	Complete
Viscosity	Value: ~ 6000 mpa

9.2. Other information

SECTION 10: Stability and reactivity

10.1. Reactivity

10.2. Chemical stability

10.3. Possibility of hazardous reactions

10.4. Conditions to avoid

Conditions to avoid Keep cool. Protect from sunlight.

10.5. Incompatible materials

10.6. Hazardous decomposition products

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Other information regarding health hazards

General The amount of product exposed to the skin is equivalent to degree of irritation and possible damage.

Potential acute effects

Inhalation	May cause respiratory irritation
Eye contact	Causes serious eye irritation
Ingestion	Irritating to mucous membranes in mouth and throat

SECTION 12: Ecological information

12.1. Toxicity

Ecotoxicity Not classified as dangerous for the environment

12.2. Persistence and degradability

Persistence and degradability description Fully biodegradable

12.3. Bioaccumulative potential

Bioaccumulative potential Completely

12.4. Mobility in soil

Mobility Easily soluble in water

12.5. Results of PBT and vPvB assessment

PBT assessment results Contains no PBT substances

vPvB evaluation results Contains no vPvB substances

12.6. Other adverse effects

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Product classified as hazardous No

waste	
Packaging classified as hazardous waste	No
EWC waste code	EWC: 16 50 73 EWC: 12 03 01 aqueous washing liquids

SECTION 14: Transport information

14.1. UN number

14.2. UN proper shipping name

14.3. Transport hazard class(es)

Comments	The product is not covered by international regulation on the transport of dangerous goods (IMDG, IATA, ICAO or ADR/RID).
----------	---------------------------------------------------------------------------------------------------------------------------

14.4. Packing group

14.5. Environmental hazards

14.6. Special precautions for user

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

References (laws/regulations)	Regulation on classification and labeling of hazardous chemicals, 16.07.2002 No. 1139 CLP Regulations, 16.06.2012. REACH regulation Annex II. Transportforskriften FOR 01.04.2009 No. 384.
-------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

15.2. Chemical safety assessment

SECTION 16: Other information

Hazard symbol



Irritant	
R-phrases	R36 Irritating to eyes.
Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]	Eye Irrit. 2; H319;
List of relevant R-phrases (under headings 2 and 3).	R36 Irritating to eyes.
List of relevant H-phrases (Section 2 and 3).	H319 Causes serious eye irritation.
Information which has been added, deleted or revised	Text compared and adjusted with the cons product.
Last update date	04.04.2017
Version	5
Responsible for safety data sheet	Valhall NGP as

Revision date 07.10.2016

SAFETY DATA SHEET

Corrogel Offshore

The safety data sheet is in accordance with Commission Regulation (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

SECTION 1: Identification of the substance / mixture and of the company / undertaking

Date issued	18.06.2008
Revision date	21.04.2017

1.1. Product identifier

Product name	Corrogel Offshore
Formula	Formulated product

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/preparation	Rust remover
----------------------------------	--------------

1.3. Details of the supplier of the safety data sheet

Downstream user

Company name	NorKem AS
Office address	Lagerveien 12B
Postal address	Postboks 77
Postcode	4064
City	STAVANGER
Country	Norway
Tel	+47 51951830
Fax	+47 51951831
E-mail	post@norkem.no

1.4. Emergency telephone number

Emergency telephone	Tel: +47 22 59 13 00
	Description: Toxic Information

SECTION 2: Hazards identification

2.1. Classification of substance or mixture

Classification according to Regulation (EC) No 1272/2008 [CLP / GHS]	Eye Irrit. 2; H319 Skin Irrit. 2; H315
Substance / mixture hazardous properties	Causes skin irritation. Causes serious eye irritation.

2.2. Label elements

Hazard Pictograms (CLP)

Signal word	Warning
Hazard statements	H315 Causes skin irritation. H319 Causes serious eye irritation.
Precautionary statements	P101 If medical advice is needed, have product container or label at hand. P102 Keep out of reach of children. P280 Wear protective gloves / protective clothing / eye protection / face protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P313 Get medical advice / attention.

2.3. Other hazards

PBT / vPvB	This product is not classified as PBT or vPvB.
Health effect	Causes skin irritation. Causes serious eye irritation.

SECTION 3: Composition/information on ingredients**3.1. Substances**

Substance	Identification	Classification	Contents
Phosphoric acid...%	CAS no.: 7664-38-2 EC no.: 231-633-2	Skin Corr. 1B; H314 Note : B	10 - 24 %
Substance comments	For a complete list of risk phrases, look at section 16.		

SECTION 4: First aid measures**4.1. Description of first aid measures**

Inhalation	General first aid, rest, warmth and fresh air. Get medical attention if any discomfort continues.
Skin contact	Remove affected person from source of contamination. Remove contaminated clothes. Flush skin thoroughly with water. Get medical attention if any discomfort continues.
Eye contact	Remove any contact lenses. Immediately flush with plenty of water for up to 15 minutes, also under eyelids. Immediately seek out eyedoctor/doctor. Continue flushing during transport to doctor.
Ingestion	DO NOT INDUCE VOMITING! Rinse nose, mouth and throat with water. Drink plenty of water. Do not give victim anything to drink if he is unconscious. Get medical attention.

4.2. Most important symptoms and effects, both acute and delayed

General symptoms and effects	Inhalation: Gas or vapour may irritate respiratory system.
	Skin contact: Irritating to skin. Defatting, drying and cracking of skin.
	Eye contact: Irritating and may cause redness and pain. May cause serious eye damage.
	Ingestion: Ingestion may cause severe irritation of the mouth, the oesophagus and the gastrointestinal tract. nausea, vomiting and diarrhoea

4.3. Indication of any immediate medical attention and special treatment needed

Other Information	When seeking medical advice, bring the safety data sheet or label.
-------------------	--------------------------------------------------------------------

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media Water spray, dry powder, alcohol resistant foam or carbon dioxide.

5.2. Special hazards arising from the substance or mixture

Fire and explosion hazards The product is not flammable. Contact with metals can produce Hydrogen, which can give explosive concentration with air.

5.3. Advice for firefighters

Personal protective equipment Use self-contained breathing apparatus when the product is involved in fire.

Other Information Flame exposed containers is cooled with water. If possible without any risk, remove container from fireplace.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Personal protection measures Wear protective clothing as described in Section 8 of this safety data sheet. In case of spills, beware of slippery floors and surfaces.

6.2. Environmental precautions

Environmental precautionary measures Attempt to stop the leak, if no risk is involved. Do not discharge into drains, water courses or onto the ground. Contain spillages with sand, earth or any suitable adsorbent material. Flush with water.

6.3. Methods and material for containment and cleaning up

Clean up Small spillage is dried or flushed with water. Collect with non-combustible absorbent material. Dike for large spills. Inform Authorities if large amounts are involved.

6.4. Reference to other sections

Other instructions See section 8 and 13 for further information.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Handling Wear protective clothing as described in Section 8. Observe good laboratory hygiene practices.

7.2. Conditions for safe storage, including any incompatibilities

Storage Store at cool temperature and in closed containers. Store separated from: Alkalies.

7.3. Specific end use(s)

Specific use(s) The identified uses for this product are detailed in Section 1.2.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Substance	Identification	Value	TWA Year
Phosphoric acid...%	CAS no.: 7664-38-2	TWA (8h): 1 mg/m ³ Exposure Limit Letter Letter code: E	TWA Year: 2013

Other Information about threshold limit values	References (laws/regulations): Norwegian regulation on exposure limits: "FOR-2011-12-06-1358. Explanation of the notations: E = The substance has an EU workplace exposure limit
------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

8.2. Exposure controls

Safety signs



Precautionary measures to prevent exposure

Instruction on measures to prevent exposure	All handling to take place in well-ventilated area. Personal protecting equipment should be chosen according to the CEN standards and in discussion with the supplier of the personal protective equipment. Provide eyewash, quick drench. Avoid contact with eyes and prolonged skin contact. Avoid eating, drinking and smoking when using the product.
---------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Eye / face protection

Suitable Eye Protection	Use CE-labeled safety goggles or face shield. EN 166
-------------------------	------------------------------------------------------

Hand protection

Suitable gloves type	Material : Nitrile rubber Glove thickness : 0,4 mm Breakthrough time: : > 480 min Material : Fluorinated rubber Glove thickness : 0,4 mm Breakthrough time: : > 480 min
Hand protection comments	Use CE-labeled gloves according to EN 374. Choose gloves to protect hands against chemicals depending on the concentration and quantity of the hazardous substance and specific to place of work. For special applications, we recommend clarifying the resistance to chemicals of the aforementioned protective gloves with the glove manufacturer

Skin protection

Suitable protective clothing	Wear appropriate clothing to prevent repeated or prolonged skin contact.
------------------------------	--------------------------------------------------------------------------

Respiratory protection

Recommended type of equipment	In case of inadequate ventilation use suitable respirator. Use respiratory equipment with gas filter, type BE + P3. Use CE-labeled protecting equipment. Use EN 140 for half face mask, EN 136 for full face mask. Particle filter: EN 143, Gasfilter: EN 14387.
-------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	Jelly-like.
Colour	White.
Odour	Slight odour.
pH	Status: In delivery state

	Value: ~ 1.2
Boiling point / boiling range	Value: ~ 150 °C
Flash point	Value: > 80
Specific gravity	Value: 1080 kg/m ³

9.2. Other information

SECTION 10: Stability and reactivity

10.1. Reactivity

Reactivity Not known.

10.2. Chemical stability

Stability Stable under the prescribed storage conditions.

10.3. Possibility of hazardous reactions

Possibility of hazardous reactions May react with strong alkali.

10.4. Conditions to avoid

Conditions to avoid Avoid contact with alkalis.

10.5. Incompatible materials

Materials to avoid Alkalies. Affects metals, wood, etc.

10.6. Hazardous decomposition products

Hazardous decomposition products Fire or high temperatures can create: Phosphoroxides.

Other information

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity	Type of toxicity: Acute
	Effect Tested: LD50
	Route of exposure: Oral
	Value:
	Comments: Not known.
	Type of toxicity: Acute
	Effect Tested: LD50
	Route of exposure: Oral
	Value:
Comments: Not known.	
Type of toxicity: Acute	
Effect Tested: LD50	
Route of exposure: Oral	
Value:	
Comments: Not known.	

Substance	Phosphoric acid...%
Acute toxicity	Type of toxicity: Acute Effect Tested: LD50 Route of exposure: Oral Value: 1,53 g/kg Animal test species: Rat Type of toxicity: Acute Effect Tested: LD50 Route of exposure: Dermal Value: 2,74 g/kg Animal test species: Rabbit

SECTION 12: Ecological information

12.1. Toxicity

Acute aquatic, fish	Comments : Not known.
Acute aquatic, fish LCLo	
Acute aquatic, algae	Comments : Not known.
Acute aquatic, Daphnia	Comments : Not known.

12.2. Persistence and degradability

Persistence and degradability	The product is biodegradable.
-------------------------------	-------------------------------

12.3. Bioaccumulative potential

Bioaccumulative potential	The product is not bioaccumulating.
---------------------------	-------------------------------------

12.4. Mobility in soil

Mobility	The product is water soluble and may spread in water systems.
----------	---------------------------------------------------------------

12.5. Results of PBT and vPvB assessment

PBT assessment results	This product does not contain any PBT or vPvB substances.
Substance	Phosphoric acid...%
PBT assessment results	According to Regulation nr. 1907/2006, no PBT or vPvB assessment have been done because the product is inorganic.

12.6. Other adverse effects

Environmental details, summation	The product lowers the pH in water.
----------------------------------	-------------------------------------

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Specify the appropriate methods of disposal	Absorb in vermiculite or dry sand and dispose of at a licenced hazardous waste collection point.
EWC waste code	EWC waste code: 060104 phosphoric and phosphorous acid Classified as hazardous waste: Yes
NORSAS	7131 Acids, inorganic
Other Information	EWC waste code: 060104 phosphoric and phosphorous acid.

SECTION 14: Transport information

Dangerous goods Yes

14.1. UN number

Comments Not relevant.

14.2. UN proper shipping name

Comments Not relevant.

14.3. Transport hazard class(es)

Comments Not relevant.

14.4. Packing group

Comments Not relevant.

14.5. Environmental hazards

Comments Not relevant.

14.6. Special precautions for user

Special safety precautions for user Not relevant.

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

ADR / RID - Other information

Tunnel restriction code Not relevant.

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

References (laws/regulations)	EC-directives 67/548/EEC and 1999/45/EC. Regulation (EC) No. 648/2004 on detergents. Regulation on classification, labeling and packaging of substances and mixtures (CLP). Commission Regulation (EU) No 453/2010 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Annex II. Administrative norms for pollution of the atmosphere, the latest edition, from Norwegian labour inspection authority. Norwegian regulations on waste, no. 930/2004. Dangerous Goods regulations.
Declaration no.	170620

15.2. Chemical safety assessment

Chemical safety assessment performed No

SECTION 16: Other information

List of relevant H-phrases (Section 2 and 3).	H314 Causes severe skin burns and eye damage. H315 Causes skin irritation.
-----------------------------------------------	-------------------------------------------------------------------------------

Classification according to Regulation (EC) No 1272/2008 [CLP / GHS]	H319 Causes serious eye irritation. Eye Irrit. 2; H319 Skin Irrit. 2; H315
CLP Classification, comments Information which has been added, deleted or revised	Classification procedure: calculation method. REVISIONS: ----- 13.11.2012: REACH Annex II. 25.11.2014: CLP classification. 03.08.2016 13.09.2016: Changes to section 8. 21.04.2017: General revision.

1. IDENTIFICATION OF PREPARATION AND COMPANY

PRODUCT IDENTIFIER

Trade name: Avesta Cleaner 401
Avesta Classic Cleaner 401

RELEVANT IDENTIFIED USES AND USES ADVISED AGAINST

Application and use: Cleaning of stainless steel
Not to be used on: Other metals than stainless steel

DETAILS OF THE SUPPLIER OF THE SAFETY DATA SHEET

Manufacturer: **Böhler Welding Group Nordic AB**
Avesta Finishing Chemicals
Lodgatan 14, 211 24 MALMÖ, Sweden
Telephone: +46 (0)40 288 300
E-mail: safety@avestafinishing.com

EMERGENCY TELEPHONE NUMBER

+44 1 132 450 530 (Leeds)

MISCELLANEOUS

Issue date: 2013-08-16
Version No: 7
Valid from: 2013-08-31

2. HAZARDS IDENTIFICATION

CLASSIFICATION

Health hazard in case of accidental exposure (R-phrases):

The product is classified as corrosive. Risk for injuries on skin and mucous membranes.

Environmental effects:

Will reduce pH in water. Must be neutralised. See also section 12.

Physical and chemical risks:

When heated phosphorus gases and hydrogen can be emitted.

LABEL ELEMENTS

Hazard symbols:



Corrosive

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

1/9

Risk phrases:

R 34

Safety phrases:

S 1/2

S 26

S 28

S 36/37/39

S 45

OTHER HAZARDS

Not known

3. COMPOSITION/INFORMATION ON INGREDIENTS

PREPARATION

Chemical identity: Colourless acid solution with corrosive properties.

INFORMATION ON INGREDIENTS

CLASSIFICATION ACCORDING TO REGULATION 67/548/EEG OR 1999/45/EG					
Hazardous components, chemical name, formula	CAS No.	EC No.	Contents weight-%	Hazard symbol/ Risk phrase*	
Phosphoric acid , H ₃ PO ₄	7664-38-2	231-633-2	16	C, R34	
Alcohols, C11-14-iso-, Cl3-rich, ethoxylated	78330-21-9	-	3-5	Xn, R22, 41	
CLASSIFICATION ACCORDING TO REGULATION (EG) no 1272/2008					
Hazardous components, chemical name, formula	CAS No.	EC No.	Contents weight-%	Hazard category	Hazard statements cod
Phosphoric acid , H ₃ PO ₄	7664-38-2	231-633-2	16	1 1B	H290 H314
Alcohols, C11-14-iso-, Cl3-rich, ethoxylated	78330-21-9	-	3-5	1 4	H318 H302

*The full texts of the phrases are shown in section 16.

Additional information Classification according to directive 67/548/EEC.

Symbols and risk phrases are for concentrated substances.

4. FIRST AID MEASURES

DESCRIPTION OF FIRST AID MEASURES AND INDICATION OF IMMEDIATE AND SPECIAL TREATMENT NEEDED

Inhalation:

Remove to fresh air. Keep victim lying down, quiet and warm. Rinse nose and mouth with water. Might require assistance with breathing. Seek medical care even if only slight discomfort occurs.

Ingestion:

Drink at once milk or water. Seek medical care.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

Skin contact:

Rinse immediately with plenty of water, seek medical care.

Eye contact:

Protect intact eye. Rinse immediately with plenty of water for at least 15 minutes and seek immediate medical care (eye specialist). Keep rinsing during transport.

SYMPTOMS ACUTE AND DELAYED

Not known

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA

The most appropriate media to extinguish surrounding fire is depending on what is burning.

SPECIAL HAZARDS ARISING FROM THE MIXTURE

Chemical exposure risks caused by released gases/vapours:

The Pickling Fluid will emit toxic fumes and phosphoric oxides when exposed to heat/fire.

ADVICE FOR FIREFIGHTERS

Danger of fire/explosion:

Fluid is non-flammable. Bottles close to fire should be removed or cooled with water.

Protective clothing for firemen:

Appropriate protective acid-resistant clothing should be used.

Breathing protection:

Gas mask with filter according to CEN (Central European Norms).

How to clean or destroy soiled fire equipment:

Thoroughly wash with water.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES

Personal precautions:

Avoid direct contact. If there is still a risk of direct contact or stench protect with some form of acid-resistant material. Wear eye protection, skin protection, rubber gloves and breathing apparatus. Keep working area well ventilated.

ENVIRONMENTAL PRECAUTIONS

Spillage (water, air, soil):

Prevent spillage from entering sewage or public waters or nature.

METHODS AND MATERIAL FOR CONTAINMENT AND CLEANING UP

Methods for cleaning up:

Neutralise with Avesta Neutralising Agent or a strong alkaline compound i.e. slaked lime. Embank with sand. Arrange for pick up. Rinse with plenty of water.

Spillage should be picked up and disposed of in full compliance with federal, state and local regulations as acid waste.

REFERENCE TO OTHER SECTIONS

Handling and storage section 7, exposure control/personal protection section 8 and disposal considerations section 13.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

3/9

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING

Technical measures:

Working place and methods should be worked out in order to avoid direct contact. Work and storage area should be well ventilated. A closed rinse water system with filtration and reuse of clear water is recommended.

To prevent fire and explosion:

Bottles close to fire should be removed or cooled with water.

Precautions:

Avoid fume generation and accumulation by using in a well-ventilated area. Use in areas having local exhaust and general ventilation.

Emergency eyewash and safety shower must be available at the working place.

CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES

Technical measures:

Storage room should be kept separate, cool, dry, well ventilated and closed to unauthorised persons.

Incompatible products:

Not applicable.

Storage conditions:

Keep containers securely closed when not in use and in an upright position. Store in areas where temperature remains between 0-30 °C at all times.

Packaging materials:

Package must be of acid resistant plastic material.

SPECIFIC END USES

See section 1. Contact the manufacturer for more information.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

CONTROL PARAMETERS

Phosphoric acid:

EU: IOEL 1,0 mg/m³ (8 hr), 2,0 mg/m³ (15 min)

EXPOSURE CONTROLS

Respiratory protection:

Gas mask with a filter according to CEN (Central European Norms)

Hand protection:

Acid resistant rubber gloves, i.e. Butyl and Nitrile rubber.

Eye protection:

Face shield.

Skin and body protection:

Rubber boots and acid resistant clothes, which covers all body parts exposed to splashes.

Specific hygienic measures:

Do not inhale fumes, avoid contact with eyes, skin and clothes. It is not allowed to eat, drink and smoke at workplace.

Environmental exposure controls: See section 6 and 7.

9. PHYSICAL AND CHEMICAL PROPERTIES

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

4/9

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

INFORMATION ON BASIC PHYSICAL AND CHEMICAL PROPERTIES

Physical state (form, colour, smell) at 20°C:

Transparent liquid with a slight smell.

Boiling point:

80-100°C

Flash point / Explosion properties:

Not applicable

Specific temperatures:

Solid-fluid 0°C, Fluid-gas 80-100°C

Vapour pressure at 20°C:

< 0.01 kPa

pH:

0,6 at 20°C

Density:

1.1 g/cm³ at 20°C

Solubility in water at 20°C:

100 weight %

10. STABILITY AND REACTIVITY

REACTIVITY

Reacts vigorously with alkaline substances

CHEMICAL STABILITY

Stable under normal conditions.

POSSIBILITY OF HAZARDOUS REACTIONS

Polymerization will not occur

CONDITIONS TO AVOID

Avoid high temperatures, must not be exposed to direct sunshine. When heated, phosphoric gases will be emitted.

INCOMPATIBLE MATERIALS

Contact with alkaline compounds causes a heavy exothermic reaction with heat development.

HAZARDOUS DECOMPOSITION PRODUCTS

Will emit phosphoric gases and hydrogen gas.

11. TOXICOLOGICAL INFORMATION

INFORMATION ON TOXICOLOGICAL EFFECTS

Acute toxicity

LD₅₀ rat oral 1530 mg/kg (Phosphoric acid)

Effects on the skin:

Will irritate, burn and may cause wounds.

Effects on the eyes:

Fumes may cause irritation. Splashes can cause serious damage to the eye.

After ingestion:

May cause damage to mucous membranes, pain, vomiting and diarrhoea.

Upon inhalation:

Inhalation of fumes or mist might cause aches, cough and difficulty in breathing. Risk for pulmonary oedema.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

OTHER RELEVANT INFORMATION

CMR-effects:

Not known

12. ECOLOGICAL INFORMATION

PERSISTENCE AND DEGRADABILITY

No data

BIOACCUMULATIVE POTENTIAL

The product is not regarded as bioaccumulative.

MOBILITY IN SOIL

The product can hike down to the groundwater.

RESULTS OF PBT AND vPvB ASSESSMENT

Non-current

OTHER ADVERSE EFFECTS

The product is soluble in water and in its concentrated form will lower the pH of ground water.

13. DISPOSAL CONSIDERATIONS

WASTE TREATMENT METHODS

Methods of disposal the product:

Discarded product and related waste is hazardous waste. Alloting of EWC-code should be made on the basis of the source causing the waste.

Suggested EWC-code is 11 01 05* Pickling acids.

Waste from residues:

Contaminated residues i.e. wastewater must be neutralised and heavy metals from the process should be removed and these constitute hazardous waste.

Contaminated packing:

Rinse with plenty of water.

Additional information:

Effluent must be separated and disposed of as acidic waste. A filtration system for rinse water is recommended.

Consult with your local authorized and licensed waste disposal agency and ministry of environment for instructions and procedures for approved waste disposal.

14. TRANSPORT INFORMATION

UN-Classification No:

3264

UN PROPPER SHIPPING NAME

CORROSIVE LIQUID, ACIDIC, INORGANIC N.O.S. (phosphoric acid)

TRANSPORT HAZARD CLASS(ES)

Classification Code:

C1

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

6/9

PACKING GROUP

III

ENVIRONMENTAL HAZARDS

IMDG (Sea):

Class 8 EmS F-A, S-B

Marine Pollutant: No

ADR/RID (road, rail):

Class 8

Tunnel restriction code:

(E)

IATA/DGR (air):

Class 8

ADDITIONAL INFORMATION

The product is to be transported according to dangerous goods regulations.

15. REGULATORY INFORMATION

SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS

Regulations:

1907/2006/EC, 1272/2008/EC Table 3.1, 67/648/EEC, EWC 2000/532/EC

Other regulations:

IMDG

ADR/RID

IATA/DGR

Chemical Safety Assessment:

Has not been carried out for this product (or substances in the preparation).

16. OTHER INFORMATION

CHANGES MADE SINCE LAST VERSION

Information on dual classification of elements in section 3, explanation of the hazard classes referred to in section 16.

TRAINING ADVICE

The Avesta Welding "Handbook for the pickling and cleaning of stainless steel" and "Guidelines for Planning and Designing a Pickling Workshop".

KEY LITERATURE REFERENCES AND SOURCES FOR DATA

Standard Practice for cleaning stainless steel (ASTM-A-380),

International Standard ISO 11014-1

Print date: 2013-09-09 by Castro Milma

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

7/9

Digitalt styrt dokument, utskriften måste jämföras med digitala kopian innan användning.

LIST OF RELEVANT R- AND S-PHRASES, HAZARD CATEGORIES AND STATEMENTS CODES AS WELL AS PRECAUTIONARY STATEMENTS IN SECTION 2 AND 3.

Risk phrases:

R 22: Harmful if swallowed.

R 34: Causes burns

R 41: Risk of serious damages to eyes.

Hazard classes to the hazard categories and hazard statements codes

1/H290: May be corrosive to metals

1B/H314: Causes severe skin burns and eye damage

1/H318: Causes serious eye damage

4/H302: Harmful if swallowed

Safety phrases:

S 1/2: Keep locked up and out of the reach of children.

S 26: In case of contact with eyes rinse immediately with plenty of water and seek medical advice.

S 28: After contact with skin, wash immediately with plenty of water or Avesta First Aid Spray.

S 36/37/39: Wear suitable protective clothing, gloves and eye/face protection.

S 45: In case of accident or if you feel unwell, seek medical advice immediately. Show the label where possible.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

1. IDENTIFICATION OF PREPARATION AND COMPANY

PRODUCT IDENTIFIER

Trade name: Avesta BlueOne™ Pickling Paste 130
Avesta BlueOne™ Pickling Gel 130

RELEVANT IDENTIFIED USES AND USES ADVISED AGAINST

Application and use: Pickling/cleaning of stainless steel
Not to be use on Other metals than stainless steel

DETAILS OF THE SUPPLIER OF THE SAFETY DATA SHEET

Manufacturer: **Böhler Welding Group Nordic AB**
Avesta Finishing Chemicals
Lodgatan 14, 211 24 MALMÖ, Sweden
Telephone: +46 (0)40 288 300
E-mail: safety@avestafinishing.com

EMERGENCY TELEPHONE NUMBER

+44 1 132 450 530 (Leeds)

MISCELLANEOUS

Issue date: 2013-08-15

Version No: 7

Valid from: 2013-08-31

2. HAZARDS IDENTIFICATION

CLASSIFICATION

Health hazard in case of accidental exposure (R-phrases):

Toxic by inhalation, contact with skin and if swallowed. It causes severe burns.

Environmental effects:

Pickling Fluid will strongly reduce pH in water. Must be neutralised. See also section 12.

Physical and chemical risks:

When heated nitrous gases can be formed.

LABEL ELEMENTS

Hazard symbols:



Toxic



Corrosive

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

1/10

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

Risk phrases:

R 23/24/25

R 35

Safety phrases:

S 1/2

S 7/47

S 23

S 26

S 28

S 36/37/39

S 45

S 61

OTHER HAZARDS

The mixture contains sulphates which in the acidic environment can form sulphuric acid.

3. COMPOSITION/INFORMATION ON INGREDIENTS

PREPARATION

Chemical identity: Strong acid paste/solution with corrosive properties.

INFORMATION ON INGREDIENTS

CLASSIFICATION ACCORDING TO REGULATION 67/548/EEG OR 1999/45/EG					
Hazardous components, chemical name, formula	CAS No.	EC No.	Contents weight-%	Hazard symbol/ Risk phrase*	
Nitric acid, HNO ₃	7697-37-2	231-714-2	15-25	O, C: R8, R35	
Hydrofluoric acid, HF	7664-39-3	231-634-8	2-6	T+, C: R26, 27, 28-35	
CLASSIFICATION ACCORDING TO REGULATION (EG) no 1272/2008					
Hazardous components, chemical name, formula	CAS No.	EC No.	Contents weight-%	Hazard category	Hazard statements cod
Nitric acid, HNO ₃	7697-37-2	231-714-2	15-25	1 1A	H290 H314
Hydrofluoric acid, HF	7664-39-3	231-634-8	2-6	2 1 2 1A	H330 H310 H300 H314

*The full texts of the phrases are shown in section 16.

Additional information Classification according to directive 67/548/EEC.

Symbols and risk phrases are for concentrated substances.

4. FIRST AID MEASURES

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

2/10

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

DESCRIPTION OF FIRST AID MEASURES AND INDICATION OF IMMEDIATE AND SPECIAL TREATMENT NEEDED

Inhalation:

Remove to fresh air. Keep victim lying down, quiet and warm. Rinse nose and mouth with water. Might require assistance with breathing. Seek medical care even if only slight discomfort occurs.

Ingestion:

If victim is conscious and alert give milk or water to drink. Thereafter 20 lime tablets dissolved in 2 L of water. Do not induce vomiting. Seek medical care.

Skin contact:

Alternative A - Rinse immediately with plenty of water, then treat with 2.5% Calcium Gluconate gel, follow the instructions on the packaging. If not available, see alt. B.

Alternative B - Rinse immediately with *Avesta First Aid Spray 910*. Spray liberally onto the affected area, always using the complete content. Avoid rinsing with water first, as it reduces the effect of the solution.

After alternative A and B seek medical help.

Eye contact:

Protect intact eye. Rinse immediately with plenty of water for at least 15 minutes and seek immediate medical care (eye specialist).

Information for medical care:

Inform the doctor that the injury has been caused by contact with hydrofluoric, sulphuric and nitric acid mixtures.

SYMPTOMS ACUTE AND DELAYED

Pain in the mouth, throat and breast may occur at inhalation. Salivation and easier dysphonia and discomfort feeling in the breast. In contact with the skin symptoms can be delayed.

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA

The most appropriate media to extinguish surrounding fire is water.

SPECIAL HAZARDS ARISING FROM THE MIXTURE

Chemical exposure risks caused by released gases/vapours:

The Pickling Fluid will emit toxic fumes and nitrous fumes when exposed to heat/fire.

ADVICE FOR FIREFIGHTERS

Danger of fire/explosion:

Fluid is non-flammable. Bottles close to fire should be removed or cooled with water.

Protective clothing for firemen:

Appropriate protective acid-resistant clothing should be used.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

3/10

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

Breathing protection:

Gas mask with filter of chlorine type B (grey) and dust filter P2, according to CEN (Central European Norms).

How to clean or destroy soiled fire equipment:

Thoroughly wash with water.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES

Personal precautions:

Avoid direct contact. If there is still a risk of direct contact or stench protect with some form of acid-resistant material. Wear eye protection, skin protection, rubber gloves and breathing apparatus. Keep working area well ventilated.

ENVIRONMENTAL PRECAUTIONS

Spillage (water, air, soil):

Prevent spillage from entering sewage or public waters or nature.

METHODS AND MATERIAL FOR CONTAINMENT AND CLEANING UP

Methods for cleaning up:

Neutralise with Avesta Neutralising Agent or a strong alkaline compound i.e. slaked lime. Embank with sand. Arrange for pick up. Rinse with plenty of water.

Spillage should be picked up and disposed of in full compliance with federal, state and local regulations as acid waste.

REFERENCE TO OTHER SECTIONS

Handling and storage section 7, exposure contrd/personal protection section 8 and disposal considerations section 13.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING

Technical measures:

Working place and methods should be worked out in order to avoid direct contact. Work and storage area should be well ventilated. A closed rinse water system with filtration and reuse of clear water is recommended.

To prevent fire and explosion:

Bottles close to fire should be removed or cooled with water.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

4/10

Print date: 2013-09-09 by Castro Lima

Digitalt styrt dokument, utskrivna kopia måste jämföras med digitala kopian innan användning.

Precautions:

Avoid fume generation and accumulation by using in a well-ventilated area. Use in areas having local exhaust and general ventilation.

Avesta First Aid Spray 910 for both eyes and skin, should be available at the premises. Emergency eyewash and safety shower must be available at the working place.

CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES

Technical measures:

Storage room should be kept separate, cool, dry, well ventilated and closed to unauthorised persons.

Incompatible products:

Not applicable.

Storage conditions:

Keep containers securely closed when not in use and in an upright position. Store in areas where temperature remains between 0-30 °C at all times.

Packaging materials:

Package must be of acid resistant plastic material.

SPECIFIC END USES

See section 1. Contact the manufacturer for more information.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

CONTROL PARAMETERS

Hydrofluoric acid:

EU: IOEL 1,5 mg/m³ (8 hr), 2,5 mg/m³ (15 min)

Nitric acid:

EU: IOEL 0,05 mg/m³ (8 hr)

Sulphuric acid:

EU: IOEL 0,05 mg/m³ thoracic fraction (8 hr)

Chronic effects, inhalation:

Exposure to strong inorganic acid mists containing sulphuric acid is known to be a human carcinogen, based on sufficient evidence of carcinogenicity from studies in humans.

EXPOSURE CONTROLS

Respiratory protection:

Gas mask with a filter of the chlorine type B (grey) and dust filter P2

Hand protection:

Acid resistant rubber gloves.

Eye protection:

Face shield.

Skin and body protection:

Rubber boots and acid resistant clothes, which covers all body parts exposed to splashes.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

5/10

Digitalt styrt dokument, utskriven kopia måste jämföras med digitala kopian innan användning.

Specific hygienic measures:

Do not inhale fumes, avoid contact with eyes, skin and clothes. It is not allowed to eat, drink and smoke at workplace. Remove contaminated clothes immediately. Wash hands and face thoroughly after working with pickling paste. *Avesta First Aid Spray 910* should be available at the premises.

Environmental exposure controls: See section 6 and 7.

9. PHYSICAL AND CHEMICAL PROPERTIES

INFORMATION ON BASIC PHYSICAL AND CHEMICAL PROPERTIES

Physical state (form, colour, smell) at 20°C:

Blue paste/gel with a minor pungent smell.

Boiling point:

80-100°C

Flash point / Explosion properties:

Not applicable

Specific temperatures:

Solid-fluid 40°C, Fluid-gas 50-60°C (nitric fumes)

Vapour pressure at 20°C:

< 0.01 kPa

pH:

0 at 20°C

Density:

1.2-1.3 g/cm³ at 20°C

Solubility in water at 20°C:

90 weight %

10. STABILITY AND REACTIVITY

REACTIVITY

Reacts vigorously with base metals and alkaline substances

CHEMICAL STABILITY

Stable under normal conditions.

POSSIBILITY OF HAZARDOUS REACTIONS

Polymerization will not occur

CONDITIONS TO AVOID

Avoid high temperatures, must not be exposed to direct sunshine. When heated, nitrous gases will be developed.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

INCOMPATIBLE MATERIALS

Contact with low alloyed metals and alkaline compounds causes a heavy exothermic reaction with heat development and stench risk.

HAZARDOUS DECOMPOSITION PRODUCTS

Will emit nitrous gases, hydrofluoric acid and sulphuric oxides.

11. TOXICOLOGICAL INFORMATION

INFORMATION ON TOXICOLOGICAL EFFECTS

Effects on the skin:

Gives corrosive damages with yellowish discoloration of the skin, blisters and slow-healing wounds.

Effects on the eyes:

Causes intensive pain and corrosive damages. Risk of irreparable damage to the eyes.

After ingestion:

Gives corrosive damages with burning pain, possibly severe general effect and damage to kidneys and liver.

Upon inhalation:

Inhalation of fumes or mist might cause aches, cough and difficulty in breathing. Risk for pulmonary oedema.

Additional information:

Symptoms will not appear immediately.

OTHER RELEVANT INFORMATION

CMR-effects:

Exposure to strong inorganic acid mists containing sulphuric acid is known to be a human carcinogen (IARC Group 1), based on sufficient evidence of carcinogenicity from studies in humans.

12. ECOLOGICAL INFORMATION

TOXICITY (Hydrofluoric acid):

Fish (fresh water), 60ppm, lethal (time period not specified)

LC50 Fish 96h: 441 mg/l (Gambusia affinis)

EC50 Daphnia 48h: 10-100 mg/l

IC50 Algae 72 h: 2 mg/l

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

PERSISTENCE AND DEGRADABILITY

Will be protolized in water to H+ , NO-3 , SO42-, F-

BIOACCUMULATIVE POTENTIAL

The product is not regarded as bioaccumulative.

MOBILITY IN SOIL

The product is viscous and, after a period could hike down to the groundwater.

RESULTS OF PBT AND vPvB ASSESSMENT

Non-current

OTHER ADVERSE EFFECTS

Acute effects due to the lowering of pH and burns, i.e. there is a significant decrease in the number of algae at pH<6.

13. DISPOSAL CONSIDERATIONS

WASTE TREATMENT METHODS

Methods of disposal the product:

Discarded product and related waste is hazardous waste. Alloting of EWC-code should be made on the basis of the source causing the waste.

Suggested EWC-code is 11 01 05* Pickling acids.

Waste from residues:

Upon neutralization of remaining acid rests and rinsing water can heavy metals precipitate and these constitute hazardous waste. Neutralise with Avesta Neutralising Agent or slaked lime. Suggested EWC-code 11 01 09* Sludges and filter cakes containing dangerous substances.

Contaminated packing:

Rinse with plenty of water.

Additional information:

Effluent must be separated and disposed of as acidic waste. The product has in the undiluted form toxic effects on soil and water. The remaining acid rests and rinsing water can lower the pH value of wastewater and therefore should not be released until it has undergone a neutralization process.

Consult with your local authorized and licensed waste disposal agency and ministry of environment for instructions and procedures for approved waste disposal.

14. TRANSPORT INFORMATION

UN-Classification No:

2922

UN PROPPER SHIPPING NAME

CORROSIVE LIQUID, TOXIC, N.O.S. (hydrofluoric acid, nitric acid)

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

8/10

TRANSPORT HAZARD CLASS(ES)

Classification Code:

CT1

PACKING GROUP

II

ENVIRONMENTAL HAZARDS

IMDG (Sea):

Class 8 (6.1) EmS F-A, S-B

Marine Pollutant: No

ADR/RID (road, rail):

Class 8 (6.1)

Tunnel restriction code:

(E)

IATA/DGR (air):

Class 8 (6.1)

ADDITIONAL INFORMATION

The product is to be transported according to dangerous goods regulations.

15. REGULATORY INFORMATION

SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS

Regulations:

1907/2006/EC, 1272/2008/EC Table 3.1, 67/648/EEC, EWC 2000/532/EC

Other regulations:

IMDG

ADR/RID

IATA/DGR

Chemical Safety Assessment:

Has not been carried out for this product (or substances in the preparation).

16. OTHER INFORMATION

CHANGES MADE SINCE LAST VERSION

Information on dual classification of elements in section 3, explanation of the hazard classes referred to in section 16.

TRAINING ADVICE

The Avesta Welding "Handbook for the pickling and cleaning of stainless steel" and "Guidelines for Planning and Designing a Pickling Workshop".

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

9/10

Digitalt styrt dokument, utskrivna kopia måste jämföras med digitala kopian innan användning.

KEY LITERATURE REFERENCES AND SOURCES FOR DATA

Standard Practice for cleaning stainless steel (ASTM-A-380),
Fluorides WHO (Env. Health Criteria 36), International Standard ISO 11014-1I

LIST OF RELEVANT R- AND S-PHRASES, HAZARD CATEGORIES AND STATEMENTS CODES AS WELL AS PRECAUTIONARY STATEMENTS IN SECTION 2 AND 3.

Risk phrases:

R 8: Contact with combustible material may cause fire.
R 26/27/28: Very toxic by inhalation, in contact with skin and if swallowed.
R 23/24/25: Toxic by inhalation, in contact with skin and if swallowed.
R 35: Causes severe burns.

Hazard classes to the hazard categories and hazard statements codes

1/H310: Fatal in contact with skin
1/H290: May be corrosive to metals
1A/H314: Causes severe skin burns and eye damage
2/H330: Fatal if inhaled
2/H300: Fatal if swallowed

Safety phrases:

S 1/2: Keep locked up and out of the reach of children.
S 7/47: Keep container tightly closed and at temperature not exceeding 30°C.
S 23: Do not breathe fumes.
S 26: In case of contact with eyes rinse immediately with plenty of water and seek medical advice.
S 28: After contact with skin, wash immediately with plenty of water or Avesta First Aid Spray.
S 36/37/39: Wear suitable protective clothing, gloves and eye/face protection.
S 45: In case of accident or if you feel unwell, seek medical advice immediately. Show the label where possible.
S 61: Avoid release to environment. Refer to special instructions/safety data sheet.

Utgåva:	Utgivningsdatum:
7, Aktivt	2013-08-16

1. IDENTIFICATION OF PREPARATION AND COMPANY

PRODUCT IDENTIFIER

Trade name: Avesta FinishOne Passivator 630
Avesta FinishOne Passivating Agent 630

RELEVANT IDENTIFIED USES AND USES ADVISED AGAINST

Application and use: Passivation of stainless steel
Not to be use on Other metals than stainless steel

DETAILS OF THE SUPPLIER OF THE SAFETY DATA SHEET

Manufacturer: **Böhler Welding Group Nordic AB**
Avesta Finishing Chemicals
Lodgatan 14, 211 24 MALMÖ, Sweden
Telephone: +46 (0)40 288 300
E-mail: safety@avestafinishing.com

EMERGENCY TELEPHONE NUMBER

+46-8-331 231 (24 hrs)

MISCELLANEOUS

Issue date: 2012-11-26
Version No: 3
Valid from: 2012-12-01

2. HAZARDS IDENTIFICATION

The product is not classified as hazardous according to current regulations

3. COMPOSITION/INFORMATION ON INGREDIENTS

PREPARATION

Chemical identity: Colourless, odourless liquid

INFORMATION ON IGREDIENTS

Hazardous components, chemical name, formula	CAS No.	EC No.	Contents weight-%	Hazard symbol/ Risk phrase*
Hydrogen peroxide,	7722-84-1	231-765-0	<4,5	O, C: R8, R34

Error! Unknown document property name.



H ₂ O ₂				
-------------------------------	--	--	--	--

*The full texts of the phrases are shown in section 16.

Additional information Classification according to directive 67/548/EEC.

Symbols and risk phrases are for concentrated substances.

4. FIRST AID MEASURES

DESCRIPTION OF FIRST AID MEASURES AND INDICATION OF IMMEDIATE AND SPECIAL TREATMENT NEEDED

Inhalation:

Remove to fresh air.

Ingestion:

Drink at once, milk or water to drink. Do not induce vomiting. Seek medical care.

Skin contact:

Remove clothes immediately and rinse with plenty of water, seek medical care.

Eye contact:

Protect intact eye. Rinse immediately with plenty of water for at least 15 minutes and seek immediate medical care (eye specialist).

Information for medical care:

Inform the doctor that the injury has been caused by contact with hydrogen peroxide solution.

SYMPTOMS ACUTE AND DELAYED

Not known

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA

The most appropriate media to extinguish surrounding fire is water. Do not use foam or dry powder.

SPECIAL HAZARDS ARISING FROM THE MIXTURE

Chemical exposure risks caused by released gases/vapours:

The product will emit oxygen gas and fumes when exposed to heat/fire.

ADVICE FOR FIREFIGHTERS

Danger of fire/explosion:

Fluid is non-flammable. Bottles close to fire should be removed or cooled with water.

Protective clothing for firemen:

Appropriate protective acid-resistant clothing should be used.

How to clean or destroy soiled fire equipment:

Thoroughly wash with water.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES

Personal precautions:

Avoid direct contact. If there is still a risk of direct contact or stench protect with some form of acid-resistant material. Wear eye protection, skin protection and rubber gloves. Keep working area well ventilated.

ENVIRONMENTAL PRECAUTIONS

Spillage (water, air, soil):

Prevent spillage from entering sewage or public waters if the product is not sufficient diluted.

METHODS AND MATERIAL FOR CONTAINMENT AND CLEANING UP

Methods for cleaning up:

Embank with sand. Arrange for pick up. Rinse with plenty of water.

Spillage should be picked up and disposed of in full compliance with federal, state and local regulations.

REFERENCE TO OTHER SECTIONS

Handling and storage section 7, exposure control/personal protection section 8 and disposal considerations section 13.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING

Technical measures:

Working place and methods should be worked out in order to avoid direct contact. Work and storage area should be well ventilated.

To prevent fire and explosion:

Bottles close to fire should be removed or cooled with water.

Precautions:

Emergency eyewash and safety shower must be available at the working place.

CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES

Technical measures:

Storage room should be kept separate, cool, dark, dry, well ventilated and closed to unauthorised persons.

Incompatible products:

Not applicable

Storage conditions:

Keep containers securely closed when not in use and in an upright position. Store in cool and dark areas.

SPECIFIC END USES

See section 1. Contact the manufacturer for more information.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

CONTROL PARAMETERS

Hydrogen Peroxide:

EU: Not specified

EXPOSURE CONTROLS

Respiratory protection:

Gas mask with an appropriate filter should be use.

Hand protection:

Acid resistant rubber gloves as Nitrile or Butyl rubber is recommended.

Eye protection:

Face shield or safety glasses.

Skin and body protection:

Use protective clothes when necessary.

Specific hygienic measures:

It is not allowed to eat, drink and smoke at workplace. Wash hands thoroughly after working with chemicals products.

Environmental exposure controls: See section 6 and 7.

9. PHYSICAL AND CHEMICAL PROPERTIES

INFORMATION ON BASIC PHYSICAL AND CHEMICAL PROPERTIES

Physical state (form, colour, smell) at 20°C:

Colourless, odourless liquid.

Boiling point:

101°C

Flash point / Explosion properties:

Not applicable

Specific temperatures:

Solid-Fluid-3°C

Vapour pressure at 20°C:

2,4 kPa

pH:

6,5-7,5 at 20°C

Density:

1.0 g/cm³ at 20°C

Solubility in water at 20°C:

100 weight %

10. STABILITY AND REACTIVITY

REACTIVITY

Reacts with alkaline and organic substances, heavy metals and UV radiation.

CHEMICAL STABILITY

Stable under normal conditions.

CONDITIONS TO AVOID

Avoid high temperatures, must not be exposed to direct sunshine.

INCOMPATIBLE MATERIALS

Contact with metals (other than stainless steel), salts of metals and alkaline and organic compounds cause decomposition.

HAZARDOUS DECOMPOSITION PRODUCTS

Will emit oxygen and hydrogen gas, fumes and heat.

11. TOXICOLOGICAL INFORMATION

INFORMATION ON TOXICOLOGICAL EFFECTS

Toxicity

Even though the product is not classified as hazardous, it does contain a small percentage of a substance that is corrosive.

Acute toxicity

Non data

Effects on the skin:

Can give temporary and harmless skin-bleach.

Effects on the eyes:

Causes pain and irritation.

After ingestion:

Causes illness.

OTHER RELEVANT INFORMATION

CMR-effects:

Not known.

12. ECOLOGICAL INFORMATION

TOXICITY (Hydrogen peroxide):

Non data

PERSISTENCE AND DEGRADABILITY

In contact with water or soil the product will be decomposed to oxygen and water.

BIOACCUMULATIVE POTENTIAL

The product is not regarded as bioaccumulative.

RESULTS OF PBT AND vPvB ASSESSMENT

Non-current

OTHER ADVERSE EFFECTS

Not known.

13. DISPOSAL CONSIDERATIONS

WASTE TREATMENT METHODS

Methods of disposal the product:

Discarded product and related waste is hazardous waste. Alloting of EWC-code should be made on the basis of the source causing the waste.

Suggested EWC-code is 16 09 03* Hydrogen peroxide.

Waste from residues:

It may discharge to sewer and water if sufficient diluted.

Contaminated packing:

Rinse with plenty of water.

Additional information:

Consult with your local authorized and licensed waste disposal agency and ministry of environment for instructions and procedures for approved waste disposal.

14. TRANSPORT INFORMATION

The product is not classified as dangerous goods according to transport regulations (ADR/RID; DGR and IMDG code).

15. REGULATORY INFORMATION

SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS

Regulations:

1907/2006/EC, 1272/2008/EC Table 3.1, 67/648/EEC, EWC 2000/532/EC

Other regulations:

IMDG

ADR/RID

IATA/DGR

Chemical Safety Assessment:

Has not been carried out for this product (or substances in the preparation).

16. OTHER INFORMATION

CHANGES MADE SINCE LAST VERSION

Information about labeling moved from section 15 to section 2, information about other hazards in section 2, as well as updating the template according to CLP.

TRAINING ADVICE

The Avesta Welding "Handbook for the pickling and cleaning of stainless steel" and "Guidelines for Planning and Designing a Pickling Workshop".

KEY LITERATURE REFERENCES AND SOURCES FOR DATA

Standard Practice for cleaning stainless steel (ASTM-A-380),
Fluorides WHO (Env. Health Criteria 36), International Standard ISO 11014-1

LIST OF RELEVANT R- AND S-PHRASES, HAZARDS STATEMENTS AND/OR PRECAUTIONARY STATEMENTS IN SECTION 3.

Risk phrases:

R 8: Contact with combustible material may cause fire.

R 34: Causes burns.

SIKKERHETSATABLAD

i henhold til REACH (1907/2006/EF, ved endring av 453/2010/EF)

Revisjonsdato: N/A

Utgivelsesdato: 24.12.2015

SDS nr.

A-05

SEKSJON 1: IDENTIFIKASJON AV STOFFET/STOFFBLANDINGEN OG SELSKAPET/FORETAKET

1.1 Produktidentifikator

InnoTek Beise Spray 2020

1.2 Relevante identifiserte anvendelser av stoffet eller blandingen og anvendelser som frarådes

Syrebasert kjemikalje for rensing av rustfritt stål og syrefast stål

1.3 Detaljer angående leverandøren på sikkerhetsdatapladet

Leverandør:

InnoTek Kjemi AS
Djupedalsveien 26
4330 Ålgård
Tel.: +47 91005035

Kontaktperson:

Steffen Link (E-post: steffen.link@innotek-kjemi.no)

1.4. Nødnummer

Ring 112 eller Giftinformasjonssentralen alle dager, døgnåpen telefon: 22 59 13 00
www.giftinfo.no

SEKSJON 2: FAREIDENTIFIKASJON

2.1 Klassifisering av stoffet eller blandingen

Klassifisering i henhold til CLP (EC) No 1272/2008 [CLP/GHS]

Acute Tox. 3: H310 Giftig ved hudkontakt
Acute Tox. 3: H301 Giftig ved svelging
Acute Tox. 3: H331 Giftig ved innånding
Skin Corr. 1A: H314 Gir alvorlige etseskader på hud og øyne

2.2 Etikettelementer

Klassifisering i henhold til CLP (EC) No 1272/2008 [CLP/GHS]

Farepiktogrammer:



Signalord:

Fare

Risikosekvenser:

R-35 Sterkt etsende
R-23/24/25 Også giftig ved innånding, hudkontakt og svelging

Faresetninger:

Acute Tox. 3: **H310** Giftig ved hudkontakt
Acute Tox. 3: **H301** Giftig ved svelging
Acute Tox. 3: **H331** Giftig ved innånding
Skin Corr. 1A: **H314** Gir alvorlige etseskader på hud og øyne

Sikkerhetssetninger:

P260 Unngå innånding av støv/ røyk/ gass/ tåke/ damp/ aerosoler.
P262 Må ikke komme i kontakt med øyne, huden eller klær.
P280 Benytt vernehansker/ verneklær/ vernebriller/ ansiktsskjerm.
P301+P310 VED SVELGING: Kontakt umiddelbart et GIFTINFORMASJONSSENTER eller lege.

P303+P361+P353 VED HUDKONTAKT (eller håret):
Tilsølte klær må fjernes straks. Skyll/ dusj huden med vann.

P304+P340 VED INNÅNDING: Flytt personen til frisk luft og sørg for at vedkommende hviler i en stilling som letter åndedrettet.

P305+P351+P338 VED KONTAKT MED ØYNENE: Skyll forsiktig med vann i flere minutter. Fjern eventuelle kontaktlinser dersom dette enkelt lar seg gjøre. Fortsett skyllingen.

2.3 Andre farer

Oppfyller kriteriene for vPvB

Nei

Oppfyller kriteriene for PBT

Nei

Andre farer som ikke fører til klassifisering

Ingen kjente farer.

SEKSJON 3: SAMMENSETNING/OPPLYSNINGER OM BESTANDDELER

3.1 Stoffe

Dette produktet er en blanding.

3.2 Blandinger

Farlige ingredienser

Komponentnavn	EC-nr.	CAS-nr.	Innhold	Symbol	Klassifisering
Hydrogenfluorid	231-634-8	7664-39-3	< 7 %	T+, C	R-26/ 27/ 28, R-35
Salpetersyre	231-714-2	7697-37-2	< 25 %	C, O	R-8, R-35

CLP

Komponentnavn	REACH-nr	Innhold	Symbol	Klassifisering	CAS-nr
Hydrogenfluorid	01-2119458860-33-0000	< 7 %	GHS06, GHS05, Fare	Acute Tox. 2: H300 Acute Tox. 1: H310 Acute Tox. 2: H330 Skin Corr. 1A: H314	7664-39-3
Salpetersyre		< 25 %	GHS05, GHS03, Fare	Ox. Liq. 3: H272 Skin Corr. 1A: H314	7697-37-2

Forklaring til R-setninger

R-26/27/28 Meget giftig ved innånding, hudkontakt og svelging.

R-35 Sterkt etsende.

Forklaring til H-setninger

R-8 Brannfarlig ved kontakt med brennbare stoffer.

H272 Kan forsterke brann, oksiderende.

H300 Dødelig ved svelging.

H310 Dødelig ved hudkontakt.

H314 Gir alvorlige etseskader på hud og øyne.

H330 Dødelig ved innånding.

SEKSJON 4: FØRSTEHJELPSTILTAK

4.1 Beskrivelse av førstehjelpstiltak

Generelt

Unngå sprut. Unngå direkte kontakt med øyne, hud og klær.

Bruk tettverneklær.

Ta hensyn til vern av første hjelp personel. Ved bevisstløshet, plasseres transporteres den skadede i stabilt sidestilling. Selv på en mistenkt forgiftning medisinsk undersøkelse er nødvendig.

Forgiftningssymptomer kan også oppstå etter mange timer, og derfor ha legetilsyn minst inntil 48 timer etter en ulykke.

Innånding

Sørg for ro, varme og frisk luft. Kontakt lege øyeblikkelig.

	Alvorlige tilfeller: Gi kunstig åndedrett hvis personen ikke puster. Calsiumglukonat, 2,5% i normal saltoppløsning kan gis i pusteapparatet Den skadede må holdes må holdes under observasjon av spesialist (lege) i minst 48 timer.
Hudkontakt	Skyll straks tilsølt hud med vann. Fjern øyeblikkelig gjennomfuktede klær og skyll huden med vann. Gni hud som har vært i kontakt med produktet med kalsiumglukonatgel 2,5%. Gni til smerten er forsvunnet og i 15 minutter mer. La gelen være på huden. Skyll straks tilsølt hud med vann. Fjern øyeblikkelig gjennomfuktede klær og skyll huden med vann. Kontakt lege.
Øyekontakt	Skyll straks med rikelige mengder vann i opptil 15 minutter. Fjern evt. kontaktlinser og åpne øyet godt opp. Transporter straks til sykehus eller øyenlege. Skyll med 1% calsiumglukonatoppløsning i en til to timer. Om øyenlege ikke er umiddelbart tilgjengelig, drypp en eller to dråper tetrakainhydrokloridløsning eller annen vannbasert bedøvelsesmiddel for øyne og fortsett skylling. Ikke anvend benzalkoniumkloridløsning som er beregnet til hudbehandling. Unngå å gni i øynene.
Svelging	Gi straks et par glas melk eller vann hvis den skadde er ved full bevissthet. Fremkall ikke brekning. Kontakt lege.

4.2 De viktigste symptomene og effekter, både akutte og forsinkede

Spesifikk førstehjelp

Hvis tilgjengelig, gnis kalsiumglukonat-salve inn i det skadete hudpartiet. Etter svelging av fluorider gis melk eller kalsiumglukonat gjennom munnen.

Informasjon til helsepersonnel

Toksis lungeskade. Behandle symptomatisk.

Akutte symptomer og virkninger

Ved peroralt inntak må det ikke benyttes natriumbikarbonat eller kalsiumkromat til nøytralisering. Etsende. Danner blemmer og kan gi sårdannelse. Svie i øyne. **Rødhet**. Hoste. Irritasjon i luftveiene.

Forsinkede symptomer og virkninger

Samme som de akutte symptomene.

4.3 Informasjon om umiddelbar legehjelp og spesiell behandling som eventuelt er nødvendig

Medisinsk behandling

Ved store hudbrannår, ved svelging samt ved eksponering i luftveiene kan det oppstå vanskelige systemiske skader. Overvåk og korrigjer for hypokalsemi, arytmi, hypomagnesemi og hypokalemi. I visse tilfeller kan hemodialyse indikeres. Ved visse brannskader, spesielt på pekefingerne, kan anvendelse av calsiumglukonat brukes. Ved eksponering i luftveiene behandles som lungebetennelse. Konferer evt. giftinformasjonssentralen. Kontakt yrkesmedisinsk ekspertise. Risiko for lungeødem.

Annen informasjon

Redningsmannskapet må beskytte seg selv. Den skadede bringes straks under legebehandling. Ta av tilsølte klær øyeblikkelig på en sikker måte og skyll under rennende vann i minst 20 minutter. Hvis spesifikk behandling for eksponering av flussyre finnes kan spyling med vann begrenses til 5 minutter. Smør deretter inn med calsiumglukonat 2,5%. Alternativt 0,1% løsning av benzalkoniumklorid. Ytterligere behandling skal utføres av lege. Uansett konsentrasjon så er flussyre alltid farlig, noen ganger med forsinket effekt. Det er tre hovedklassifiseringer avhengig av konsentrasjonen;

fra 0-20%: Smerter og rødhet kan opptre opp til 24 timer etter kontakt med produktet.

fra 20-50%: Smerter opptrer fra 1 til 8 timer etter eksponering.

over 50%. Øyeblikkelig etsende virking.

SEKSJON 5: BRANNSLOKKINGSTILTAK

5.1 Brannslukningsmidler

Passende brannslukningsmidler

Vannspray, skum, pulver eller karbondioksid.

Større branner; alkoholresistent skum, Vannspray

Bruk ikke samlet vannstråle

Uegnet brannslukningsmidler

Brannbekjempelse

Unngå innånding av røykgasser. Beholdere i nærheten bør flyttes eller kjøles med vann.

5.2 Spesielle farer som stoffet eller blandingen kan medføre

Brann-og eksplosjonsfarer

Produktet er ikke klassifisert som brannfarlig. Kan danne giftige eller eksplosive damper i kontakt med enkelte metaller. Hydrogengass.

Ved brann eller høy temperatur dannes: Nitrøse gasser (NOx), Hydrogenfluorid (HF), etsende gasser/ damper/ røyk.

5.3 Anvisninger for brannmanskaper

Personlig verneutstyr

Bruk friskluftmaske når produktet er involvert i brann.

Ved rømning brukes godkjent rømningsmaske. Se

Annen informasjon

Beholdere i nærheten av brann flyttes straks eller kjøles med vann.

SEKSJON 6: TILTAK VED UTILSIKTEDE UTSLIPP

6.1 Personlige forholdsregler, personlig verneutstyr, og nødprosedyrer

Generelle tiltak

Større utslipp meldes til myndighetene ved brannvesenet tlf: 110.

Sikkerhetstiltak for å beskytte personell

Benytt personlig verneutstyr som angitt i seksjon 8. Pass på! Produktet er etsende. Advar alle om de potensielle farene og evakuer om nødvendig.

6.2. Sikkerhetstiltak for å beskytte ytre miljø

Sikkerhetstiltak for å beskytte ytre miljø

Forhindre utslipp til kloakk, vassdrag eller grunn.

6.3. Metoder for opprydding og rengjøring

Metoder for opprydding og rengjøring

Små mengder nøytraliseres med natriumbikarbonat eller kalk og spyles til kloakk med store mengder vann. Store sølmengder: Samles opp med absorberende, ikke-brennbart materiale i egnede beholdere. Spill samles opp i egnede beholdere og leveres som farlig avfall (se seksjon 13).

6.4. Referanse til andre seksjoner

Andre anvisninger

Se seksjon 7 og 8.

SEKSJON 7: HÅNTERING OG LAGRING

7.1. Forholdsregler for sikker håndtering

Håndtering

Bruk angitt verneutstyr. Hell aldri vann direkte i produktet, dette kan føre til en kraftig reaksjon/koking. Ved fortykning skal produktet alltid helles forsiktig i vann. Sørg for god ventilasjon. Unngå innånding. Unngå kontakt med huden og øynene. Øyedusj og nøddusj skal finnes på arbeidsplassen.

7.2. Betingelser for sikker oppbevaring, inklusiv eventuelle uforenligheter

Oppbevaring	Oppbevares i originalemballasjen. Oppbevares på et kjølig, godt ventilert sted. Lagres beskyttet mot varme og direkte sollys. Holdes unna varme, gnist og åpen ild. Oppbevares adskilt fra: Organiske stoffer, Sterkt alkaliske produkter, Baser. Metaller. Oksiderende materiale: Holdes borte fra brannfarlig eller brennbart materiale.
Lagringskategori	Lagres som giftig stoff. Lagres som etsende stoff.
7.3 Spesifikk bruk	
Særlig(e) bruksområde(r)	Identifiserte bruksområder for dette produktet er beskrevet i punkt 1.2. eller se teknisk databladet og kontakt leverandør for ytterligere opplysninger.

SEKSJON 8: EKSPONERINGSKONTROLL/PERSONLIG BESKYTTELSE

8.1. Kontrollparametere

Eksponeringskontroll/ Administrative normer

Hydrogenfluorid

EC-Nr:	231-634-8
CAS-Nr:	7664-39-3
Indeksnr.:	009-003-00-1
Verdi:	8 t.: 0,6 ppm 8 t.: 0,5 mg/m ³ 15 min.: 1,8 ppm 15 min.: 1,5 mg/m ³
Norm år	2013

Salpetersyre

EC-Nr.:	231-714-2
CAS-Nr:	7697-37-2
Indeksnr.:	007-004-00-1
Verdi:	8 t.: 2 ppm 8 t.: 5 mg/m ³
Norm år	2011

8.2 Begrensning av eksponering på arbeidsplassen

Begrensning av eksponering på arbeidsplassen

Øyevern	Sørg for tilstrekkelig ventilasjon. Det må ikke spises, drikkes eller røykes under arbeidet. Personlig verneutstyr bør velges i henhold til CEN-standard og i samarbeid med leverandøren av personlig verneutstyr. Bruk godkjente vernebriller eller ansiktsskjerm. EN 166:2001
Åndedrettsvern	Ved utilstrekkelig ventilasjon eller hvis det er fare for innånding av damper, må det brukes egnet åndedrettsvern med Filter Typ E-P2/P3 etter EN 141 standard
Håndvern	I full kontakt: Handske av Viton Tykkelse (mm): 0,4 Gjennombruddstid (min.): > 480 Ved Sprut: Handske av Butylkautschuk Tykkelse (min): 0,5 Gjennombruddstid (min.): > 240
Kropsbeskyttelse Verneklær	Syrefast verneklær og gummistøvel Hensiktsmessige verneklær for beskyttelse ved mulig hudkontakt skal velges ut i henhold til farestoffkonsentrasjon og –mengde.
Hygieniske rutiner	Ta straks av gjennomtrengelige klær som er blitt våte.

Vask straks hud som er blitt tilsølt.
Vask huden ved slutten av hvert skift og før spising, røyking og bruk av toalett.

SEKSJON 9: FYSISKE OG KJEMISKE EGENSKAPER

9.1. Informasjon om grunnleggende fysiske og kjemiske egenskaper

Form/konsistens:	Pasta
Farge:	Fargeløs/ matt
Lukt:	Stikkende
Løselighetsbeskrivelse:	Ubegrenset oppløselig i vann
Kokepunkt (°C, intervall)	106
Tetthet (g/cm ³):	1,173 ± 0,04 g/cm ³
pH-verdi (20°C):	1,6 ± 0,3
Spaltningstemperatur (°C):	> 106
Oksiderende Egenskaper:	Oksidasjonsmiddel
Viskositet, dynamisk (mPas/20°C):	4,000 ± 0,25
Eksplorative Egenskaper:	Produktet er ikke eksplosjonsfarlig, men kan danne eksplosive damp / luft blanding.

9.2 Andre opplysninger av betydning for helse, miljø og sikkerhet

Andre fysiske og kjemiske data blitt ikke bestemt.

SEKSJON 10: STABILITET OG REAKTIVITET

10.1. Reaktivitet

Reagerer voldsomt (sterk varme) med lut. Reagerer med metaller (stål, sink, Aluminium) med utvikling av hydrogen.

10.2. Kjemisk stabilitet

Stoffer som skal unngås: Baser, metaller

10.3 Mulighet for skadelige reaksjoner

Kontakt med aktive klorholdige produkter fører til dannelsen av giftige gasser (klor).

10.4. Forhold som skal unngås

Beskyttes mot frost og temperaturer over 35 ° C.

10.5 Uforenlige stoffer

Baser. Alkalier. Organiske stoffer (f.eks. tre, tekstiler, papir). Alkali-metaller. Massive metaller. Metallpulver. Eksoterm reaksjon i kontakt med sterke baser og alkalier.

10.6 Farlige nedbrytingsprodukter

I tilfelle av brann: hydrogenfluorid (HF) Nitrogenoksider (NOx)

SEKSJON 11: TOKSIKOLOGISKE OPPLYSNINGER

11.1 Informasjon om toksikologiske effekter

Akutte toksikologiske data

Hydrogenfluorid

EC-Nr.:	231-634-8
Registrerings-Nr.:	01-2119458860-33
LD50 Oral	86,44 mg/kg
LD50 (Dermal)	86,44 mg/kg
LD50 (Inhalativ)	10,17 mg/l, damp

Sapetersyre

EC-Nr.:	231-714-2
Registrerings-Nr.:	01-2119487297-23
LDLO (oral, menesker)	> 6000 mg/kg

Irriterende / etsende effekt	Giftig ved svelging. Sterkt etsende. Selv små mengder kan forårsake alvorlige indre skader og død. Giftig ved hudkontakt. Virker sterkt etsende. Kan forårsake alvorlige vevskader. Sterkt etsende. Kontakt med konsentrert kjemikalie kan gi umiddelbar alvorlig skade, eventuelt synstap. Øyeblikkelig førstehjelp er nødvendig. Giftig ved innånding. Damper virker etsende.
Sensibilisering	Basert på tilgjengelige data klassifiseringskriteriene ikke er oppfylt (konvensjonell metode)
Kreftfremkallende egenskaper	Ikke testet
Reproduksjonstoksitet	Ikke testet

SEKSJON 12: ØKOLOGISKE OPPLYSNINGER

12.1. Toksitet

Økotoksitet

Store mengder av produktet kan påvirke pH i vannmiljøet med risiko for skadevirkninger for vannorganismer. Produktet skal ikke merkes som miljøfarlig i henhold til gjeldende regelverk. Dette utelukker ikke at tilfeldige større utslipp eller ofte gjentatte mindre utslipp kan ha en skadelig eller forstyrrende effekt på miljøet.

12.2. Persistens og nedbrytbarhet

Ikke noe mer relevant informasjon tilgjengelig.

12.3 Bioakkumuleringspotensial

Ikke relevant, uorganiske komponenter.

12.4 Jordmobilitet

Produktet er vannløselig og kan spres i vannmiljøet.

12.5 Resultater av PBT- og vPvB-vurderinger

Ifølge den informasjonen som er tilgjengelig, er kriteriene for klassifisering som PBT eller vPvB ikke oppfylt.

12.6. Andre skadevirkninger

Ingen kjent informasjon.

Ingrediens: **Salpetersyre**

Økotosikologiske data

LC50, 96 t, Fisk, mg/l
Bioakkumulasjonspotensial
Fordelingskoeffisient (log Pow)

Akuttgiftighet. EC50 48 timer alge 33-100 mg/l (Ophryotrocha diaderma)
72 (Gambusia affinis)
Bioakkumulerer ikke.
-2,3

Ingrediens: **Hydrogenfluorid**

LC50, 96 t, Fisk, mg/l
EC50, 48 t, Daphnia, mg/l
IC50, 72 t, Alger, mg/l
Bioakkumulasjonspotensial
Fordelingskoeffisient (log Pow)

441 (Gambusia affinis)
10 - 100 (Daphnia magna)
2
BCF:150
Bioakkumulering er mulig.
0,23

SEKSJON 13: INSTRUKSER VED DISPONERING

13.1 Avfallsbehandlingsmetoder

Generelt

Ikke kast produktmengder over 1 liter i avløpsvann.

Behandlingsmetoder	Farlig avfall etter Forskrift om gjenvinning og behandling av avfall (avfallsforskriften). Hvis gjenvinning ikke er mulig, må kastes i samsvar med Forskrift om gjenvinning og behandling av avfall.
Avfallskode EAL	Avfall skal deponeres på en forsvarlig måte og leveres til godkjent behandlings- eller mottaksstasjon. 070600, Nasjonal avfallgruppe: 7131 Slam fra fysisk-kjemisk behandling som inneholder farlig avfall. Den oppgitte EAL-kode er veiledende, og avhengig av hvordan avfallet er oppstått. Sluttbruker må selv vurdere valg av riktig kode. Fra en avhending av produktet via kloakken er ikke anbefalt.
Forurenset emballasje	Forurenset emballasje: Tomme, ikke-tørkede containere skal kastes som farlig avfall.

SEKSJON 14: TRANSPORTOPPLYSNINGER

14.1 UN-Nummer

UN 2922

14.2 Korrekt transportnavn, UN

Varenavn, nasj.

ETSENDE VÆSKE, GIFTIG, N.O.S. (blanding av <50 % salpetersyre og flussyre)

Varenavn, internasj.

CORROSIVE LIQUID, TOXIC N.O.S. (mixture of <50 % nitric acid and hydrofluoric acid)

14.3 Transportfareklasse(r)

ADR-klasse

8

ADR faresedler

8 + 6.1

Klassifiseringskode

CT1

ADR-farenr.

86

Veitranportopplysninger

Limited quantity: LQ22

Jernbanetransport (RID)

RID-klasse

8

RID faresedler

8 + 6.1

Sjøtransport(IMDG):

IMDG-klasse

8

EmS-nr.

F-A, S-B

Transport på innsjøer og elver (ADN):

Flytransport (IATA-DGR / ICAO-TI):

IATA/ICAO-klasse

8

IATA/ICAO-fareseddel

8 + 6.1

14.4. Emballasjegruppe

II (Stoffer med middels fare)

14.5 Skadevirkninger i miljøet

ADR / RID / IMDG-kode:

nei

ICAO-TI / IATA-DGR:

nei

14.6. Spesielle forholdsregler for brukeren

Se avsnitt: 6-8

14.7. Transport i bulk i samsvar med vedlegg II til MARPOL 73/78 og IBC-koden

Levering skjer kun i egnet emballasje godkjent i henhold til trafikkreglene.

SEKSJON 15: REGELVERKSMESSIGE OPPLYSNINGER

15.1 Sikkerhets-, helse- og miljøforskrifter eller lovverk som er spesifikke for stoffet eller blandingen

EU-direktiv

Dette/de tensidet(ene) som inngår i denne blandingen oppfyller kriteriene for biologisk nedbrytning i EU

Annen merkeinformasjon	regulativ nr. 648/2004 som omhandler vaske- og rengjøringsmidler. Data som underbygger denne påstanden er tilgjengelige for medlemsstatenes rette myndighet og vil bli gjort tilgjengelige for dem ved direkte forespørsel, eller på forespørsel fra en produsent av vaske- og rengjøringsmidler. Europaparlaments- og rådsforordning nr. 1272/2008 av 16. desember 2008 om klassifisering, merking og emballering av stoffer og stoffblandinger og om endring og oppheving av direktiv 67/548/EØF og 1999/45/EF og om endring av forordning (EF) nr. 1907/2006, med endringer.
Lover og forskrifter	Administrative normer for forurensning i arbeidsatmosfære 2009, med endringer. Forskrift 2004 nr. 922 om begrensning i bruk av helse- og miljøfarlige kjemikalier og andre produkter (Produktforskriften). Forskrift om klassifisering, merking m.v. av farlige kjemikalier, 16.07.2002 nr. 1139, med endringer. Forskrift 2008 nr. 516. Forskrift om registrering, vurdering, godkjenning og begrensning av kjemikalier (REACH). Forskrift om gjenvinning og behandling av avfall (avfallsforskriften). 01.06 2004 nr. 930, med endringer.
Deklarasjonsnr. <u>15.2 Kjemisk sikkerhetsvurdering</u>	Kjemisk sikkerhetsrapport (CSR) er ikke utarbeidet for dette produktet.
Ytterligere regulatoriske informasjon	Opplysningene støtter seg til dagens kjennskaper og erfaringer. Sikkerhetsdatabladet beskriver produkter med henblikk på sikkerhetskrav.

SEKSJON 16: ANDRE OPPLYSNINGER

Revisjonskommentar:	Ikke relevant
Kontaktperson:	InnoTek Kjemi AS Djupedalsveien 26 N-4330 Ålgård Steffen Link Mail: steffen.link@innotek-kjemi.no
Utstedelsesdato	24.12.2015
Revisjonsnr.	Ikke relevant
Databladstatus	REACH-474/2014 CLP-605/2014
Ansvarlig for Sikkerhetsdatablad Forbehold om ansvar	InnoTek AS Opplysningene i dette datablad anses korrekte i henhold til dagens kunnskaper og erfaring, men det kan ikke gis noen garanti at informasjonen er fullstendig. Det er derfor i brukerens interesse å forsikre seg om at informasjonen er tilstrekkelig for det tiltenkte bruksområde.

Appendix C

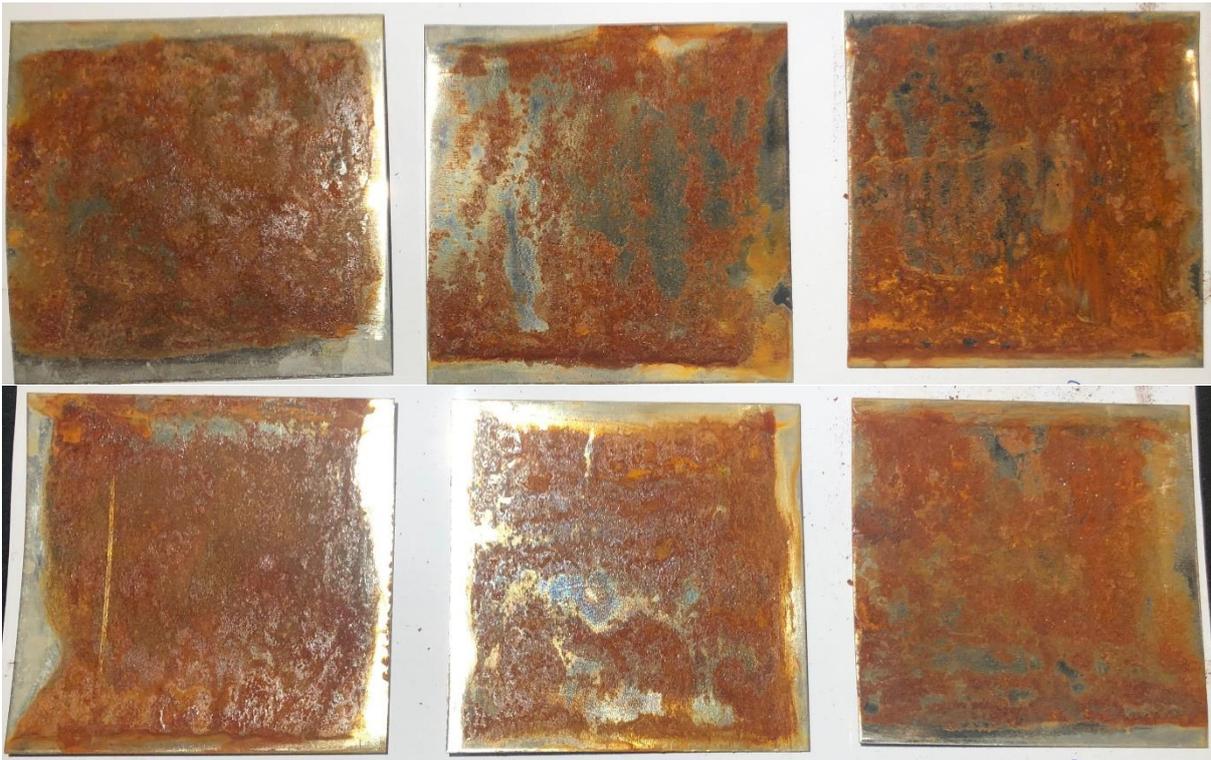


FIGURE 1: SAMPLES 2.1.1-2.1.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 2: SAMPLES 3.1.1-3.1.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 3: SAMPLES 2.2.1-2.2.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 4: SAMPLES 3.2.1-3.2.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 5: SAMPLES 2.3.1-2.3.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 6: SAMPLES 3.3.1-3.3.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.

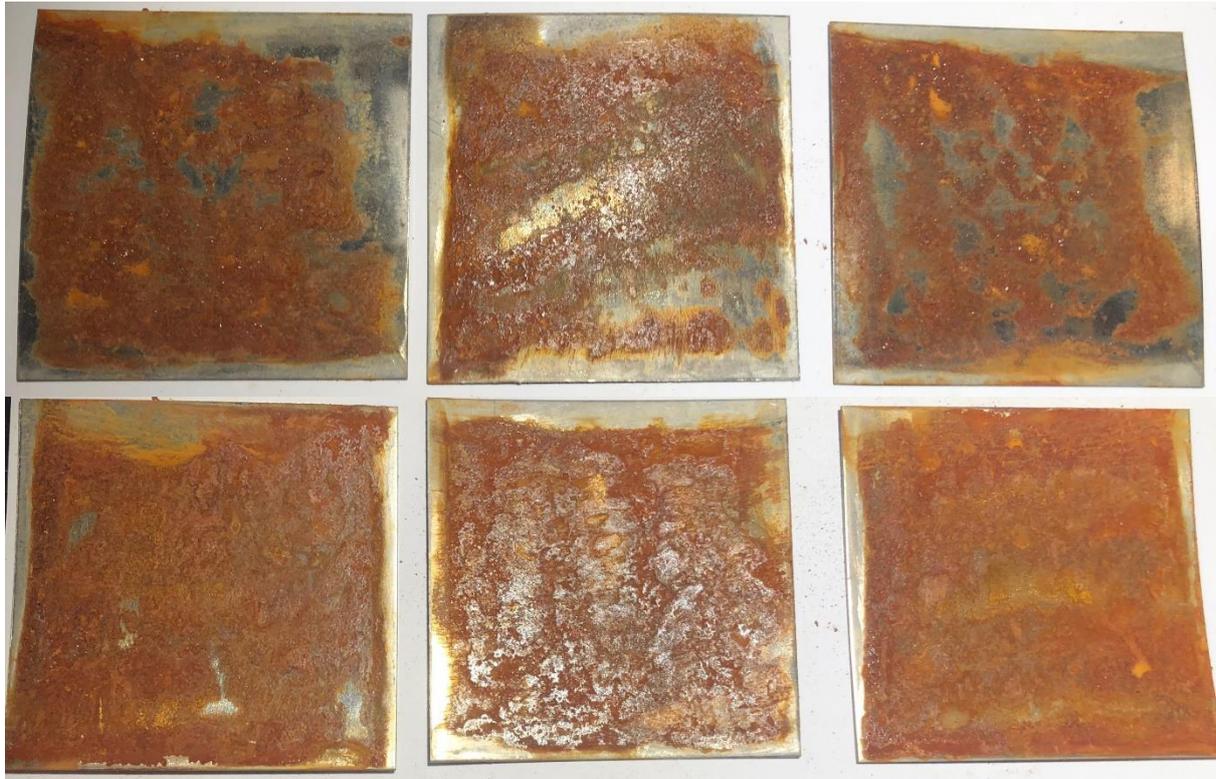


FIGURE 7: SAMPLES 2.4.1-2.4.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 8: SAMPLES 3.4.1-3.4.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 9: SAMPLES 2.5.1-2.5.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 10: SAMPLES 3.5.1-3.5.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.

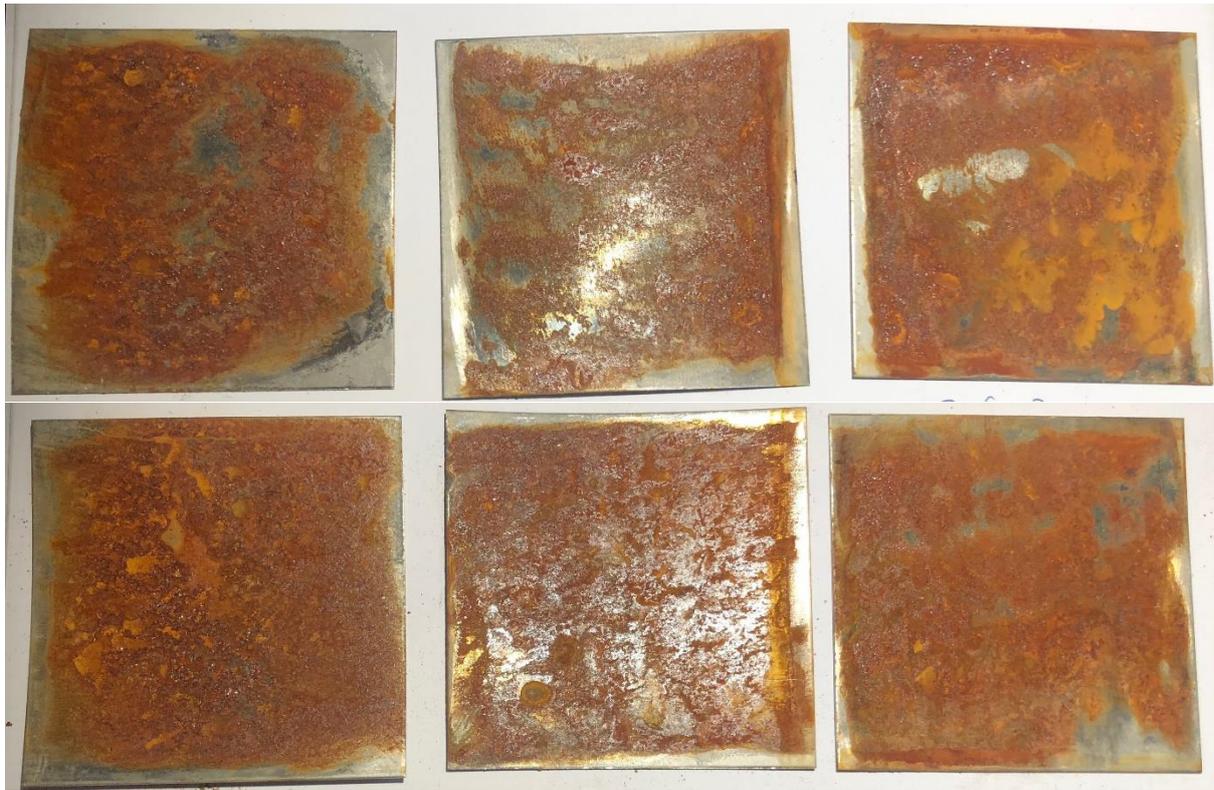


FIGURE 11: SAMPLES 2.6.1-2.6.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 12: SAMPLES 3.6.1-3.6.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 13: SAMPLES 2.7.1-2.7.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 14: SAMPLES 3.7.1-3.7.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 15: SAMPLES 2.8.1-2.8.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.



FIGURE 16: SAMPLES 3.8.1-3.8.3 FRONTSIDE AND BACKSIDE WERE EXPOSED FOR ROTARY STEEL BRUSH WITH HARD BRAIDED THREADS EQUIPPED BY A GRINDER AND AFTERWARD EXHIBITED FOR MARINE ATMOSPHERE FOR 1 ROUND.

Appendix D

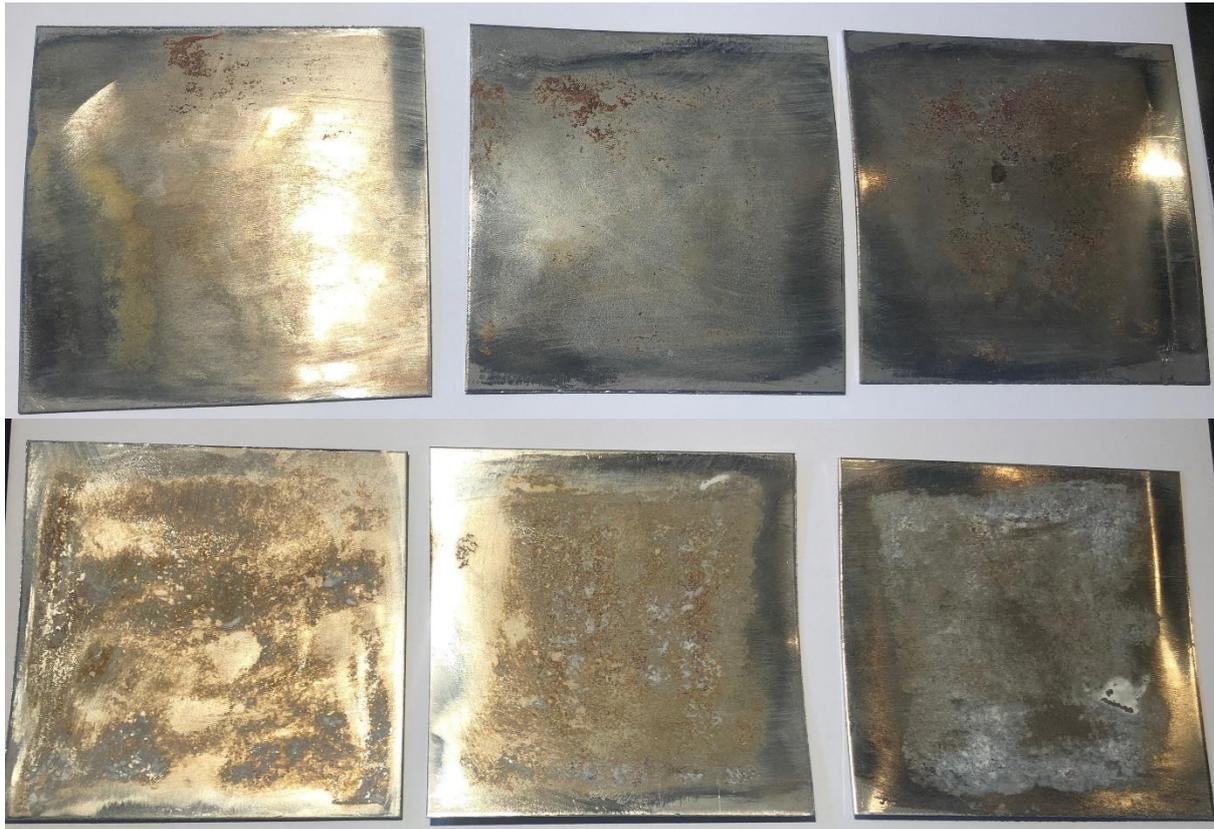


FIGURE 17: SAMPLES 3.2.1-3.2.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.



FIGURE 18: SAMPLES 3.3.1-3.3.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.



FIGURE 19: SAMPLES 3.4.1-3.4.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.



FIGURE 20: SAMPLES 3.5.1-3.5.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.

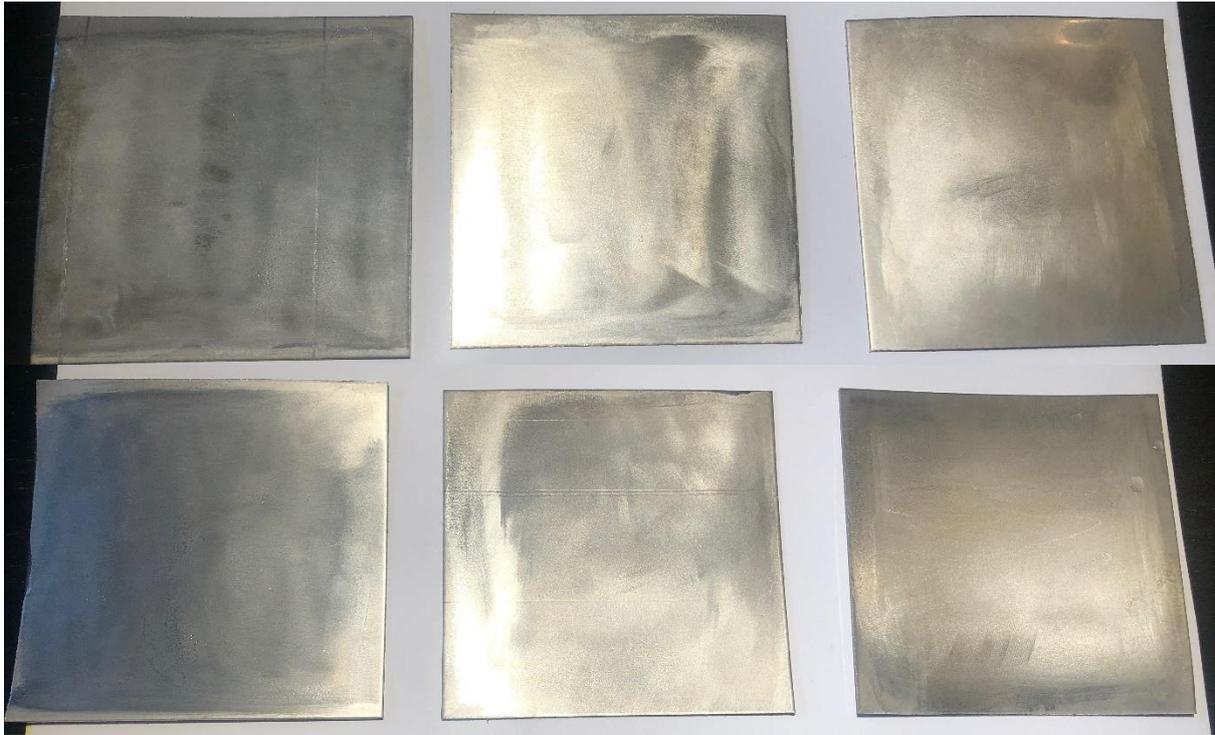


FIGURE 21: SAMPLES 3.6.1-3.6.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.

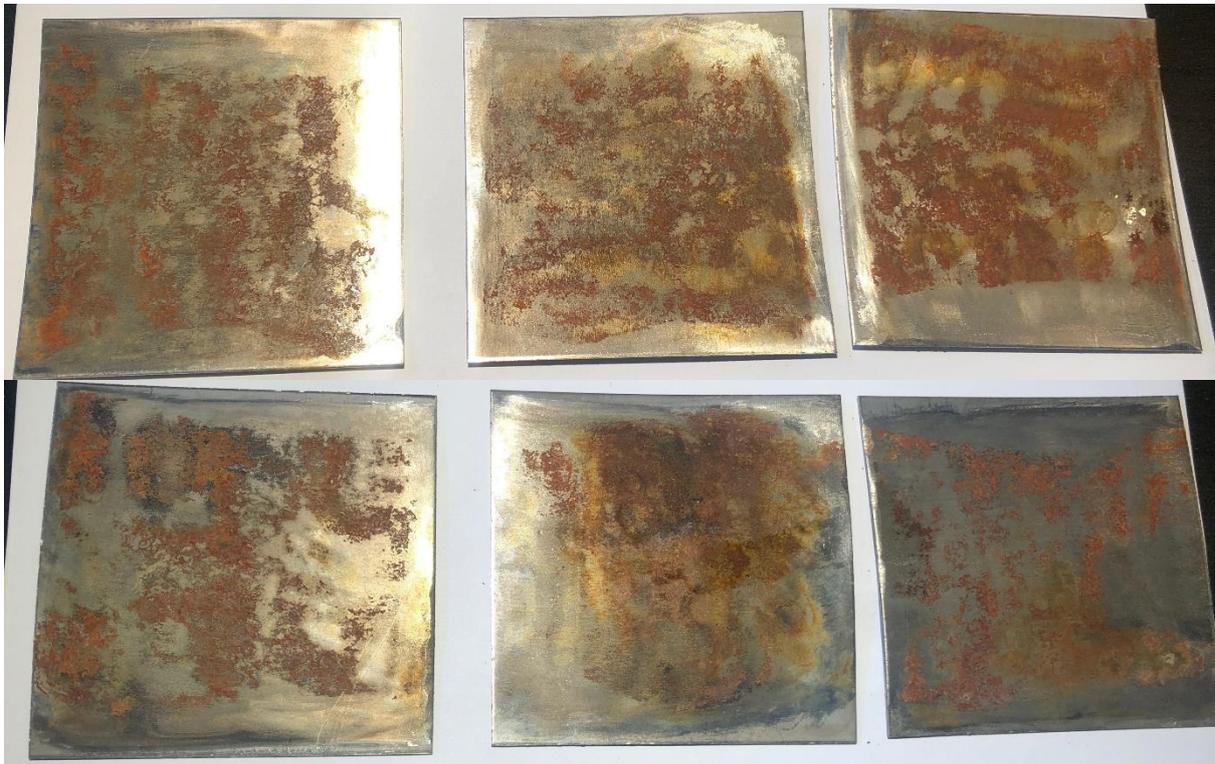


FIGURE 22: SAMPLES 3.7.1-3.7.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.



FIGURE 23: SAMPLES 3.8.1-3.8.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND ONE TIME REPASSIVATION.

Appendix E



FIGURE 24: SAMPLES 3.3.1-3.3.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND REPASSIVATION.



FIGURE 25: SAMPLES 3.4.1-3.4.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND REPASSIVATION.



FIGURE 26: SAMPLES 3.6.1-3.6.3 EXPOSED SECOND TIME MARINE ATMOSPHERE AND REPASSIVATION.

Appendix F

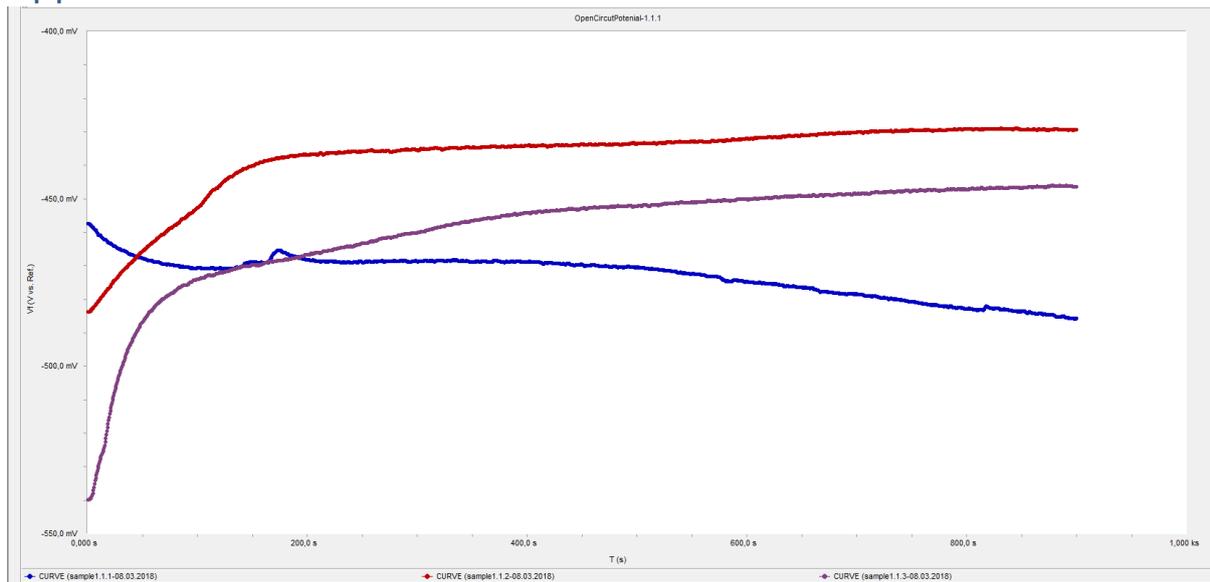
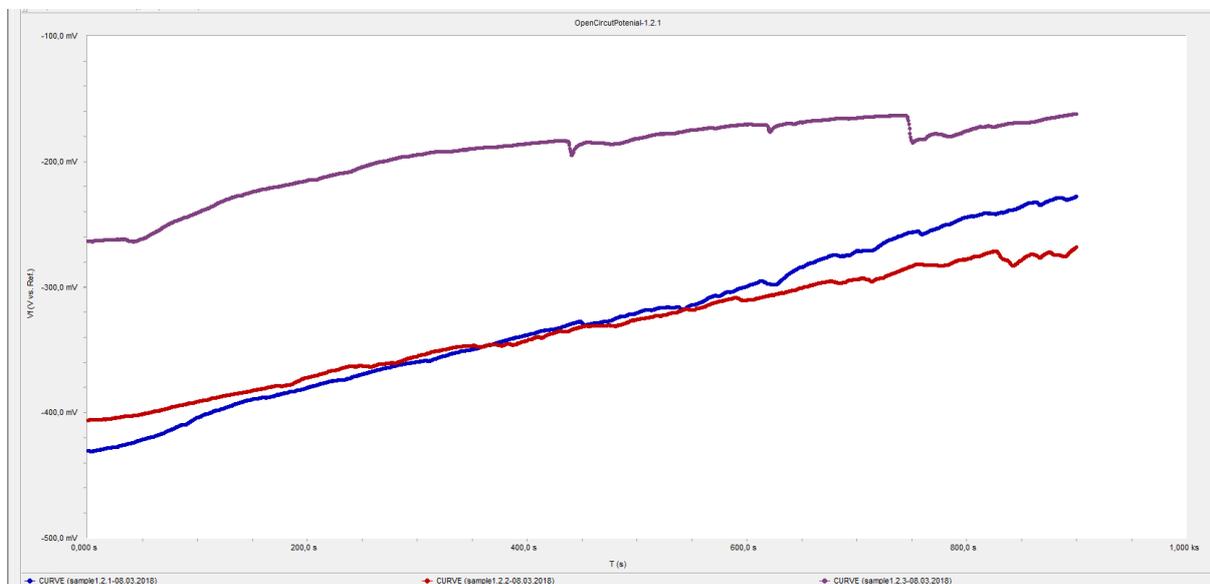
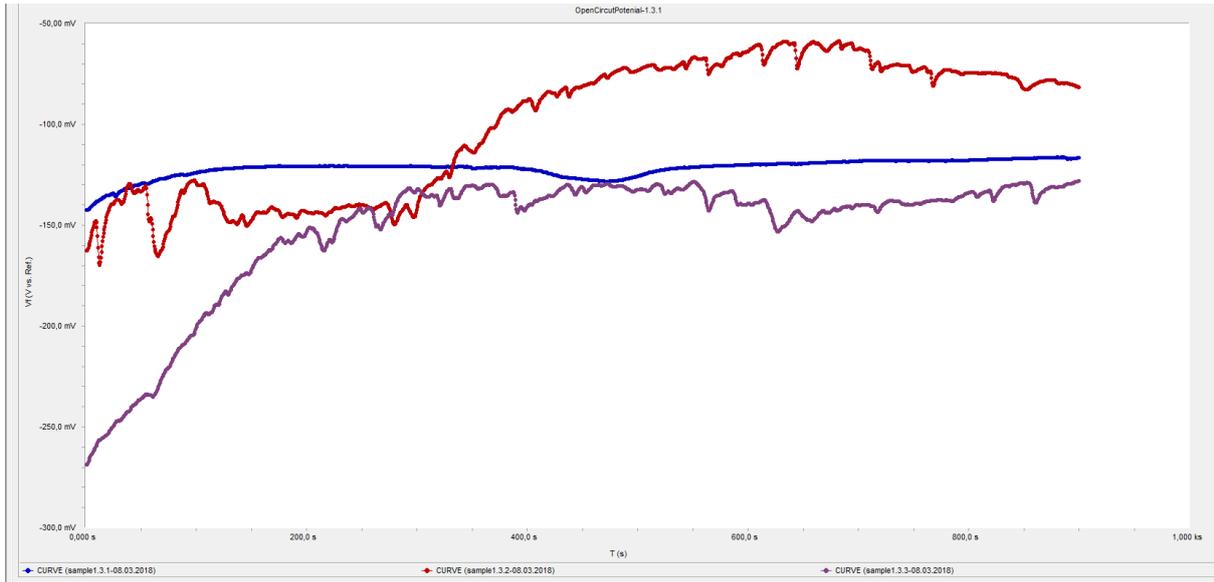


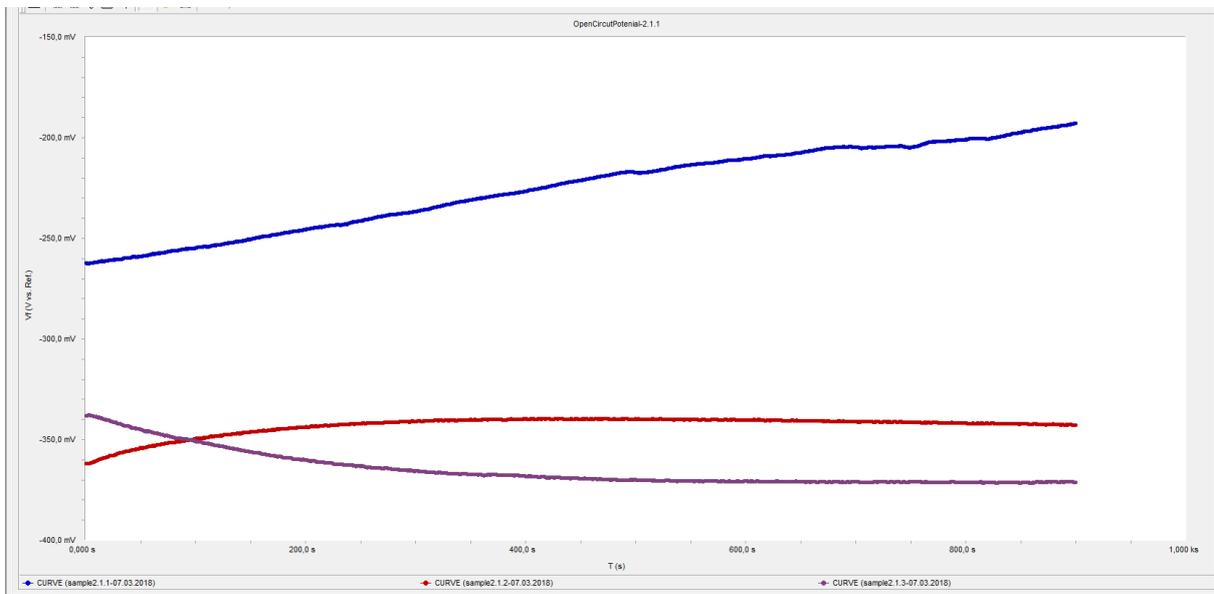
FIGURE 27: SAMPLE 1.1.1-1.1.3 OPEN CIRCUIT POTENTIAL GRAPHS.



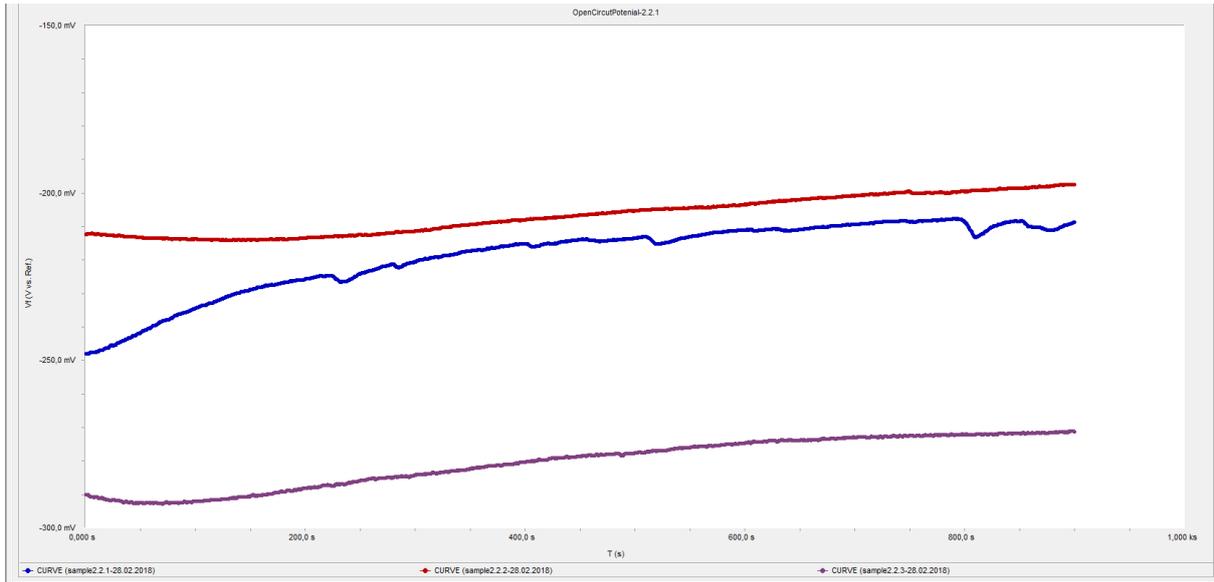
FIGUR 28: SAMPLE 1.2.1-1.2.3 OPEN CIRCUIT POTENTIAL GRAPHS.



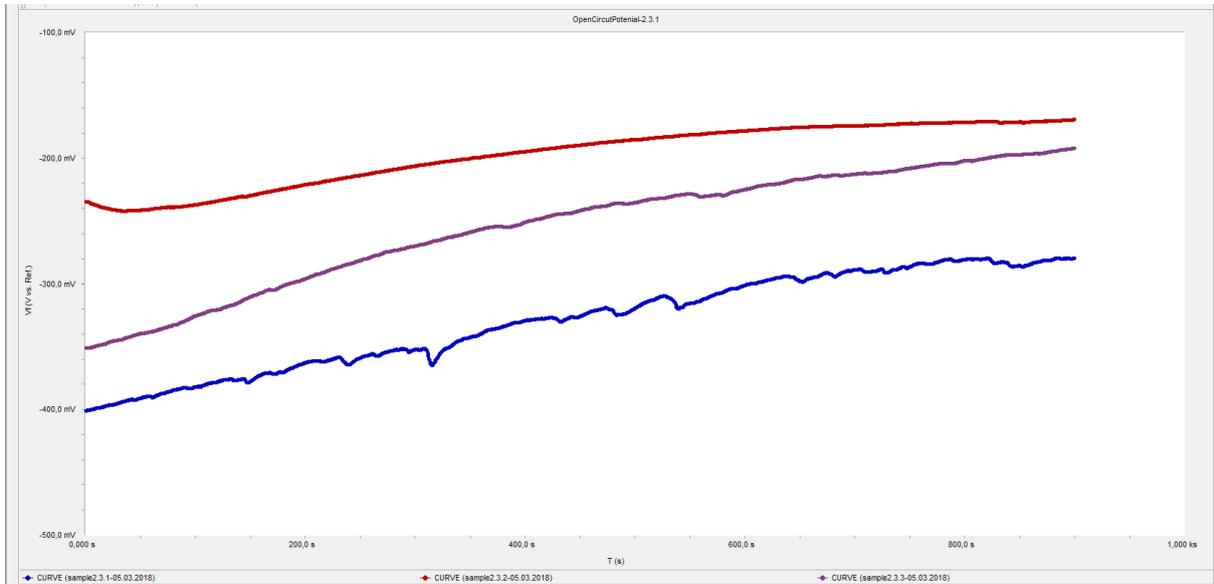
FIGUR 29: SAMPLE 1.3.1-1.3.3 OPEN CIRCUIT POTENTIAL GRAPHS.



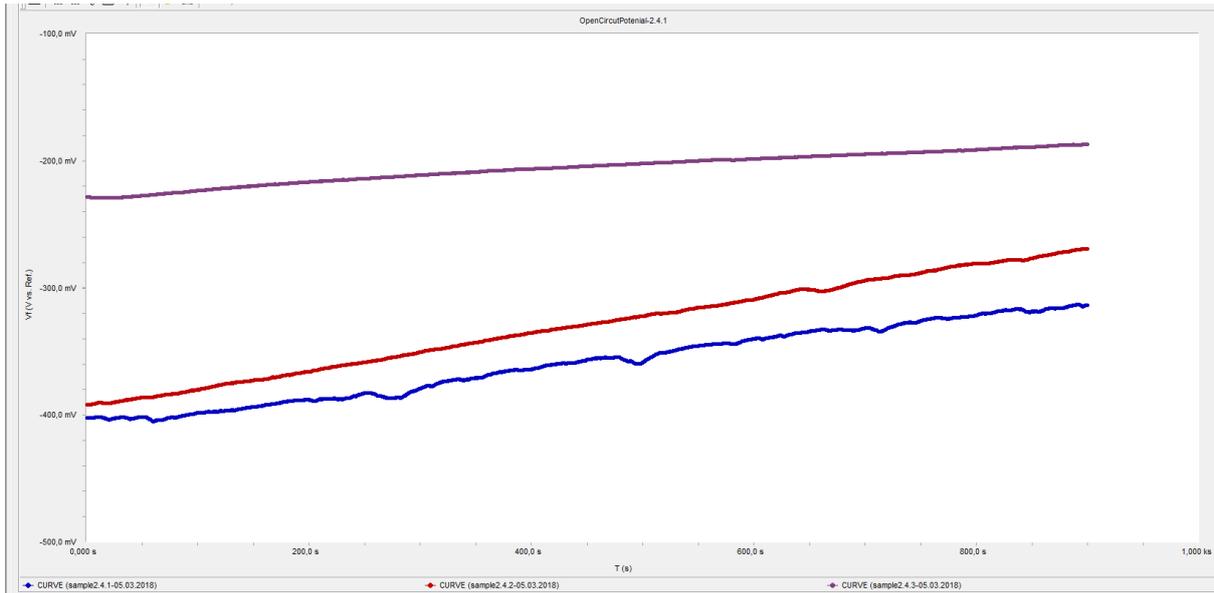
FIGUR 30: SAMPLE 2.1.1-2.1.3 OPEN CIRCUIT POTENTIAL GRAPHS.



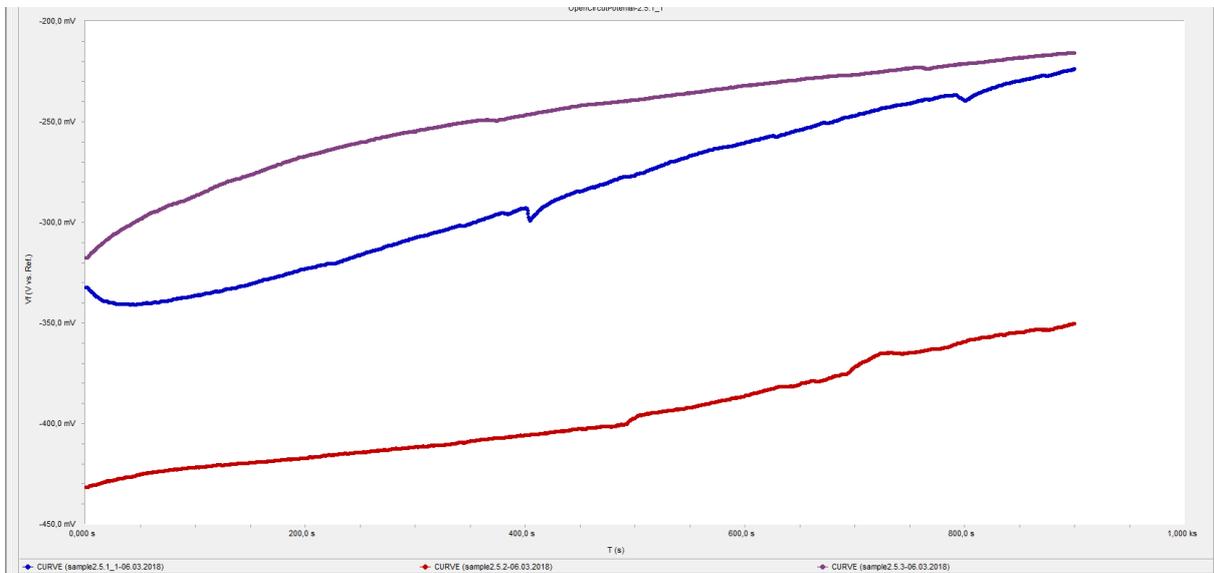
FIGUR 31: SAMPLE 2.2.1-2.2.3 OPEN CIRCUIT POTENTIAL GRAPHS.



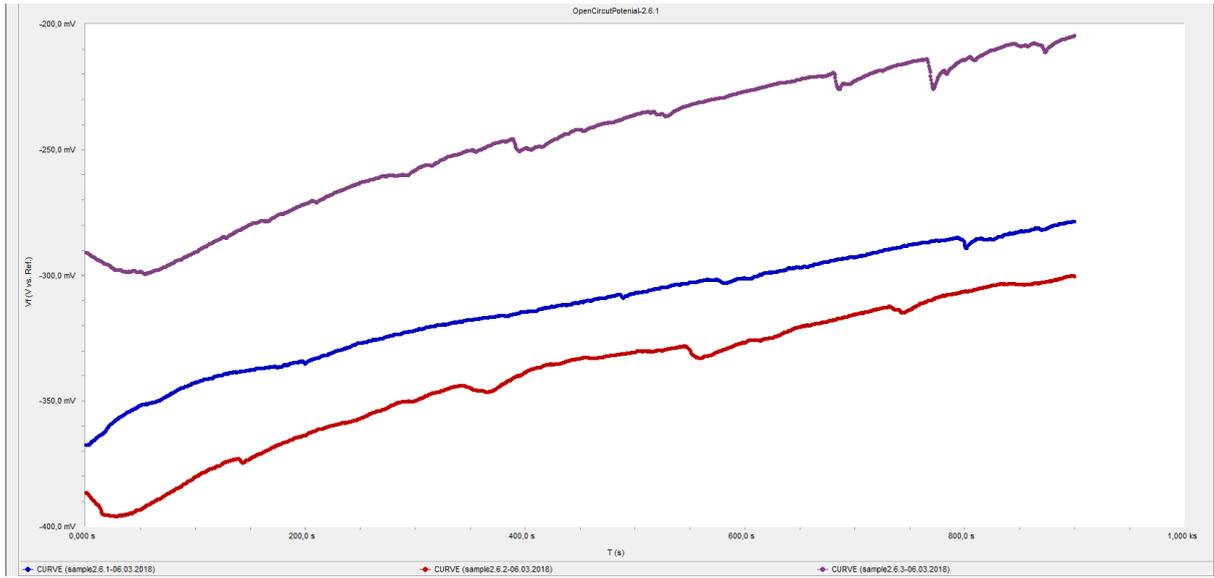
FIGUR 32: SAMPLE 2.3.1-2.3.3 OPEN CIRCUIT POTENTIAL GRAPHS.



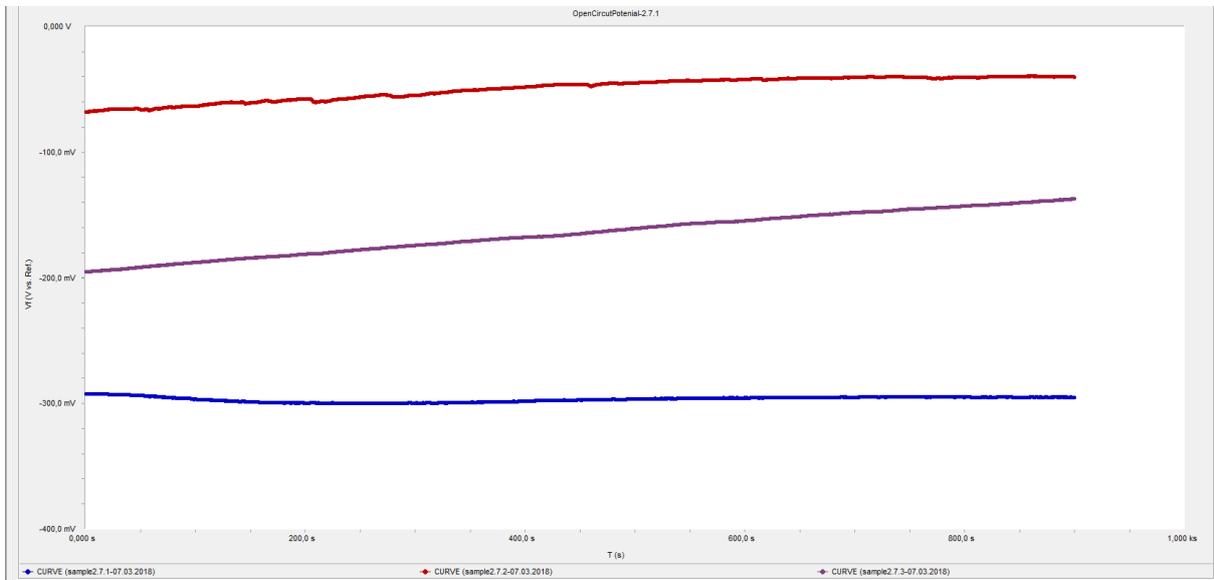
FIGUR 33: SAMPLE 2.4.1-2.4.3 OPEN CIRCUIT POTENTIAL GRAPHS.



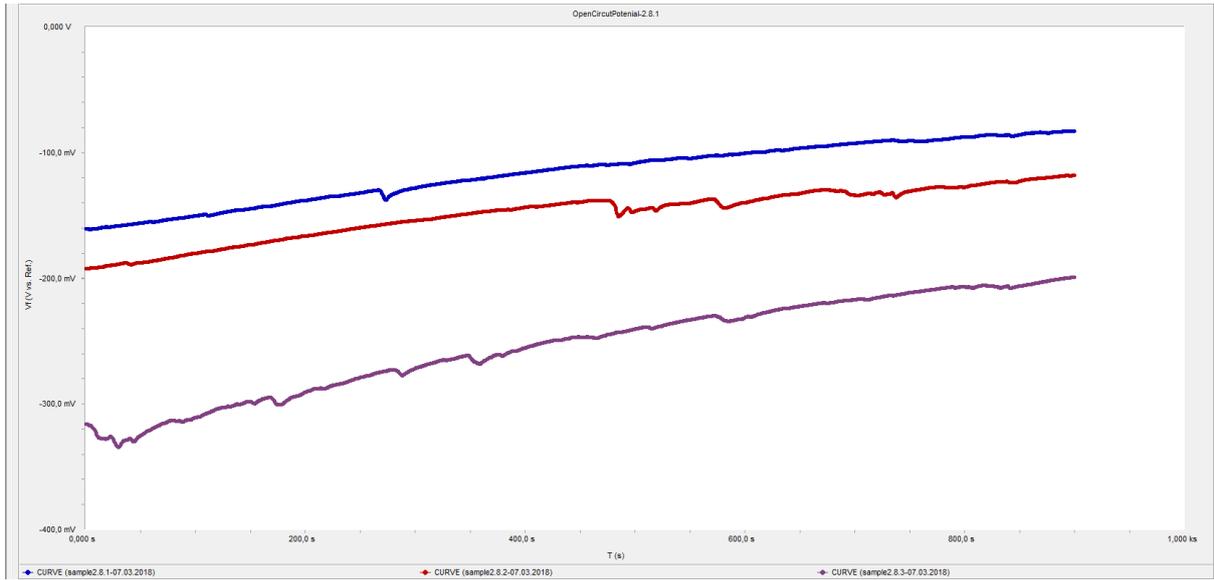
FIGUR 34: SAMPLE 2.5.1-2.5.3 OPEN CIRCUIT POTENTIAL GRAPHS.



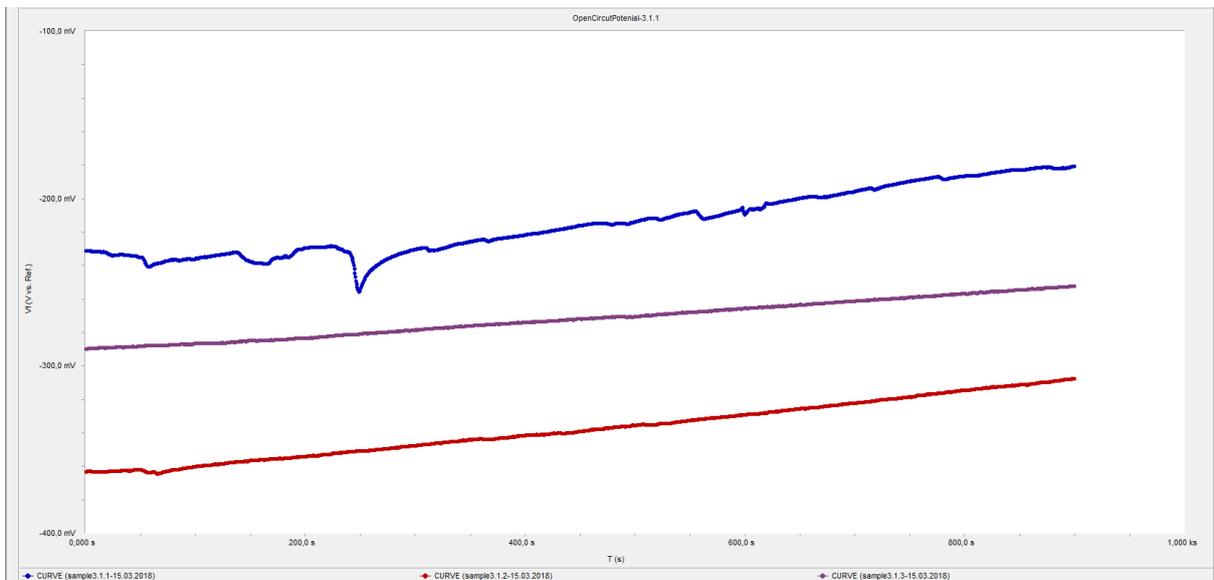
FIGUR 35: SAMPLE 2.6.1-2.6.3 OPEN CIRCUIT POTENTIAL GRAPHS.



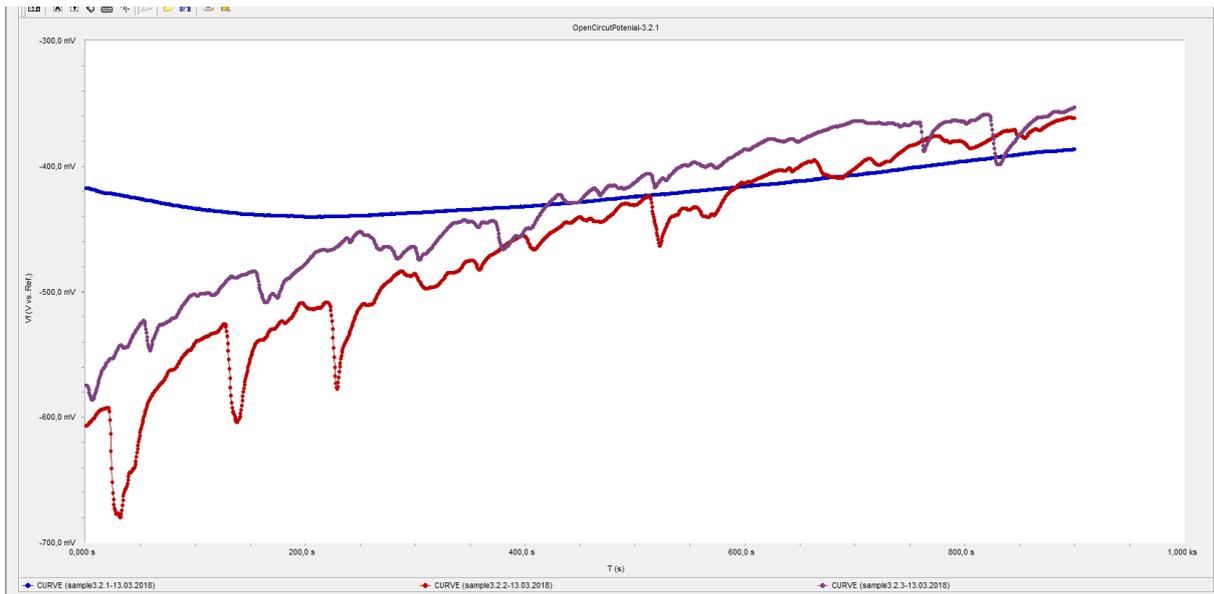
FIGUR 36: SAMPLE 2.7.1-2.7.3 OPEN CIRCUIT POTENTIAL GRAPHS.



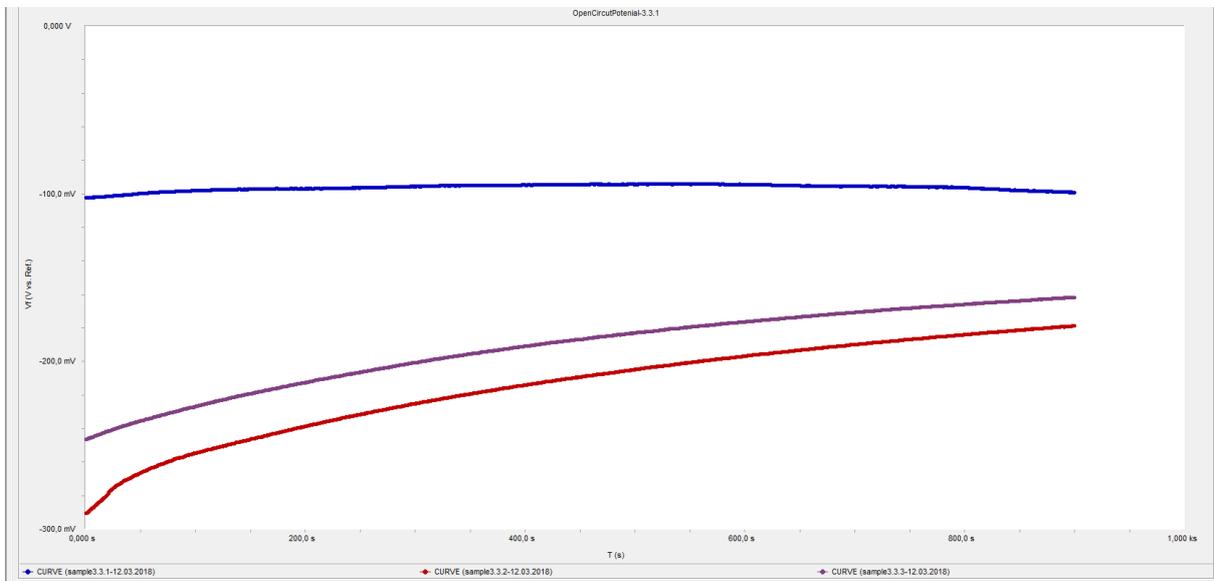
FIGUR 37: SAMPLE 2.8.1-2.8.3 OPEN CIRCUIT POTENTIAL GRAPHS.



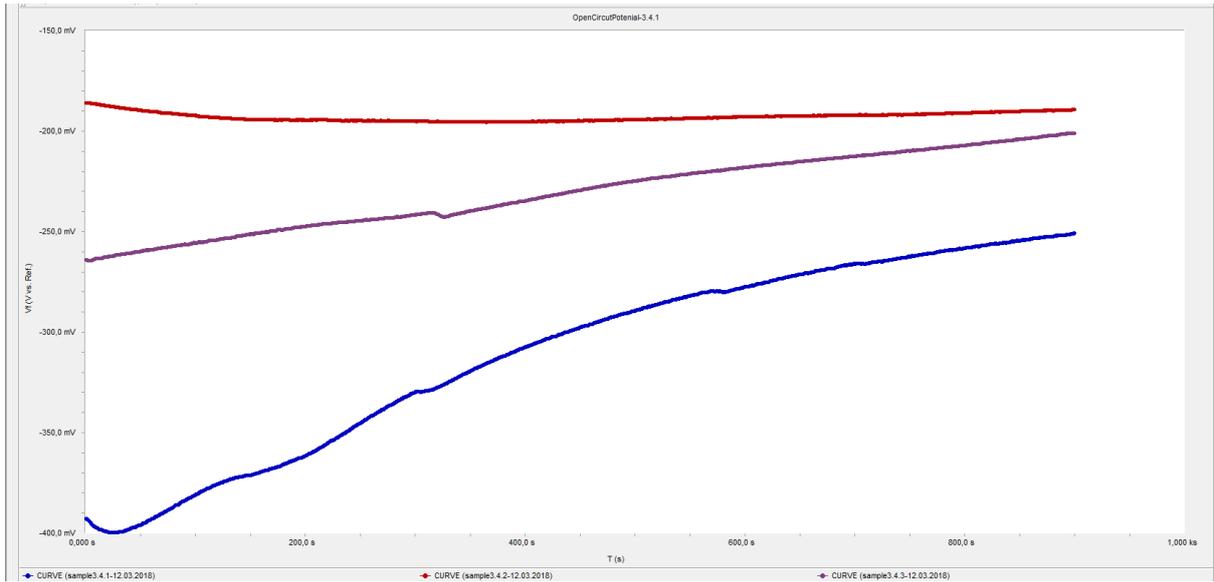
FIGUR 38: SAMPLE 3.1.1-3.1.3 OPEN CIRCUIT POTENTIAL GRAPHS.



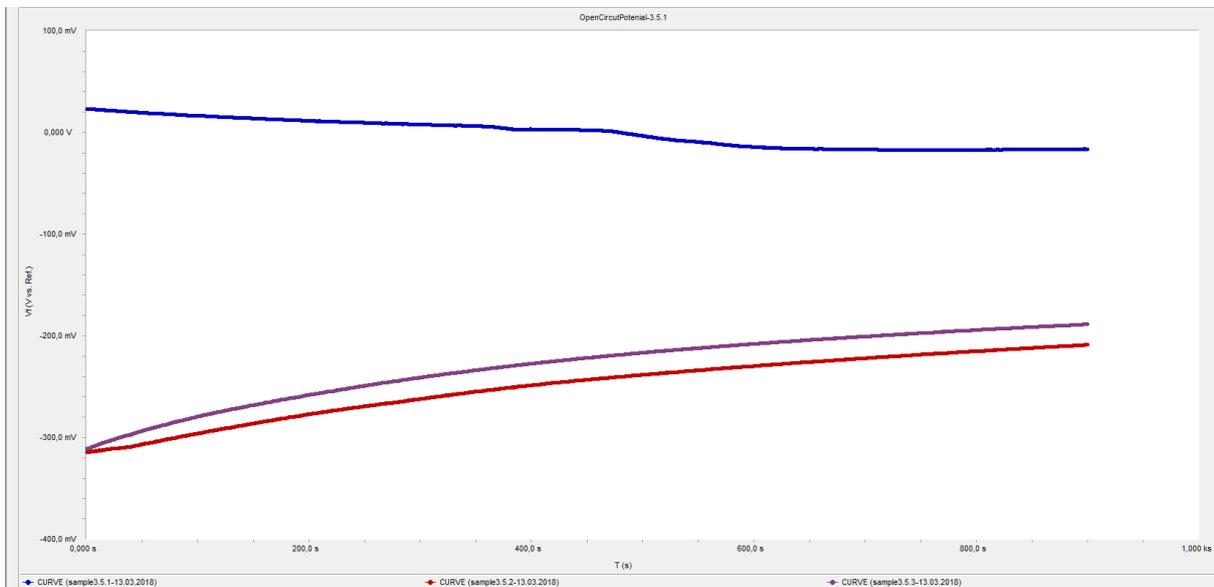
FIGUR 39: SAMPLE 3.2.1-3.2.3 OPEN CIRCUIT POTENTIAL GRAPHS.



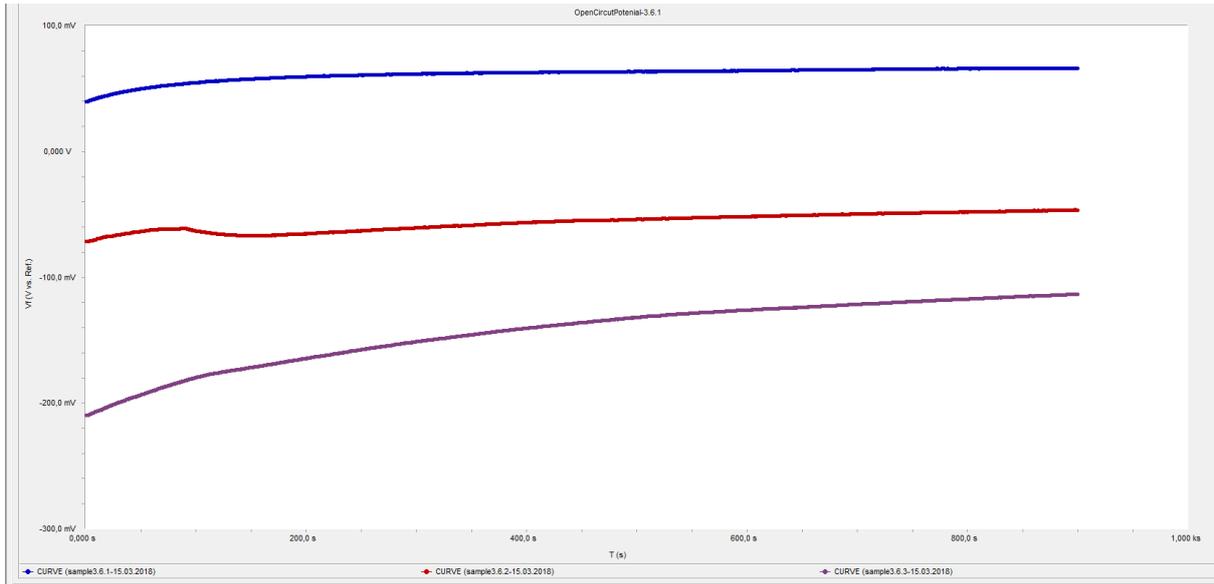
FIGUR 40: SAMPLE 3.3.1-3.3.3 OPEN CIRCUIT POTENTIAL GRAPHS.



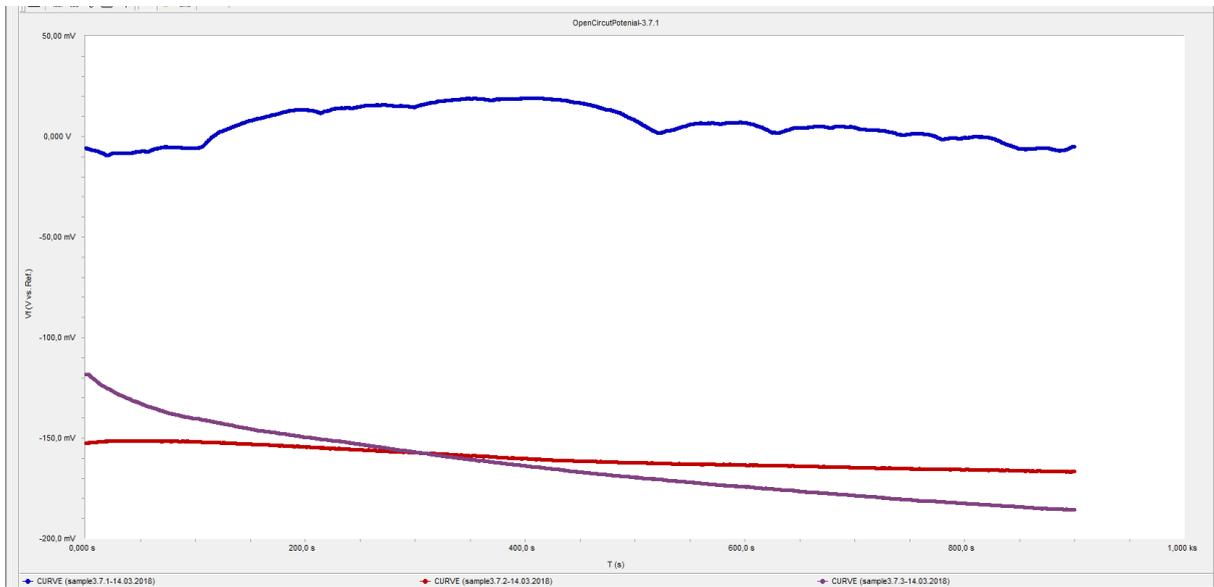
FIGUR 41: SAMPLE 3.4.1-3.4.3 OPEN CIRCUIT POTENTIAL GRAPHS.



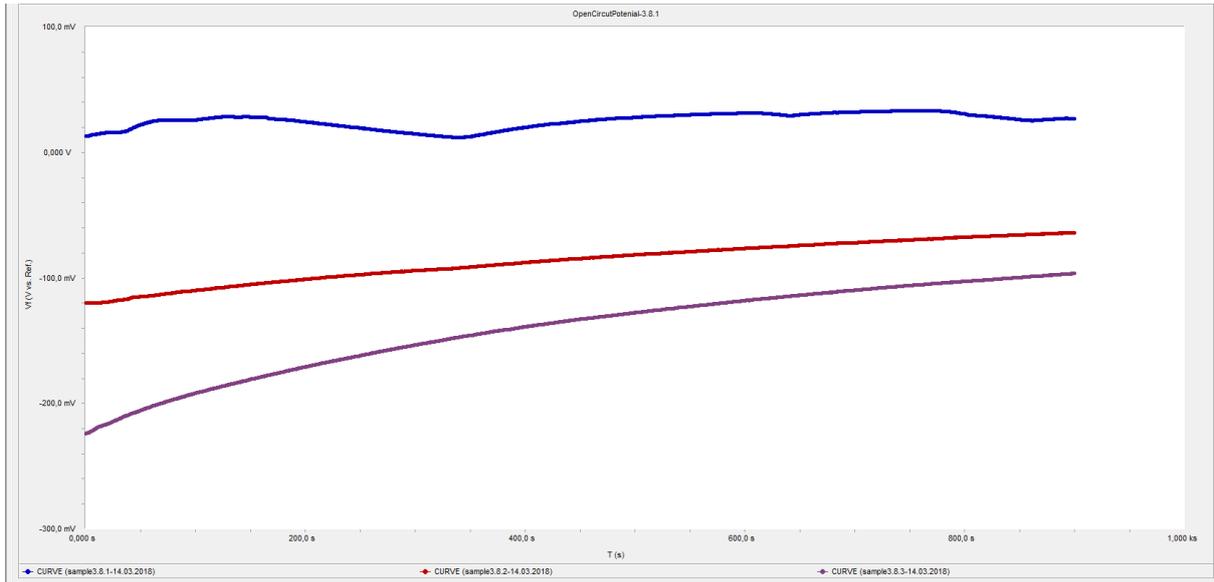
FIGUR 42: SAMPLE 3.5.1-3.5.3 OPEN CIRCUIT POTENTIAL GRAPHS.



FIGUR 43: SAMPLE 3.6.1-3.6.3 OPEN CIRCUIT POTENTIAL GRAPHS.



FIGUR 44: SAMPLE 3.7.1-3.7.3 OPEN CIRCUIT POTENTIAL GRAPHS.



FIGUR 45: SAMPLE 3.8.1-3.8.3 OPEN CIRCUIT POTENTIAL GRAPHS.