

**THE EFFECT OF SOLUTION ANNEALING ON THE CORROSION
RESISTANCE OF A WELDED 0.36%C STEEL IN CHLORIDE
ENVIRONMENT**

BY

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COREN REGD.**



**DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF BENIN
BENIN CITY**

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**A THESIS WRITTEN IN THE DEPARTMENT OF MECHANICAL ENGINEERING
AND SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES, UNIVERSITY
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INDUSTRIAL METALLURGY AND CORROSION MANAGEMENT**

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NIGERIA**

JULY, 2021

CERTIFICATION

This thesis titled ‘The Effect of Solution Annealing on the Corrosion Resistance of a Welded 0.36%C Steel in Chloride Environment’, submitted to the School of Postgraduate Studies, University of Benin, Benin City, Edo State, Nigeria for the award of Doctor of Philosophy in Industrial Metallurgy and Corrosion Management is an original research carried out by Oghenerobo Awheme in the Department of Mechanical Engineering, University of Benin, Benin City under the supervision of Professor B.O Onyekpe and Dr. N. Enoma. The research work has not been previously submitted in whole or in part to any other institution to qualify for an academic award.

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Certificate of Thesis/Dissertation on Plagiarism

We the undersigned attest and declare that the thesis of Oghenerobo Awheme entitled The Effect of Solution Annealing on the Corrosion Resistance of a Welded 0.36%C Steel in Chloride Environment has successfully passed the anti-plagiarism test and does not violate any copyright regulations.

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DEDICATION

This research work is dedicated to God Almighty whose mercy, strength, wisdom, grace and divine protection were made abundant in my life throughout the period of my study, to Him be all glory, honour and adoration.

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ABSTRACT

Medium carbon steel is highly used in the petroleum and chemical industry, and solution annealing has been demonstrated in other kind of steel to be very effective in controlling corrosion. This thesis intends to investigate the effect of solution annealing on the corrosion resistance of a welded 0.36%C steel in chloride environment.

The specimens were machined into weldable specifications and welded using the technique of shielded metal arc welding (SMAW). The samples were then solution annealed to determine optimum holding time and temperature. On establishing the optimum time and temperature, samples were now solution annealed at these optimum conditions to determine associated microstructural properties. For the microstructural analysis, the specimens were subjected to optical microscopy (OM) and energy dispersive X-ray spectrometry (EDX). Also hardness tests were conducted using Vickers microhardness testing (VMT) as prescribed by American Standard Testing Method (ASTM) A384/89 standard. The corrosion rate was determined using gravimetric analysis in 1.0M NaCl environment at intervals of 20 days for the period of 100 days. Potentiostatic measurement method was also used to determine corrosion rate, corrosion potential, corrosion current from tafel slope, polarization resistance, open circuit potential, electrochemical noise, and electrochemical impedance spectroscopy respectively.

The result obtained from the solution annealing process established the optimum annealing temperature and time for the 0.36%C steel as 990 °C and 2.0 hours respectively. The hardness results obtained showed that the solution annealed samples have higher hardness property than the control samples at the welded zone, heat affected zone and the parent metal. When exposed to corrosion, the obtained corrosion rate from gravimetric analysis and Potentiostatic measurement method showed that the solution annealed samples were found to be more noble in the chloride environment than the control samples. The nobility of the samples was found to decrease across the welded zones. The solution annealed parent metal was found to have a higher polarization resistance of 786.061 $\Omega\cdot\text{cm}^2$ and with a lower corrosion rate of 0.591 mm/yr, while the control parent metal was found to have a lower polarization resistance of 269.867 $\Omega\cdot\text{cm}^2$ and with a higher corrosion rate of 1.673 mm/yr. The solution annealed heat affected zone was found to have a higher polarization resistance of 180.452 $\Omega\cdot\text{cm}^2$ and with a lower corrosion rate of 1.017 mm/yr, while the control heat affected zone was found to have a lower polarization resistance of 61.263 $\Omega\cdot\text{cm}^2$ and with a higher corrosion rate of 3.143 mm/yr. The solution annealed welded zone was found to have a higher polarization resistance of 54.483 $\Omega\cdot\text{cm}^2$ and with a lower corrosion rate of 3.207 mm/yr, while the control welded zone was found to have a lower polarization resistance of 41.133 $\Omega\cdot\text{cm}^2$ and with a higher corrosion rate of 4.832 mm/yr. The solution annealed samples were not prone to pitting corrosion and less susceptible to uniform corrosion compared to the control samples that were found to be prone to pitting corrosion and more susceptible to uniform corrosion. The susceptibility of the samples was found to increase from the parent metal, to the heat affected zone with the welded zone as the most. This study, therefore shows that the solution annealing heat treatment was effective toward corrosion protection of the investigated steel in chloride environment. Welded medium carbon steel used for oil and gas pipelines will therefore fare better under the influence of solution annealing in seawater in Nigeria.

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NOMENCLATURE

Symbol	Meaning	Unit
A	Total Surface Area	cm ²
AISI	American Iron and Steel Institute	
API	American Petroleum Institute	
ASM	American Society for Metals	
ASTM	America Standard Test Method	
AWS	American Welding Society	
CPR	Corrosion Penetration Rate	mg/cm ² /yr
IIW	International Institute of Welding	
L	Length of Samples	cm
r	Radius of Samples	cm
SML	Specific Metal Loss	mg/cm ²
T	Absolute Temperature	
W	Weight Loss	mg
W _f	Final Weight Loss	mg
W _i	Initial Weight Loss	mg

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Carbon steel is fundamentally an alloy comprising of iron and carbon, and other alloying elements such as manganese with 1.0% maximum content and silicon with 0.3% maximum content (Onyekpe, 2002). It is the most important steel used in petroleum and chemical industries since it accounts for over 98% of the construction materials. Carbon steels materials are predominantly used for flow lines, transmission pipelines and downhole tubulars in the oil and gas industry, most possibly owing to their low cost (Nesic et al, 2010; Ghareba et al, 2010; Liu et al, 2011; Badr, 2009). For instance, the cost of stainless steels especially that of austenitic steels (AISI 304 & 316) is currently about 8 times greater than that of carbon steels (Panossian et al, 2012; Finsgar et al, 2014). Among the most widely used carbon steel is the medium carbon steel. It is classified on the basis of their carbon content varying from 0.25% to 0.5%. The carbon steel that has been mostly used as the main production material for transmission pipelines, downhole tubulars, and flow lines in the oil and gas industry is API N80 (Walker, 1994; Yadav et al, 2012; Vishwanatham et al, 2008; Zhu et al, 2011), with carbon varying from 0.23% - 0.52%, (Finsgar et al, 2014). However, this material is susceptible to corrosion when used in chloride environment without any form of surface treatment or protection (Seidu and Ketulu, 2013).

Welding is considered one of the most used techniques of fabricating medium carbon steels. It is essentially a union of two or more pieces of metal by the use of heat and occasionally pressure (Agarwal, 1992). Welding comprises of a broad range of scientific variables such as welding speed, power input, electrode, temperature, and time (Jariyanbon et al, 2007; Lothongkum et al, 2001; Karadeniz et al, 2007). Research findings have proved that failure do occur in welded materials as a result of poor mechanical properties owing to the existence of gases, irregular grain size and internal stress in the heat affected zone of the welded material (James, 2000). Furthermore,

the microstructure of a steel weld metal is a complex combination of two or more constituents, such as ferrite carbide aggregates, acicular ferrite, polygonal ferrite, proeutectoid ferrite, aligned and non-aligned side plate ferrite (IIW, 1988, Da trindade et al, 2004). This complex microstructure combination can results in varied properties of the weld, hence making the welded material to become susceptible to corrosion attack.

Solution annealing heat treatment which is one of the heat treatments carried out on medium carbon steel is a practical and useful method to resolve these aforementioned problems in the welded materials and improves the corrosion resistance characters of the steel. Solution annealing involves the heating of steel up to the austenitic temperature and holding it long enough for the carbon to go into solution and by fast cooling to prevent the carbon/carbide from coming out of solution (Gigovic-Gekic et al, 2011; Totten, 2006; Iwuoha et al, 2012). Solution-annealed material is in the most corrosion-resistant condition (Iwuoha et al, 2012).

One of the main factors in any corrosion condition is the environment. This has found a broader effect on material performance behaviour and material strength. Environment is a variable that can change with conditions and time, its effect on metal relates to the micro environmental situations (Popoola et al, 2011). Chloride environment is an aggressive solution, with high application in most manufacturing and production sector as cleaning agent. It also has its application in oil and gas exploration, as an essential constituent of drilling fluids in well drilling. Chloride environment is used to flocculate and to increase the density of the drilling fluid in order to overcome high down well gas pressure, it is likewise used to increase the curing of concrete in cement casting. It has its application in the food, medicine and agricultural industry (Mason, 2006). Deslouis, (2007) and Lu et al., (2016) reported that oilfield water comprises of abundant Cl^- ions.

Corrosion which is an irreversible damaging attack on steel by electrochemical or chemical reaction with its environment (Roberge, 2000; Popoola et al, 2013) and a likely potential hazard related with oil and gas transportation facilities (Kermani et al, 1997) is worth examining in oilfield

uses, because corrosion problems denote a large percentage of the total cost for oil and gas producing companies annually worldwide. The cost credited to corrosion damages of all types has been valued to be in the order of 3% to 5% of developed countries' Gross National Product (Uhlig, 1949; Neil et al., 2007; Popoola et al, 2013). The total yearly cost of corrosion in the petroleum industry is valued at \$1.372 billion, broken down into \$589 million in external pipeline and facility cost, \$463 million yearly in downhole tubing expenditures, and another \$320 million in capital expenditure associated to corrosion (Simon, 2008; Popoola et al, 2013). Corrosion costs the petroleum industry tens of billion of dollars in treatment costs and lost income annually (Champion, 2012). Corrosion cost United State of America industries alone an estimated \$170 billion annually in which the petroleum industry accounts for more than half of these costs (Tuttle, 1987; Popoola et al, 2013). Corrosion in oilfields take place at all stages from surface equipment to downhole and processing facilities. Corrosion appears as leaks in pipelines, casting, tanks, tubing, and other equipment (Osman et al, 2003; Nesic et al, 2010; Finsgar et al, 2014). Corrosion problems are typically associated with equipment maintenance and operating problems, leading to repeated partial or total process shutdown, resulting in serious economic losses (Garcia-Arriaga et al, 2010). Reports around the globe have established that some petroleum firms had their pipeline cracked owing to corrosion and that oil leakages are experienced which no doubt caused ecological pollution; furthermore, resources are lost in cleaning up this ecological mess, and lastly, large-scale environmental damage resulted from corrosion effects (Oyelami et al, 2011; Popoola et al, 2013). In Nigeria, corrosion is said to be the largest contributor to oil spill. Fifty percent of oil spill in Nigeria is attributed to corrosion (Baird, 2010; Aniefiok et al., 2013). The corrosion of materials used in chloride (marine) environment has continued to pose a lot of challenges to researchers. Many investigation have been done on how to improve the corrosion resistance of stainless steel in certain environments by solution annealing (Ihsan-ul-Haq, 2014; Yanjun et al, 2014; Martina et al, 2011; Hidenori et al, 2011; Kai and Tjong, 2014; Elki et al, 2017; Kciuk and Kurc-Lisiecka,

2012; Anburaj et al, 2012; Rosemann et al, 2015), However, there is dearth of information or relevant literatures on the effect of solution annealing on corrosion of welded medium carbon steel in chloride environment. It is therefore, appropriate for a holistic investigation of the effect of solution annealing on the corrosion resistance of welded medium carbon steel in chloride environment.

1.2 Statement of the Problem

Several structural failures due to corrosion of welded materials have been reported. For instance, 18% of the structural corrosion failures encountered in oil and gas industry were initiated by weld corrosion (Voruganti et al., 1991). Weld corrosion of carbon steel has been reported to have occurred in chemical plants, oil industry and ships for over 65 yrs (Nimmo et al, 2001). Failure does occur in welded materials as a result of mechanical stress that are built up at the weldment and the heat affected zone (James, 2000). The microstructure of a steel weld metal is a complex combination of two or more constituents, such as ferrite carbide aggregates, acicular ferrite, polygonal ferrite, proeutectoid ferrite, aligned and non-aligned side plate ferrite (IIW, 1988, Da trindade et al, 2004). This complex microstructure combination has been reported to aid the welded material to become susceptible to corrosion attack (Abdurrahim et al., 2003). Appropriate corrosion control of welded material can help to prevent numerous potential disasters that can cause severe issues. It is therefore pertinent to study the effect of solution annealing on the corrosion of medium carbon steel in chloride environment, so that appropriate measures can be taken to reduce the impact of corrosion on welded materials.

1.3 Aim and Objectives of the study

The aim and objectives of this study is as listed.

1.3.1 Aim

This work is aimed at investigating the effect of solution annealing on the corrosion resistance of welded 0.36%C steel in chloride environment.

1.3.2 Objectives

The specific objectives are to:

- i. Determine optimum heat treatment conditions (temperature and holding time) for solution annealing treatment of 0.36%C steel;
- ii. Examine the effect of solution annealing on microstructural evolution and how it relates to the hardness properties of the different regions of the welded steel;
- iii. Determine the effect of solution annealing on the corrosion behaviour of welded 0.36%C steel in chloride environment; and
- iv. Examine the effect of solution annealing on microstructural evolution and how it relates to corrosion rate of 0.36%C steel in chloride environment.

1.4 Scope of the Study

The scope of this research work is to study the effect of solution annealing on the corrosion resistance of welded 0.36%C steel in chloride environment. As such, this research covers and is limited to 0.36%C steel and 1.0M NaCl environment, Machining of samples to welding specimen's specification, Shielded Metal Arc Welding (SMAW) of samples, Solution annealing of welded and un-welded samples, Preparation of 1.0M NaCl solution, Exposure of samples to 1.0M NaCl solution to determine corrosion penetration rate using weight loss method for the period of 100 days at an interval of 20 days and Potentiostatic measurement method to determine corrosion rate, corrosion potential, corrosion current (density) from tafel slope, polarization resistance (PR), open circuit potential (OCP), electrochemical noise (EN), and electrochemical impedance spectroscopy (EIS)., Micro hardness testing of the solution annealed and as-received welded samples, Metallography, optical microscopy examination (OME) and energy dispersive X-ray spectrometry (EDX).

1.5 Justification for the Study

Eighteen percent (18%) of the structural corrosion failures encountered by oil and gas industry is attributed to weld corrosion (Voruganti et al., 1991). This results in ecological pollution as resources are lost in cleaning up this ecological mess, large-scale environmental damage resulted from corrosion effects (Popoola et al, 2013). These findings will help the oil and gas industries in Nigeria;

I. To take adequate measures to reduce corrosion in welded steel material to the barest minimum in chloride environment, thereby saving cost

II. It will help to guide their choices in choosing the best solution annealing heat treatment parameters for welded medium carbon steel used in transmission pipelines, flow lines, downhole tubulars in chloride environment.

1.6 Outline of Subsequent Chapters

Chapter Two of this thesis was titled “Literature Review”. This chapter was concerned with the review of past and related research works with a view to providing sufficient background information to this study.

Chapter Three of this work was titled “Methodology”. The chapter gave a clear description of the materials and equipment used, the procedures that were adopted in carrying out the various experiments in the study.

Chapter Four of this study was titled “Results and Discussion”. In this chapter, experimental results were presented and discussed accordingly. The findings from the study were also highlighted in this chapter.

Chapter Five of the study was titled “Conclusion and Recommendation”. The chapter presented the conclusion, relevant recommendations and advancement of the frontiers of knowledge made in this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Medium Carbon Steel

Medium carbon steel has a carbon content between 0.25% to 0.5% (Onyekpe, 2002; Finsgar et al, 2014). Medium carbon steel is used throughout the world for almost the same reasons such as, cost, ease of fabrication, properties, availability and weldability (Flenner, 2007). Its machinability is better than low and high carbon steel and they are weldable and heat-treatable. Medium carbon steel is a versatile material and is one of the most vastly used materials in the industry (Flenner, 2007; Bruce, 2002). A key example of the versatile nature of medium carbon steel is in the automobile industry where it is the choice material. It is used in the production of parts such as bolts, gears, crankshaft of the vehicle (Onyekpe, 2002). It has found application not only in many of the steam-pressure and water containing systems in power plants but also in the support for these systems (Flenner, 2007). It has also found application in the construction of pipes used in the cooling process of plants e.g. heat exchangers and gas production facilities. Medium carbon steel has also been used as the main production material for transmission pipelines, flow lines, and downhole tubulars in the petroleum industry and a prime example is API N80 (Walker, 1994; Yadav et al, 2012; Vishwanatham et al, 2008; Zhu et al, 2011). The chemical composition of API N80 steels is shown in Table 2.1

Table 2.1: Chemical composition in wt.% of different AISI/UNS/DIN/API N80 materials

Designation	Chemical Components												
	C	Mn	Cr	Mo	Si	P	S	Ni	V	Nb	Cu	Al	Ti
API N80	0.31	0.92	0.20	-	0.19	0.01	0.008	-	-	-	-	-	-
API N80	0.52	1.50	-	-	0.23	0.011	0.008	0.02	-	<0.005	0.07	0.01	-
API N80	0.24	1.19	0.036	0.021	0.22	0.013	0.004	0.028	0.017	0.006	0.0019	-	0.011
N80	0.31	0.92	0.20	-	0.19	0.01	0.008	-	-	-	-	-	-
N80	0.23	1.35	0.05	0.01	0.22	0.017	0.012	0.02	-	-	-	-	-
N80	0.31	0.92	0.20	-	0.19	0.01	0.008	-	-	-	-	-	-

Source: Finsgar and Jackson, 2014

2.1.1 Effect of Alloying Elements in Medium Carbon Steels

The prime alloying elements found in medium carbon steels are Carbon, Manganese, Silicon (Dowling, 1999). Carbon which is regarded as the most important alloying element in steel is an essential alloying element in medium carbon steel. It is cheap and has a strong effect on strength and hardness (Bruce, 2002). It causes the formation of bainite and martensite to occur over a long time (Solimen et al., 2010). Manganese, which is also an important alloying element in medium carbon steel has several role as an alloying element. It helps in deoxidation of the steel, inhibits the formation of iron sulfide and inclusions, and it brings about better strengthening of the steel by increasing the hardenability (Flenner, 2007). Manganese brings about an increase in the solubility of carbon in austenite (Murugaiyan et al., 2006) and equally lowers the pearlitic reaction which results in cooling rates taking place over an extended period of time. It precipitates carbide in austenite when it is in excess amount in the steel (Bleck, 2002). Silicon, which is found in small amount in the steel, basically act as a deoxidizer in the steel and in weld metal with moderate effect on strength even though it is usually not added for the purpose of strength. It is a ferrite stabilizer and is added to the steel to enhance its electrical properties (Bruce, 2002). Silicon in the steel helps to raise the temperature at which eutectoid transformation occur and at same time decreased the activity of carbon in ferrite (Smith, 1993). Steel with high Silicon content can hardly accommodate cementite owing to low solubility of Si in cementite (Ray et al., 1981; Ray et al., 1982; Bhadeshia and Christian, 1990; Lesile and Rauch, 1978). Chromium, is an influential alloying element in steel with strong effect on hardenability, decreases elongation and austenite retention (Kim et al., 2000). Chromium in steel tend to efficiently extend the austenite field and as a result moves the bainite and pearlite phase fields towards longer times (Pichler and Stiaszny, 1999). Phosphorus, which is considered a residual alloying element is usually limited to a percentage between 0.02 - 0.04. Phosphorus, being an interstitial alloying element like carbon considerably strengthens the steel (Bruce, 2002). Phosphorus greatly inhibits the formation of carbide and as a result allows

more carbon to be segregated toward austenite in solution. Chen et al., (1989) noted that fewer carbide was present in phosphorus alloyed steels when compared to alloyed steel that is free of phosphorus.

2.2 Welding

Welding is a major fabrication process used in the manufacturing of metal structure in order to obtain a desired shape. It is a joining process used to bring about the fusion of similar or dissimilar metals with the purpose of achieving complete coalescence (Hendesen, 2004; Dodo et al., 2016). The welding of materials requires the use of heat. The equipment used for welding can make use of laser light, electric arc or flames to generate heat (Davies, 1992; Mohammed et al., 2013). Welding is more suitable, cheaper and less a risk to corrosion or failure in comparison to other joining procedures. Due to the benefits of welding as compared to other joining processes, various welding approaches have been established (Khanna, 1999). Welding as an industrial process is used in the fabrication of structural parts such as bridges, boilers, pressure vessel tanks, steel reservoirs and pipelines (Sharma, 2004; Rohit and Jha, 2014). The welding cost plays a vital position in the manufacturing decision.

2.2.1 Welding Metallurgy

During welding, the metal to be welded undergoes a thermal cycle due to rapid heating of the metal and its slightly slower rate of cooling. The temperature cycle of the heated metal strongly influences the microstructure and properties of the metal (Radhakrishnan, 2007). Welding affects the development of temperature gradient and it varies from the maximum temperature in the center of the weld pool down to the ambient temperature in the weld axis (Parma, 2011). The welded joint, though a single integral structure, could be considered to comprise of three distinct zones which includes: the parent metal (PM), heat affected zone (HAZ) and the welded zone (WZ) (Parma, 2011). A schematic representation of the various zones is shown in Figure 2.1

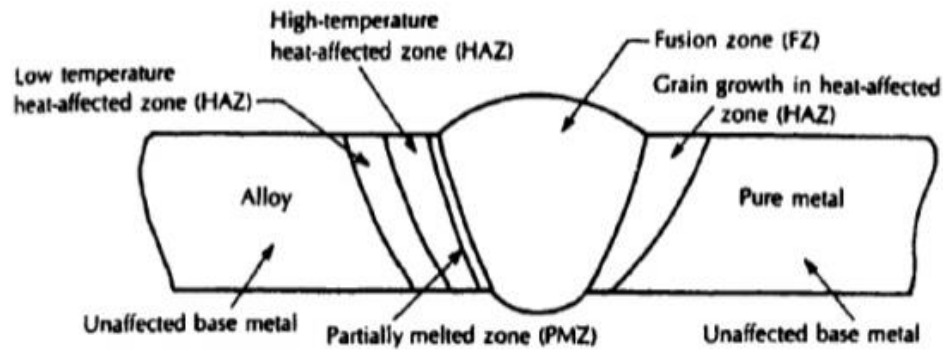


Figure 2.1: Different Welded Zones of Carbon Steel (Parma, 2011)

The performance of the steel weldment principally with reference to its mechanical properties such as, strength, toughness and hardness, depends on the type of microstructure attained in the weld zone and HAZ (Radhakrishnan, 2007; Raghavan, 1989). The different rate of cooling across the steel material has been found to influence the steel properties most especially its hardness (Sathiya et al., (2007), Raghavan, (1989) and Adedayo et al., (2010). The loss of quenching elements from the weld zone (WZ) and their coarse structure were found to decrease the hardness property of steel (Xin et al., (2016; Blondeau, 2008; Lippold, 2015; Dodo et al., 2016; and Nandan et al., 2008). The existence of coarse grain size in the welded zone (WZ) can also be attributed to the heat cycle, low dislocation density and dissolution of precipitation (Ueji et al., 2006). According to (Xin et al., 2016; Sathiya et al., 2007; and Nandan et al. 2008), the parent metal (PM) which is the section of the steel that is not affected by the heat input was observed to have higher hardness in comparison with the HAZ and the WZ due to its finer grain size.

2.2.2 Shielded Metal Arc Welding (SMAW)

Shielded metal arc welding (SMAW) technique is a fusion process that enables complete union of the metals which is attained via the heat generated from an electric powered arc between the workpiece and the electrode (Groover, 2007; Soy et al., 2011). This technique is considered one of the most used method of constructing metal components and for repair works, because of its versatility, flexibility, portability and low cost (Afnan et al., 2018). It is basically a fusion of metals which could be two or more workpiece by the use of heat and at times pressure (Agarwal, 1992).

SMAW entails a wide variety of scientific variables which includes time, electrode, temperature, welding speed and power input (Jariyabon et al., 2007; Lothongkum et al., 1999; Lothongkum et al., 2001; Karadeniz et al., 2007). In this technique, welding parameters are the most essential factors that affects productivity and quality of the welding joint (Karadeniz et al., 2007). Parameters which includes electrode diameter, welding current, arc length, welding speed, electrode advance angle, welding position, electrode movement and oscillation, welding direction and the welding slot forms are major factors that determined the welding quality of SMAW (Afolabi, 2008; Chan et al., 1999; Ates and Turker, 1999). In an attempt to achieve high exceptional welds in SMAW technique, choice of ideal parameters has to be made according to engineering principles. In SMAW technique, the electrode is covered with a protective flux of a suitable composition. The flux melts collectively with the metallic core of the electrode, resulting in the formation of a gas and a slag, shielding the arc and the weld pool. The flux stabilizes the arc, protects the molten steel from oxidation, input some alloying elements to the weld, and also help to clean the surface of the metal. After solidification of the weld the slag is removed (Ugur et al., 2011). A schematic representation of SMAW is shown is Figure 2.2.

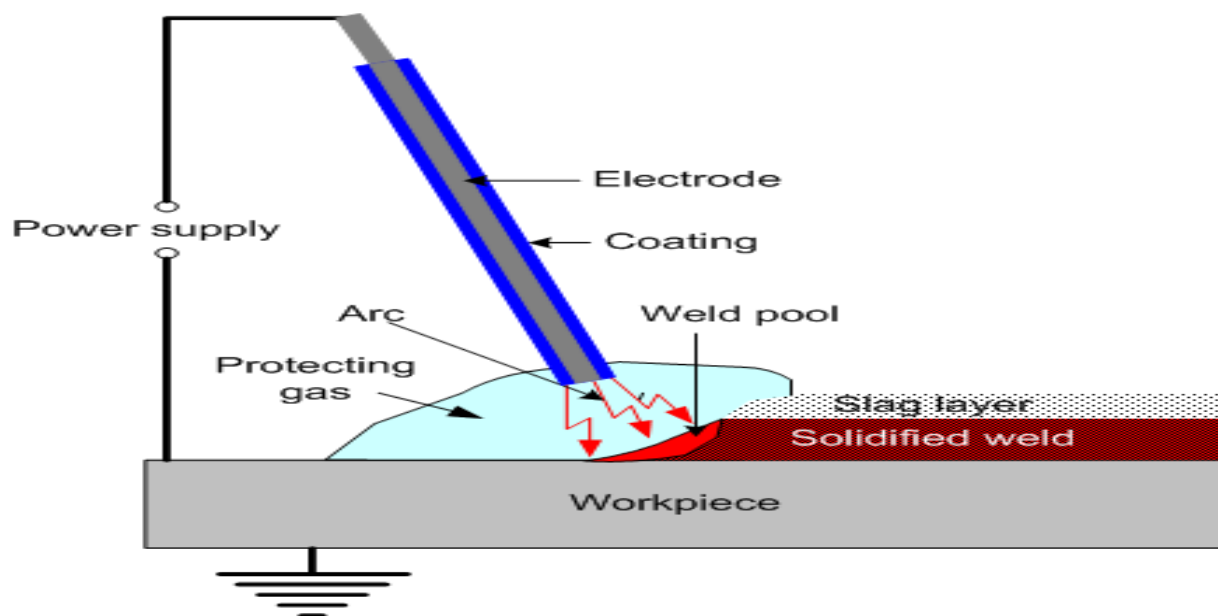


Figure 2.2: Diagrammatic Image of SMAW. Source: Kopeliovich, 2010

As presented in this figure, SMAW technique comprises of electrode and its coating, arc creation, shielding gas, weld pool and solidified weld.

Mohammed et al., (2013) examined the effect of shielded metal arc welding process (SMAW) on the metallurgical and mechanical properties of medium carbon steel at parent metal, heat affected zone and the weld metal. They reported that (SMAW) improved the strength of the weld joint and most especially the heat affected zone (HAZ), as shown by higher hardness values and tensile strength and lower impact strength as compared with the weld and parent metal. This they credited to the fine pearlite distribution and fine ferrite matrix as compared to the welded zone and parent metal. But, there was a decrease in ductility at the welded joint resulting in the brittleness of the material. The un-welded sample had the highest toughness and also the most ductile as compared to the heat affected zone and the weld metal. The welded metal was found to possess a considerable amount of hardness and a decrease in toughness displaying less ductility than the parent metal, but was observed to be more ductile than the HAZ. The heat affected zone was reported to have the least impact strength, highest hardness and tensile strength displaying that it is the most brittle as compared to the welded metal and the parent metal. Alay Shah et al., (2015), investigated the mechanical properties of single pass welded joints, single v-groove of America Standard Test Method (ASTM) A515 Grade 60 low carbon steel using submerged arc welding (SAW) and shielded metal arc welding (SMAW). The authors reported that the impact test and hardness show that the original hardness and toughness of SAW sample are recovered by the repair SMAW made on formerly SAW specimen. This they say clearly justifies the practicality of carrying out SMAW repair on damaged SAW weld joints in order to recover its lost mechanical properties. The authors also reported that there was grain growth in the HAZ and WZ of the steel and that grain refinement was observed to have taken place during the repair. This finding aligns with Blondeau, (2008) and Lippold, (2015). They observed that the WZ takes a longer time to solidify thereby promoting grain growth to give a coarser carbide in the ferrite matrix compared to the HAZ and the PM.

Dhananjay and Dharamvir, (2015) studied the influence of welding procedure on distortion of weld joints with 304L stainless steel. The weld joints were produced by TIG and SMAW joining process involving varied type of joint configuration. The authors observed that the TIG weld joints exhibited lower angular distortion value with SMAW weld joint exhibiting maximum angular distortion value. The authors attributed the positive effect of angular distortion to increase in the length of plates and diameter of electrode and the negative effect of angular distortion to increased current and time gap between passes. Singh et al., (2012) examined the effects of varied welding parameters on penetration in mild steel having 5 mm thickness using SMAW method. They observed that a solid joint of mild steel was produced by using SMAW method. Rajeev, (2014) investigated to optimize varied welding factors for SMAW method using factorial design methodology. The authors findings correspond with the findings of Singh et al., (2012) that a solid joint of mild steel was found to be produced by SMAW technique.

2.2.3 Shielded Metal Arc Welding Electrodes

The welding electrodes used in SMAW are divided into two major groups as filler and joining welding electrodes with respect to the purpose of the welding. The diameter and length of the metal wire used in the process is between 1.5 to 6.5mm and 20 and 45 cm respectively (Black and Kohser, 2008). The workpiece thickness, amount of material to be added, weld properties, welding slot form, current, welding position and material type are fundamental for the selection of electrode to be used in SMAW (Ugur et al., 2011; Sathish et al., 2012). The welding slot form and material thickness are responsible for the changes in electrode diameter. The frequently used electrodes in SMAW applications are 2.50, 3.25 and 4.00 mm core diameter (Oz et al., 2011). The type of coating, the position of the welding in which they may be used, the ideal type of current and polarity and the deposited weld metal tensile strength are all used for the classification of the coated electrode. The coated electrodes are coated with flux (Gurpreet and Sukhpal, 2012). The flux decomposes to give off gases which help to prevent weld impurity, inputs deoxidizers to cleanse

the weld and provides slag film to shield weld surface, increases the arc solidity and inputs alloying elements to increase the weld quality (Jeffus, 1999; Jeffus, 2010). SMAW uses a varied range of coated electrodes and these diverse coating vary the welding position, electrode penetration and the quantity of hydrogen in the gas shield (Wallace, 1979). The commonly used coated electrodes for SMAW are basic electrodes and cellulosic electrodes (Gurpreet and Sukhpal, 2012).

The electrode (E7018) is a basic electrode which is also branded as low hydrogen electrode with a coating containing the mixture of fluorspar (CaF_2), limestone (CaCO_3) and clay asbestos. Mechanical properties such as notch toughness and ductility accounts for its superiority to other electrode types. The deposition of basic electrodes has been found to have high ability to mitigate hot and cold cracking, hence very useful for the welding of steel with high strength. Good bead form, average speed of deposition and moderate penetration are given by these electrodes. Basic electrodes are of different types which are E7016, E7018, and E7028 etc (Radhakrishnan, 2007). O'Con, (2000) reported that the E7016 electrode gave an arc wastefully penetrating and curved weld surface with heavy, easy and friable removable slag which makes it suitable for welding mild, 490MPa high strength and also for medium to thick base metals due to its superior ability to mitigate crack. The E7018 electrodes according to American Society for Metals (AWS, 1976); Wallace, (1979), and Moarrefzadeh, (2012), have a smooth, standard arc penetration and low spatter. They also reported that E7018 electrode is used in all position AC or DC polarity and that it is suitable for welding medium to thick base metals due to its excellent crack mitigation, welding speed, recovery and its ability to impart high toughness on the weld.

2.2.4 Classification of SMAW Electrodes

The E7018 electrode is categorized into a four or five-digit number preceded by the letter E according to the ASW, (1976) and Jeshvaghani et al., (2011). The electrode is denoted by letter E, and a 4-digit number. The first 2-digit numbers denote the lowest tensile strength of the welded steel in kilopound per square inch (Ksi). The welding position of that particular electrode is

specified by the second to the last digit. Finally, the electrode coating and the preferred current polarity is represented by the last digit. The classification is summed up in Figure 2.3 while the electrode coating and the preferred current polarity is given in Table 2.2.

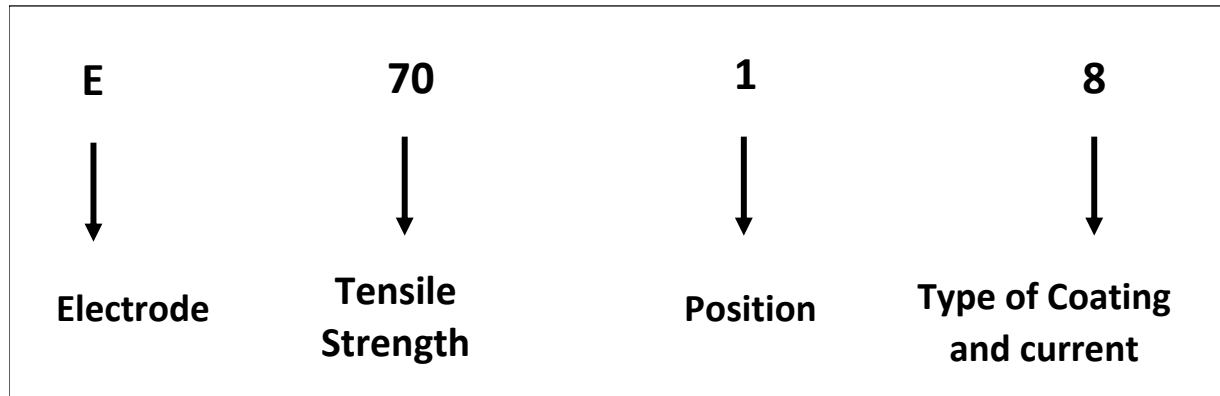


Figure 2.3: Electrode Classification (AWS, 2012)

Table 2.2: Chart displaying types of coating/welding current for the last digit

Digit	Types of Coating	Welding Current
0	High cellulose sodium	DC+
1	High cellulose potassium	AC, DC+ or DC-
2	High titania sodium	AC, DC-
3	High titania potassium	AC, DC+
4	Iron powder, titania	AC, DC+ or DC-
5	Low hydrogen sodium	DC+
6	Low hydrogen potassium	AC, DC+
7	High iron oxide, iron powder	AC, DC+ or DC-
8	Low hydrogen potassium, iron powder	AC, DC+ or DC

Source: AWS, 2012

2.3 Heat Treatment

Heat treatment involves controlled heating and cooling of a metal or alloy in its solid state with the objective of altering their microstructure, physical, mechanical and sometimes chemical properties of materials (ASM, 2015). Heat treatment plays an important role in the pursuit of advanced properties in materials. The alterations in the properties of metal by heat treatment are due to structural changes or phase transformations that ensued during the treatment (Kavousi and Mirsalehi, 2015). The temperature at which phase transformation takes place in steel is critically influenced by alloying elements, most importantly carbon. The iron-carbon equilibrium diagram indicates the temperature at which phase transformation will ensue for a particular amount of carbon when added to iron. The iron-carbon equilibrium diagram is presented in Figure 2.4.

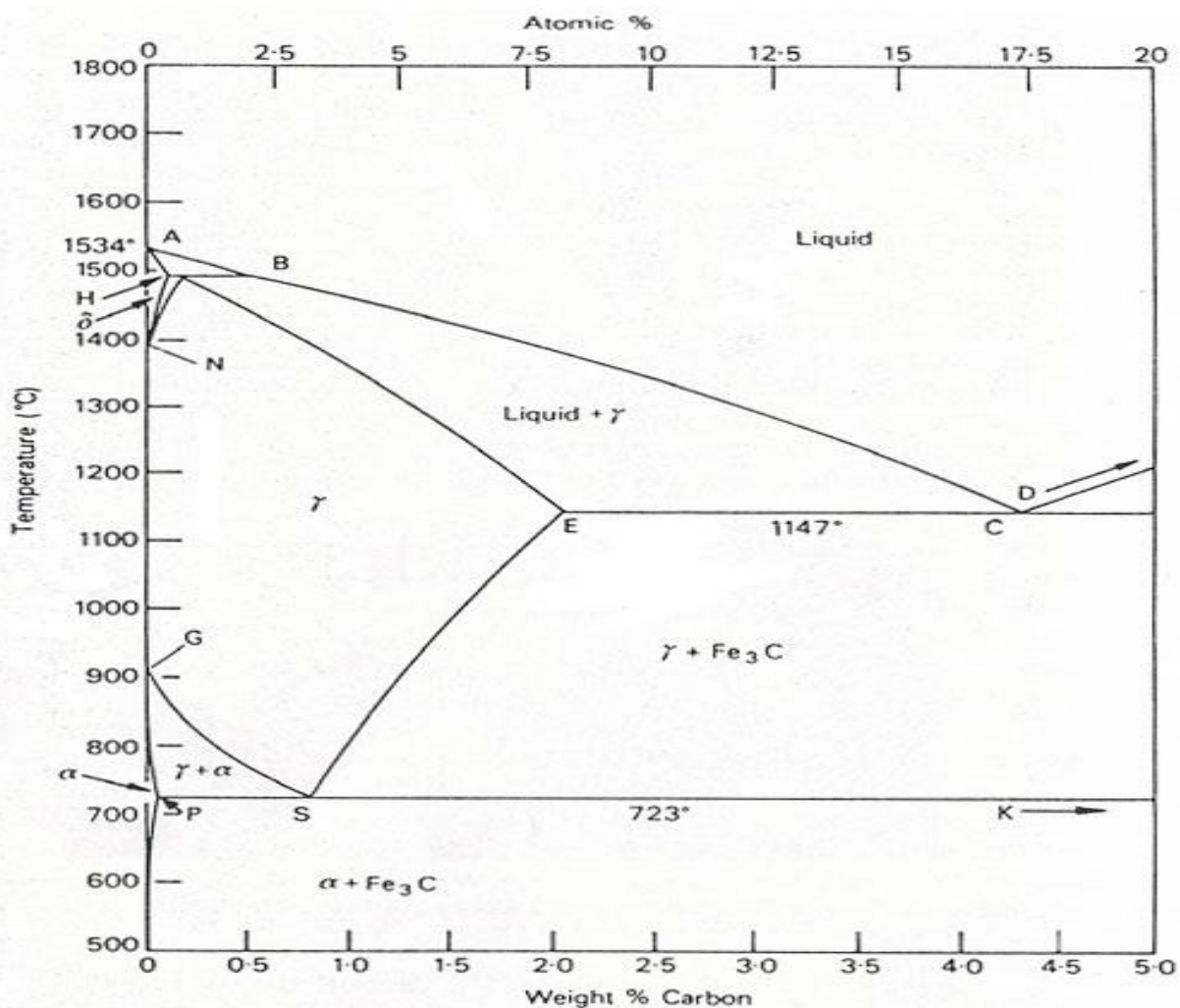


Figure 2.4. The Iron-Carbon Equilibrium Diagram (Source: ASM, 2015)

2.3.1 Effect of Solution Annealing on Steel

Solution annealing heat treatment has been observed to be one of the heat treatment carried out on steel as a useful and practical method to resolve problems in welded materials and improves the corrosion resistance characters of the steel. Solution annealing, also denoted as quenched annealing involves the heating of steel up to the austenitic temperature and holding it long enough for the carbon/carbides to go into solid solution (dissolved in the matrix) followed by fast cooling to prevent the carbon/carbide from coming out of solution (ASM, 2015; Gigovic-Gekic et al, 2011; Totten, 2006; Iwuoha et al, 2012; Anburaj et al., 2012; Elki et al., 2017; Yanjun et al., 2014). The treatment process refines the microstructure and ensure complete dissolution of the precipitates in the steel. Rajan et al., (1988) reported that the grain growth of austenite is majorly controlled by the growth of the initial formed austenite grains and thereafter by the growth of the newly formed austenite nuclei. Yang and Chen, (1991) reported that the initiation of austenite precipitation and the suppression of recrystallization are linked to the attractive interaction that exist between manganese, chromium and carbon atoms, which are simply segregated along the grain boundaries in the course of solution annealing at high temperature. The increased austenite nucleation at higher temperature, resulted in the structure becoming very enriched with more martensite on quenching (Ikpeseni et al., 2015). Solution-annealed material was observed to be in the most corrosion-resistant condition (Iwuoha et al, 2012). The resulting steel was also observed to have improved resistance to corrosion in certain acids/environment (ASM, 2015).

2.3.2 Effect of Temperature and Holding Time on Solution Annealing of Steel

Studies have shown that solution annealing heat treatment causes the homogenous dissolution of carbides in the matrix of the steel (Rosemann et al., (2015); Amini et al., (2016); Afolabi and Peleowo, (2011); Ihsan-ul-Haq, (2014); Pardo et al., (2008); Lucio-Garcia et al., (2009); and Gao et al., 2009). Temperature and holding time are critical parameters that affects heat treatment. The effect of temperature and holding time on solution annealing of steel has been extensively

investigated (Villalobos-Vera and Mendoza-Bravo, 2019; Pacyna and Rozniata, 2007; Rosemann et al., 2015; Ihsan-ul-Haq, 2014; Yanjun et al., 2014; Lima Filho et al., 2017; Soon-Hyeok et al., 2013; Tukur et al., 2014; and Zhuang et al., 2015). Most of these researchers established that austenitic microstructure free of secondary phase/carbide precipitate could be obtained at optimum temperature/holding time. Villalobos-Vera and Mendoza-Bravo, (2019) investigated the influence of solution annealing temperature on hyper duplex stainless steel. They established that balance austenitic microstructure free of secondary phase was accomplished by increasing the annealing heat treatment temperature, but the exact temperature for optimum solution annealing was not clearly stated. Pacyna and Rozniata, (2007), worked on the effect of solution annealing temperature on the structure of ledeburitic cast steel. They observed that the optimum solution annealing temperature of the test cast steel G200CrMnNi4-6-3 was between 900-950 °C. Rosemann et al., (2015) examined the influence of solution annealing temperature on martensitic (X₄₆Cr₁₃) stainless steel. They discovered in their investigation that the optimum solution annealing temperature where the carbide dissolution is complete was about 1100 °C. Ihsan-ul-Haq, (2014) worked on the influence of solution annealing temperature on stainless steel alloys. It was observed that at 1050 °C there were optimum dissolution of harmful inclusions and also the homogenization of the microstructure. Yanjun et al., (2014) examined the influence of solution annealing temperature on lean duplex stainless steel. They discovered that at 1000 °C balanced austenite phase was achieved. This finding aligns with Lima Filho et al., (2017), they studied the effect of solution annealing on maraging 300 steel. They found out that at temperature of 1000 °C, the carbides were fully solutionized. Soon-Hyeok et al., (2013) examined the influence of solution annealing temperature on duplex stainless steel. They observed that at temperature range of 1333 to 1413K, secondary phase formation was retarded due to decrease in the precipitation sites. Tukur et al., (2014) worked on the influence of solution annealing on AISI 304 stainless steel. They observed in their investigation the optimum solution annealing temperature to be 1090 °C, stating

that at this temperature the carbides were homogenously in solution of the steel samples. Zhuang et al., (2015) examined the effect of holding time on annealing of dual phase steel. They discovered that it is likely that the equilibrium/optimum austenite fraction would be attained for reasonable holding time, irrespective of the heat treatment temperature, though did not give the exact holding time. To the best of my knowledge there is dearth of information or relevant literatures on the effect of temperature and holding time on solution annealing with the view of determining the optimum temperature and holding time of welded medium carbon steel. Therefore, it is imperative to investigate the effect of solution annealing temperature and holding time on welded medium carbon steel in order to determine the optimum solution annealing temperature and holding time.

2.3.3 Effect of Solution Annealing on Hardness Property of Steel

Hardness is an important mechanical property of a welded steel that must align with the application feasibility (Ajay and Gattani, 2013; Asibeluo and Emifoniye, 2015). Hardness testing is reported to be the simplest and rapid way to obtain the mechanical property of welded steel (Boumerzoug et al., 2010; Stewart, et al., 2006). The effect of solution annealing on hardness property of steel has been widely examined, Tukur et al., (2014); Marcuci et al., (2014); Martin et al., (2009); Choi et al., (2015); Hoyos et al., (2015); Krauss, (1999) and Zhang et al., (2018). These researchers observed that the dissolution of the carbides in the matrix of the steel by solution annealing heat treatment helped to stretch the matrix of the steel and resulted in volumetric expansion with martensite formation and also helped to impede dislocation movement that ensued increased hardness of the steel. Ndaliman, (2006); DZU et al., (2002); Baker, (1991) and Garcia et al., (1992, 1996) also reported that hardening mechanism is due to the martensitic structure (phase) of the steel that is formed on quenching. Adedayo et al., (2010) and Ragunathan et al., (2015), reported that hardness increased where prior austenite grains size was smaller. Handoko et al., (2018), observed from their investigation that retained austenite enhanced hardness property as it prevented the generation of pitting holes at the grain boundary.

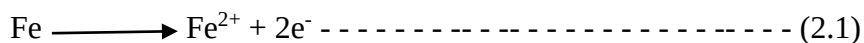
2.4 Corrosion in Steel

Corrosion is an irreversible damaging attack of a steel material by electrochemical or chemical reaction with its environment (Roberge, 2000; Popoola et al, 2013) and is a likely potential hazard related with oil and gas transportation facilities (Kermani et al, 1997). Virtually any aqueous environment has been found to support corrosion, which ensues under various complex settings in the production process of oil and gas pipeline systems (Champion, 2012). The investigation of corrosion on materials is ongoing worldwide. One main reason for this can be credited to the fact that corrosion of metal is greatly environmentally sensitive. Environmental factors such as temperature, humidity, rainfall, contaminants, sulphur dioxide (SO₂), hydrogen sulphide (H₂S) and particulate substances of sea salts differ from one nation to another (Nishimura et al., 2000; Mendoza and Corvo, 2000; Lan et al., 2006; and Castano et al., 2010). Corrosion in steel occurs by electrolysis process where the surface of the metal is found to release electrons into the environment (electrolyte). Chloride environment has been found to be an efficient electrolyte. Due to environmental changes, it is imperative for experiments to be performed on metals in order to determine its corrosiveness.

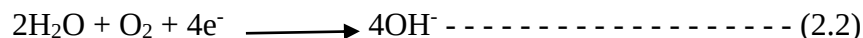
2.5 Effect of Chloride Environment on Corrosion of Steel

Generally, corrosion in chloride environment involves two reactions:

At Anode



At Cathode



In chloride solutions, the corrosion mechanism of steel is mostly accompanied by iron oxide film formation. The Oxide layers (film) formed at the surface of iron strongly limits the anodic reaction rate and prevents further chloride ions attack in the environment (Bertolini et al., 2004; Broomfield, 2007; Sherif et al., 2010 and Sherif et al., 2013). Thus, at this stage the steel surface

is said to be in a passive state. Passivity breakdown of the oxide layers (film) can ensue when the threshold value of the chloride ions concentration in the environment is exceeded (Sherif and Almajid, 2014; Ann and Song, 2007; and Sherif et al., 2013). At this instance, the steel undergoes active dissolution which ultimately results in large increase rate of oxidation of iron.

Investigations also reveal that high concentration of Cl^- in the environment effects the formation of aqueous adlayer on the material surface and that high moisture retention in certain areas of the rust leads to the formation of FeCl_2 which hydrolyzed water.



When this reaction ensues, there is an increase in the acidity of the electrolyte and the reaction at the cathode involving the evolution of hydrogen becomes important and results in the acceleration of the corrosion process. The steel surface and pits become saturated with the FeCl_2 solution, which is highly acidic. The entry of the Cl^- neutralized the hydrogen ions and the metallic cations causing the increase in the concentration of the Cl^- ions, Hence, increasing the rate of the dissolution of the steel. This leads to further entry of Cl^- ions. This mechanism of attack is enhanced by the products of corrosion produced and is sometimes stated as autocatalytic process (Shrier et al., 1994).

Chloride environment such as calcium, sodium chloride etc has been used in many applications dating back to early times (Okonkwo et al., 2015). Chloride ions have been found to be a very important corrosive agent (Wojnicki et al., 2015; Lakovleva et al., 2015). Chloride ion induced corrosion result in passive film failure and repair on steel surface (Zhu et al., (2020). Chloride ions in an environment, greatly influences the corrosion of carbon steel structures (pipelines) and may lead to pitting failure (Singh and Markeset, 2014; Pilkey et al., 1995; and Kale et al., 2004). Pitting corrosion damage is considered more catastrophic than uniform corrosion damage due to the difficulty in detecting, predicting and designing against it. Small pit with negligible metal loss can result to a complete engineering system failure (Greene and Fontana, 1958). Droplets of atmospheric water from the seashore together with residual stress are usually found to initiate

corrosion in pipeline systems (Xie and Zhang, 2015). Several researches have been carried out on the influence of chloride environment on the corrosion susceptibility of varieties of steel materials (Wang et al., 2015; Ossai et al., 2015; Liu et al., 2014). It is concluded that corrosion of steel materials (carbon steels and alloys) increases after exposure to chloride environment for certain period.

2.6 Effect of Corrosion on Welds

Failures due to corrosion often occurs at the weldments (WZ and HAZ) of the steel (Nelson, 1958). Voruganti et al., (1991) observed in their investigation that 18 % of corrosion failures recorded by key oil industries were initiated by preferential weld corrosion occurring at the weldment. They also observed that welding tend to decrease the resistance to corrosion by modifying the microstructure and composition, create physical defects, alter the mechanical properties and introduced residual stress. Nelson, (1958) and Nimmo et al., (2001) reported that for over 65yrs, preferential corrosion of carbon steel facilities such as ships, chemical plants and transmission pipelines has occurred at the weld area. These observation aligns with the investigation carried out by Dawson et al., (1982); they found out that preferential weld corrosion were vastly influenced by several factors which include, the environment, parent plate composition, flow conditions, weld procedure and weld metal composition with alterations in any one resulting in a significant effect on the corrosion behaviour. They also reported that the corrosion of HAZ may be reduced by altering the parent plate alloying composition to a potential that is more noble and also by control of the microstructure. These findings align with Abdurrahim et al., (2003) who observed from their investigation that the HAZ gave a moderate corrosion rate with the parent metal displaying the least corrosion rate. Vignal et al., (2015), they reported from their investigation that the existence of carbides at the grain boundaries in the heat affected zone (HAZ) was responsible for its high susceptibility to corrosion. Kato et al., (1978) also reported that the accelerated corrosion rates of the (HAZ) was due to massive grain growth. Rothwell and Turner, (1989), reported that the

difference in local galvanic potential between the parent metal (PM), heat affected zone (HAZ) and the welded zone (WZ) are responsible for corrosion attack. Kato et al., (1978), in their investigation reported that electrochemical difference (potential) between the parent metal (PM), heat affected zone (HAZ) and weld zone (WZ) resulted in selective corrosion. Gulbrandsen et al., (1993), reported that preferential corrosion occurs more in the welded zone (WZ) of steels. Kato et al., (1978), attributed this preferential corrosion at the welded zone to the presence of manganese sulphide (MnS) inclusion. Nejhashi et al., (1988) reported that the MnS are developed in the weld by fast reprecipitation of the manganese sulphide after dissolution during welding. They also reported that the weld area is anodic when compared to the base metal, hence, resulting in the formation of a macro-cell between the weld area (smaller portion) and the parent metal resulting in its high corrosion rate. The higher corrosion rate in the welded zone was attributed to the dissolution or removal of MnS inclusion, thus revealing more MnS inclusion available for more corrosion attack. Nejhashi et al., (1988) also reported that the application of heat treatment could help to lower the S-enriched zone around the manganese sulphide inclusion, reduced the electrochemical difference between the welded zone and the parent metal, and reduce the formation of macro-cell, thus, lowering the corrosion rate. Research has been carried out on weld corrosion (Kato et al., 1978, Voruganti et al., 1991) from the view point of corrosion destruction, which may ensue on the parent metal (PM), HAZ or the welded zone (WZ). Thus, it is imperative to investigate the effect of corrosion on welds subjected to solution annealing.

2.7 Effect of Solution Annealing on Corrosion of Steel

Solution annealing heat treatment is designed to get the material into its optimum metallurgical condition by complete homogenization of the solid solution and thereby making the material to be in its most corrosion resistant condition (Iwuoha et al., 2012). Yanjun et al., (2014) reported that solution annealing has great effect on the corrosion and mechanical properties of steel. The effect of solution annealing on corrosion of different materials has been extensively researched.

(Rosemann et al., 2015; Tan et al., 2009; Shoushtari et al., 2013; Afolabi and Peleowo, 2011; Naghizadeh and Moayed, 2015; Xinglong et al., 2017; Anburaj et al., 2012; Iwuoha et al, 2012; Ihsan-ul-Haq, 2014; Yanjun et al, 2014; Martina et al, 2011; Khaled et al., 2016; Hidenori et al, 2011; Kciuk and Kurc-Lisiecka, 2012; Soon-Hyeok et al., 2013; and Lihua et al., (2009). To the best of my knowledge there is dearth of information or relevant literatures on the effect solution annealing would have on welded medium carbon steel in 1M NaCl environment. Most of these researchers observed that solution annealing resulted in decreased corrosion rate. They attributed this to the fact that solution annealing causes the homogenous dissolution of carbides, nonmetallic inclusion alongside with other secondary phases, adjust the alloying elements and normalizes the microstructure in the matrix of the steel. This helped to reduced carbides at the grain boundaries, as the carbides present at the grain boundaries were found to be more susceptible to anodic dissolution. Most of these researchers however worked on different steel materials in various environment with non on medium carbon steel in 1M NaCl. Anburaj et al., (2012) examined the effect of solution annealing on corrosion of superaustenitic stainless steel castings in acetic acid. They discovered that the pitting corrosion resistance increases with increased solution annealing temperature. Similar results were reported in Rosemann et al., (2015), they studied how solution annealing influence the corrosion resistance of X46Cr13 martensitic stainless steel material in 0.1M sulphuric acid. They found out that higher solution annealing temperature lead to increased amount of carbon and chromium that are dissolved in solid solution and thereby resulting in decreased corrosion rate due to easier passivation. Tan et al., (2009) examined the effect of solution annealing temperature on pitting corrosion behaviour of duplex super stainless steel. They observed from their investigation that solution annealing spontaneously passivated their samples hence resulting in an increase in the resistance of the samples to pitting corrosion. Ihsan-ul-Haq, (2014) conducted an examination to determine the effect of solution annealing and Mn content on corrosion of stainless steel alloys in 0.5M NaCl. Their findings showed that as manganese content in the steel

increases the corrosion rate decreases. They also reported that alloys that were solution annealed were found to have a stable greater corrosion resistance. This they attributed to the homogenized microstructure, the dissolution of detrimental inclusions in the alloy steels and to the suppressed activity of carbides at the interface of the metal/solution. Yanjun et al, (2014) investigated how solution annealing influence the mechanical and corrosion behaviour of duplex stainless steel in 1M NaCl. They established that the elongation of the material at break attained maximum of 52.7% after solution annealing. This they attributed to the influence of martensite transformation induced plasticity. They also reported that the ferrite phase was found to have lower pitting corrosion resistance when related to the austenite phase. With solution annealing they found that localized pitting attack at the ferrite phase dropped. Shoushtari et al., (2013) examined the influence of solution annealing on mechanical and corrosion properties of 304 austenitic stainless steel. They discovered that reduced carbide precipitate resulted in better corrosion resistance as well as mechanical properties. They also found out that homogeneous carbide distribution in the matrix of the steel remarkably lead to reduced carbide at the grain boundaries which ultimately resulted in an increase in corrosion resistance of the steel. This observation is in alignment with (Hamada et al., 2006; Ebrahimi et al., 2012). Similar results were reported in Afolabi and Peleowo, (2011), they examined the influence of solution annealing treatment on corrosion of austenitic stainless steel immersed in mild acid medium. They found out that solution annealing treatment increased the resistance of their samples to pitting corrosion as a result of the dissolution of carbides and secondary phases in the matrix of the steel which would have been precipitated at grain boundaries. Hidenori et al, (2011) studied the influence of solution annealing on localized corrosion of duplex stainless steel material immersed in 3.5% NaCl solution. They observed that the corrosion state that ensued was pitting corrosion and that the initiation of corrosion was at the ferrite/austenite grain boundary. They also reported that when solution annealed, the susceptibility of the material to pitting corrosion is improved. Kciuk and Kurc-Lisiecka (2012), examined the effect of solution

annealing treatment on the mechanical properties, corrosion resistance and structure of steel X10CrNi18-8 in 3.5% NaCl. They observed that the structure was that of austenite with a small quantity of slip bands with improved corrosion resistance and mechanical property. Martina et al, (2011) researched on the influence of solution annealing on corrosion of AISI 310 austenitic stainless steel weld joint in oxalic acid. The result of their findings revealed that solution annealed weld joint is not susceptible to corrosion. Iwuoha et al, (2012) worked on the effect of solution annealing on AISI 304 stainless steel weldment to pitting corrosion immersed in natural gas liquid. Their results showed that there were pitting attack on the as-welded and the solution annealed samples with the as-welded samples indicating deep and wide pits alongside with tuberculation on the whole weld surface. Naghizadeh and Moayed, (2015) studied the influence of solution annealing on critical pitting of duplex 2205 stainless steel in 3.5% NaCl solution. They observed from their research that the specimen solution annealed in simulated pit solution had maximum current density and in the existence of salt film, the density decreased. Xinglong et al. (2017) researched on the effect of solution annealing on super duplex SAF2906 stainless steel material to pitting corrosion in 3.5% NaCl solution. They found that the Cr_2N and σ phase decreased the resistance of the material to pitting corrosion and that the corrosion resistance of the steel was significantly influenced more by the σ phase compared with Cr_2N . The study of Soon-Hyeok et al., (2013) demonstrated the influence of solution annealing on precipitation of secondary phases and pitting corrosion resistance of hyper duplex stainless steels in chloride solution. They observed from their investigation that the formation of secondary phase was retarded due to decrease in the amount of preferential precipitation sites and also the activities of W, Mo and Cr. They also observed decreased rate of pitting corrosion with the solution annealed alloy. The decreased rate was attributed to the retardation of the sigma phase (secondary phase). The influence of solution annealing heat treatment on wear and corrosion behaviour of β -metastable titanium alloy in 3.5% NaCl solution was investigated by Khaled et al., (2016). The authors reported that the solution

annealed alloys recorded the highest corrosion resistance which was caused by the spontaneous passivation of the alloys. Lihua et al. (2009) examined the effect of solution annealing temperatures on lean duplex 2101 stainless steel material to corrosion susceptibility in 1M NaCl. They observed from their investigation that the solution annealed steel exhibited lower values of pitting corrosion potential (E_{pit}) when compared to the as-received.

2.8 Effect of Microstructural Evolution on Corrosion of Steel

The corrosion susceptibility of a material hinge on its microstructure (Marcuci et al., 2014). Kadowaki et al., (2020), reported that active martensite dissolution were suppressed by carbides by enhancing the stability of the impassive state of martensite. They also reported that martensite resistance to pitting corrosion is improved by carbides in the matrix of the steel. Also, Wilson et al., (2018) attributed the reduced corrosion rate to lower boundary corrosion as a result of bainite/martensite phase. The BCT structure of martensite were observed to offer the least Fe content and hence, decreased corrosion susceptibility as it becomes the cathode (Jinlong et al., 2016). Retained austenite had been observed to have lower corrosion susceptibility damage (Handoko et al., 2018). Similar observation was observed by Kimura et al., (2000), they reported that retained austenite were observed to have no harmful effect on corrosion resistance. They also reported that the dissolution of carbon in the austenite phase decreased carbide precipitation and as a result, increase the corrosion resistance of the steel. Jiang, et al., (2017) reported that the reduction of undissolved carbides was found to increase the corrosion resistance of steels. The microstructure of un-treated steel has been found to be predominantly ferrite and cementite. Igwemezie and Ovri (2013) found out that the ferrite acts as the anode while the cementite become the cathode. Also, Shin et al. (2007) and Du et al. (2009) had similar observation, they found out that corrosion susceptibility of steel increases as the cathode/anode area increases due to galvanic effect between the ferrite and cementite. Corrosion susceptibility were observed to increase with increased carbide precipitation at the grain boundaries (Kimura et al., (2000).

2.9 Corrosion Evaluation Techniques

There are several techniques used for the evaluation of corrosion and among these are the electrochemical and gravimetric techniques.

2.9.1 Electrochemical Measurement Techniques

Potentiodynamic polarization technique which is one of the many electrochemical measurement techniques have gained certain recognition and is based on electrochemical theories. It allows the determination of instantaneous corrosion reaction rates at the interface of the electrode/solution (Badea et al., 2010). This technique is widely used in the evaluation of general corrosion (Holland, 1991; Manning, 1980; Craig and McClymonds, 1981; Obuekwe et al., 1981). This method has been found to possess certain advantages which includes; 1) The technique is fast and stress-free to run, when set up making it inexpensive; 2) the measurements are made with adequate precision, accuracy and are reproducible; 3) several parameters such as passivity range, anodic/cathodic charge, rupture potential, open circuit potential (OCP), pitting corrosion can be obtained from the same run (Holland, 1991). Other electrochemical measurement methods for estimating corrosion parameters includes; Linear polarization resistance, electrochemical noise and electrochemical impedance spectroscopy.

2.9.1.1 Corrosion Evaluation from Linear Polarization Resistance and Tafel Slope

Tafel slopes extrapolation, corrosion potential and linear polarization resistance technique which is based on polarization measurements, enable the instantaneous determination of corrosion rates even from a single experiment (Badea et al., 2010). Linear polarization resistance measurement procedure is a conventional electrochemical method used for determining corrosion rate. It is regarded to be a fast, easy and non-destructive procedure because the measurement settings are close to the steady state and also the results are near to the truth. As a result of these, it is widely used to study rebar corrosion (Zou et al., 2011). Linear polarization resistance can be used to find the polarization resistance rapidly through small-range polarization; Conversely, it cannot be used

to estimate the corrosion rate directly except the Tafel constants are stated (Andrade and Alonso, 1996). Lucio-Garcia et al., (2009) reported from their investigation that decrease in the linear polarization resistance resulted in the increase in the corrosion rate. This they attributed to the dissolution of the passive film. They also observed from their investigation that low anodic potential (E_{corr}) obtained from tafel slope extrapolation corresponds to lower corrosion rates. These findings are in strong agreement with Hilbert and James, (1984), who reported that low anodic potential results in low corrosion rates and that high anodic potential result in an increase in the corrosion rate in chloride medium. This finding also strongly align with Fontana and Greene, (1974) and Scully (1975) who reported that low anodic potential favored corrosion rate reduction.

2.9.1.2 Corrosion Evaluation from Electrochemical Noise (EN)

Electrochemical noise can be defined as haphazard fluctuations of the potential or current detected in an electrochemical method (Emerson et al., 2014). It describes the small level spontaneous fluctuation of current and potential that ensues during the corrosion process. The fluctuations in current and potential are recognized as electrochemical current noise (ECN) and electrochemical potential noise (EPN) signals (Arellano-Perez et al., 2019). In corrosion research, it is recognized as a reasonably mature electrochemical technology (Bertocci and Huet, 1995; Mansfeld, 2005), since it has the distinctive in-situ, nondestructive detection and its easy to setup (Wu et al., 2019). Meanwhile the discovery by Iverson (1968) that a metal undergoing corrosion at E_{OCP} generates random ruptures of charges as a result of steady state fluctuations in potential and current at the interface of the metal/solution, has gained significant attention in recent years (Wharton et al., 2005; Samiento et al., 2011; Montesperelli et al., 2000; Cappeln et al., 2005). Electrochemical noise investigation is a remarkable technique that allows the determination of the occurrence of metal susceptibility to corrosion at E_{OCP} devoid of the need for external potential perturbation (Loto and Cottis, 1987). Electrochemical noise usually occurs in metallic electrode as a result of changes that takes place at the surface states, for instance, the failure and repair of a protective surface film

(Hashimoto et al., 1992; Shi et al., 2007; Cheng et al., 2000; Qiao and Ou, 2007; Dong et al., 2011). It offers valuable data about complex electrochemical reactions mostly in a non-stationary state. This fact allows the technique to be useful in the investigation of environment assisted flaws (Acuna-Gonzalez et al., 2008; Gomez-Duran and Macdonald, 2006; Edgemon et al., 1997), pitting corrosion (Kiwilszo and Smulko, 2009; Cao et al., 2006; Smulko et al., 2002), grain boundaries corrosion (Pujar et al., 2009), and general or uniform corrosion (Edgemon et al., 1997; Girija et al., 2005). The analysis of EN signals has been considered to provide useful data about the corrosion rate and its type (Estupinan-Lopez et al., 2011; Hei et al., 2017; Xia et al., 2019). Time-dependent statistical usage of the random ECN and EPN signals derived from the corrosion process can be used to evaluate the corrosion rate, for instance, the standards deviation of ECN is relational to corrosion rate (Da-Hai-Xia et al., 2019). Statistical methods can be utilized to analyze and evaluate the data obtained. These include standard deviation (Da-Hai-Xia et al., 2019) and Skewness (Mansfeld, 2005), while the corrosion mechanism can be forecaste based on the analysis of certain spectral fingerprint derived from the noise signals (Cottis, 2001; Skoog et al., 2007; Bell et al., 1998; Baroux and Gorse, 1994; Hladky and Dawson, 1981). Zheng et al., (2020) showed that ECN is an effective technique that is closely related to corrosion rate. Investigation by Obot et al., (2019) revealed that sudden peak amplitude of electrochemical current noise (ECN) signals depicts pitting corrosion. This finding is also in agreement with Loto (2012) who also observed that pitting corrosion was initiated by sharp fluctuation of current noise signals. Arellano-Perez et al., (2019) further revealed that pitting corrosion is considered to occur when isolated signals or events of high peak spike amplitude occur. Loto (2018) discovered that there was a steady state fluctuation with the electrochemical noise signals. This observation was attributed to the regular and synchronized depassivation and repassivation of the brownish iron-oxide film formed on the surfaces of the sample. The study by Arellano-Perez et al., (2019) showed that uniform corrosion is considered to occur when the instantaneous fluctuation signals are uniform and continuous.

Higher standard deviation indicates higher amplitude of ECN signals and higher corrosion rate (Pistorius, 1997 and Shahidi et al., 2012).

2.9.1.3 Corrosion Evaluation from Electrochemical Impedance Spectroscopy (EIS)

Electrochemical impedance spectroscopy is a frequency domain procedure used for applying a sinusoidal perturbation in a system. Is also a technique commonly utilized for investigating corrosion of alloy and metal in an environment system. When a minute alternating current (AC) potential is supplied to the system at different number frequency, the subsequent current is measured, the impedance linked to these elements are gotten from an expression related to Ohm's law (Ribeiro and Abrantes, 2016). EIS is essentially the ability of a circuit element in a system to resist the movement of electrical current (Duo et al., 2019). EIS is viewed as a powerful non-destructive technique for characterizing a wide range of electrochemical system, in situ analysis of the phenomena that ensue at the interface of a solid/liquid and for determining the influence of electrolytic processes in the system (Gao et al., 2009). It can be utilized to examine the dynamics of mobile charges on the measurements of interface regions of steel in interaction with molten salt (Encinas-Sanchez et al., 2019; Sarvghad et al., 2018; Zeng et al., 2001; Montemor et al., 2003). It can also be used to observe surface changes in the electrodes as a function of time. Electrochemical dissolution reaction ensues on the electrode surface (anode and cathode). Results are commonly stated as a Nyquist plot of imaginary components versus real components of impedance semicircle capacitive arc (Farzad et al., 2011; Freire et al., 2011). Information obtained from electrochemical impedance spectroscopy measurement of a corroding metal, showed that dissolution reaction is closely associated with semicircle capacitive arc and also the diameter of each of the semicircle capacitive arc has a direct relationship with charge transfer resistance at the interface of the metal/solution (Ihsan-ul-Haq, 2014; Pardo et al., 2008; Lucio-Garcia et al., 2009; and Gao et al., 2009).

2.9.2 Corrosion Evaluation from Gravimetric Measurement

The gravimetric corrosion measurement also known as the weight loss or coupon test measurement is the oldest most commonly utilized non-electrochemical technique (Prosek et al., 2014; Kouril et al., 2013). As a traditional method, the gravimetric test measurement is deemed the “gold standard” of corrosion measurement and is indeed the simplest way to calculate metallic corrosion (Shuang-yu et al., 2017; Sodile, 2002; Adebisi et al 2003). This technique can be effectively used to provide accurate prediction of corrosion rate for uniform/general corrosion (Shuang-yu et al., 2017). However, the pitfall of the gravimetric test method are: it is time consuming, it only offers average corrosion rate over the period of exposure time, cannot be utilized to obtain real-time data of the corrosion process, early corrosion stage of corrosion kinetics are not achieved and has limited sensitivity (Da-Hai-Xia et al., 2019; Wang et al., 2019). The technique involves intermittent weight loss measurement of the coupon over the period of exposure time. On immersion of the coupon, there is an initial increase in corrosion rate within the first period of immersion and it continues till a passive film is formed due to initial anodic dissolution at the interface of the metal/solution (Loto et al., 1988). The driving force of film formation (surface oxide) on steel is the free energy of the reaction that occurs between the metal and the investigated environment (Brandi, 2003). The protective film barrier that is formed on the steel surface have been observed to decrease the corrosion rate (David and Denise, 2005; Awheme et al., 2018). However, chloride ion has been found to have higher tendency of destroying the iron oxide protecting film formed on the interface of the metal/solution and exposes fresh samples surface to the chloride environment (Uhlig, 2000; Silverman 2003 and Ikpeseni 2008, 2012).

2.10. Gap in the Related Literature Reviewed

The observation from the related literature reviewed revealed that several researches have been made to investigate the effect of temperature and holding time on solution annealing of steels. Most of these researchers focused mainly on different kind of stainless steels with the view of obtaining their optimum temperature and holding time. To the best of my knowledge, none from literature is yet to study solution annealing on welded medium 0.36%C steel with the view of determining the optimum temperature and holding time. Therefore, it is imperative to investigate for the optimum solution annealing temperature and holding time on welded medium carbon steel.

The effect of solution annealing on different materials on corrosion have been extensively researched. Most of these researchers however worked on different steel materials in various environment with none on medium carbon steel in 1.0M NaCl. To the best of my knowledge, none from literature has investigated the effect solution annealing would have on welded medium 0.36%C steel in 1.0M NaCl environment. It is therefore, appropriate for a holistic investigation of the effect of solution annealing on the corrosion resistance of welded medium carbon steel in chloride environment.

CHAPTER THREE

METHODOLOGY

3.1 Materials

Steel used in the research work is 16 mm diameter rod. The 0.36%C steel was procured from Universal Steel Company, Lagos. Spark spectrometer metal analyser (NCS labspark 750B) was used to determine the chemical composition of the steel at the quality control laboratory of universal steel company. The result obtained from the analysis is shown in Table 3.1

Table 3.1: Chemical Composition of the Investigated Steel

Elements	C	Si	Mn	P	S	Cr	Ni	Cu
Weight (%)	0.366	0.278	0.869	0.046	0.057	0.134	0.101	0.233
Elements	Nb	Al	B	W	Mo	V	Ti	Fe
Weight (%)	0.007	0.006	0.003	0.025	0.005	<0.0001	<0.0001	97.87

3.2 Preparation of Samples

The 0.36%C steel was used in as received condition. The samples were machined into cylindrical pieces of 12 mm diameter and 40 mm long for un-welded samples of 72 pieces and 60 mm long for welding samples of 72 pieces. The welding samples were cut into two equal halves using power hacksaw. The ends were ground into V-shape with 30° bevel angle in preparation for butt welding in accordance with the specification by American Welding Society (AWS, 1976). This welding geometry was selected based on the submission of Agarwal (1992) that suitable welding penetration could easily be attained using butt sample preparation. The joint design and welding sequences are shown in Figure 3.1 and Figures 3.2.

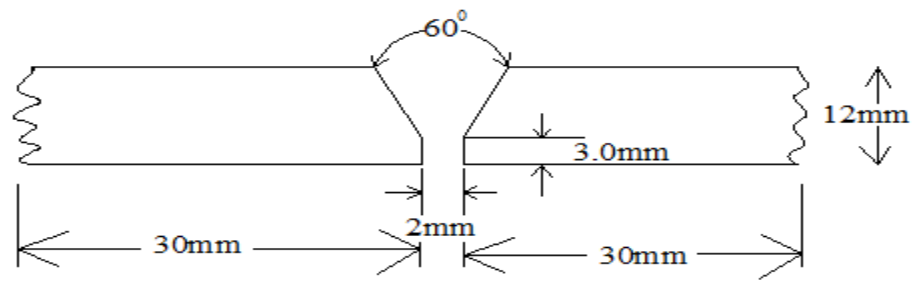


Figure 3.1: Joint Design

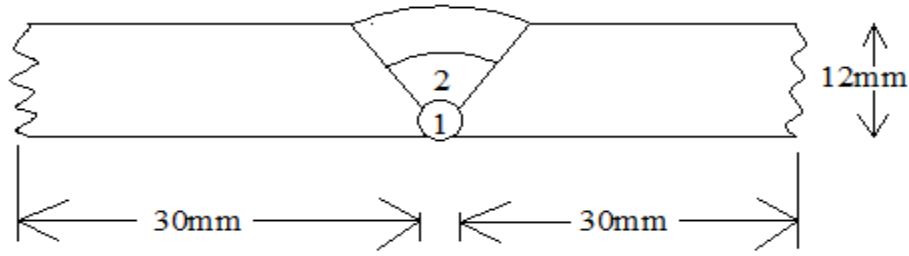


Figure 3.2: Welding Sequence

3.3 Welding Procedure

The welding of all the samples was carried out at the Department of Welding Engineering and Offshore Technology, Petroleum Training Institute, Effurun. The samples were placed on welding table and in order to avoid the undesired spin to the minimal, the proper size of stiffeners was provided at critical position where the welding process was done. The edges of these samples were firmly clamped together with a root gap of 2mm between them as required Dodo et al., (2016). The samples were welded together in pairs manually. The pieces of the medium carbon steel were butt welded. During welding, the electrode was made to run through the butt until the penetration and development of the weld pool was attained to the thickness level of the rod. Thereafter an iron brush was used to take out the covering slag and welded samples were allowed to cool in air. The welding procedure and specification is presented in Table 3.2. Shielded metal arc welding (SMAW) technique was adopted (Mohammed et al., 2013; Alay Shah et al., 2015; Singh et al., 2012; Rajeev, 2014; Dhananjay and Dharamir.,2015). The welding was carried out to a material specification of ASTM-A36. Other welding parameters are outlined in Table 3.2.

Table 3.2: Welding Parameters

Materials Specification	ASTM-A36
Welding process	Shielded Metal Arc Welding (SMAW)
Manual or Machine	Manual
Position of welding	1G
Filler metal specification	E7018
Filler metal classification	Fleet and low hydrogen
Flux	Basic/Fe ₂ O ₃
Weld metal grate	Medium steel
Single or multiple pass	Multiple
Welding current	(50 – 120) Ampere
Polarity	(21 – 37) V
Welding progression	Downhill
Root treatment	N/A
Preheat treatment	N/A

The welded samples, welding machine and the electrode used are presented in Figures 3.3 - 3.5.

**Figure 3.3:** Welding Results of some Selected Welded Samples



Figure 3.4: Welding Machine



Figure 3.5: Welding Electrode

3.4 Post Weld Heat Treatment

All of the welded samples were subjected to stress relieving heat treatment to remove internal stresses induced during welding (Seidu and Kutelu, 2013; Adedayo et al., 2010). Samples were thereafter subjected to solution annealing heat treatment (SAHT). Solution annealing comprises of heating the steel up to the austenitic temperature and soaking it long enough for the carbon to go into solution and thereafter fast cooled to prevent the carbon/carbide from coming out of solution (Gigovic-Gekic et al, 2011; Totten, 2006; Iwuoha et al, 2012). The choice of solution annealing heat treatment was based on thermodynamic thoughts linking temperature and the resultant microstructure. Solution annealing heat treatment imparts a stable carbon constituent in solid solution and as a result makes the steel to be in the most corrosion resistant state (Iwuoha et al., 2012; Rosemann et al., 2015). The identification code associated with each of the samples are presented in Table 3.3

Table 3.3 Sample Identification

Sample	Sample Description
CPM	Control parent metal
CHAZ	Control heat affected zone
CWZ	Control welded zone
SAPM	Solution annealed parent metal
SAHAZ	Solution annealed heat affected zone
SAWZ	Solution annealed welded zone



Figure 3.6: Muffle Furnace

3.4.1: Solution Annealing Heat Treatment Stage 1

Some samples were subjected to SAHT with varied holding time and temperature in order to determine the optimum solution annealing holding time. The number of samples subjected to this treatment in this investigation is presented in Table 3.4.

Table 3.4: Chart Showing Solution Annealing Heat Treatment with Varied Holding Time

Holding Time (Hrs)	860 °C		920 °C		1000 °C		Control Samples	
	Welded Samples	Un- welded Samples	Welded Samples	Un- welded Samples	Welded Samples	Un- welded Samples	Welded Samples	Un- welded Samples
1	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2		
2	2	2	2	2	2	2		
2½	2	2	2	2	2	2		
3	2	2	2	2	2	2		
3½	2	2	2	2	2	2		

3.4.2: Solution Annealing Heat Treatment Stage 2

Some samples were subjected to SAHT at a holding time of 2 hrs which was obtained from the investigation carried out from stage 1 with varied temperatures in order to determine the optimum solution annealing temperature. The number of samples subjected to this treatment in this investigation is presented in Table 3.5.

Table 3.5: Chart Showing Solution Annealing Heat Treatment with Varied Temperature

Soaking Time	840 °C		890 °C		940 °C		990 °C	
	Welded Samples	Un-welded Samples	Welded Samples	Un-welded Samples	Welded Samples	Un-welded Samples	Welded Samples	Un-welded Samples
2 hrs	2	2	2	2	2	2	2	2
	1040 °C		1090 °C		Control Samples			
	Welded Samples	Un-welded Samples	Welded Samples	Un-welded Samples	Welded Samples	Un-welded Samples		
	2	2	2	2	2	2		

3.4.3: Solution Annealing Heat Treatment Stage 3

Some samples were placed inside the Muffle Furnace (Electric furnace) and subjected to solution annealing heat treatment by heating to austenitic temperature of 990 °C and held for 2 hrs for homogenization after which the samples were immediately cooled in water in order to prevent the presence of any precipitate or intermediate phase in the microstructure (Rosemann et al., 2015; Yi et al., 2017; Lima Filho et al., 2017; Elki et al., 2017; Campbell, 2008; Anburaj et al., 2012). The number of samples subjected to this treatment in this investigation in line with literature is presented in Table 3.6.

Table 3.6: Chart showing Solution Annealing Heat Treatment at Optimum Temperature and Holding Time

SAHT (990 °C, 2hrs)		Control Samples	
Un-welded Samples	Welded Samples	Un-welded Samples	Welded Samples
10	10	10	10

3.5: Optical Microstructural Evaluation

Some of the samples after heat treatment were prepared according to standard procedures (Georgios et al., 2016), and metallographically evaluated to study their resulting microstructures. The grinding of samples was carried out with various emery papers ranging from (150 – 2500 grits) of successively finer grades lubricated by a gentle flow of water. Polishing was carried out on a rotating wheel covered with short-pile cloth impregnated with 1 μ m diamond polish and OPS (Oxide Polishing Suspensions) solution in order to remove scratches and to produce a smooth and mirror like surface in order to observe the surface morphology. Etching which helps to reveal grain boundaries and microstructure of the samples was done with 2% Nital solution (Dodo et al., 2016). Optical metallurgical microscope fitted with a photographic device and a computer fixture were then used to study the surfaces of the specimens. Magnifications of X1000 was used to evaluate the microstructure. The metallographic examination of the solution annealing heat treatment stage 1, 2 and 3 were carried out at the metallography laboratory of the Department of Welding Engineering and Offshore Technology, Petroleum Training Institute, Effurun. The results from SAHT stage 1 are presented in plate 4.1a-4.1u and Appendix A1 and A2, stage 2 are presented in plate 4.2a-4.2r, while the results from SAHT stage 3 are presented in Plate 4.3a-4.3f.

3.6 SEM-EDS Evaluation

Scanning electron microscope fitted with a digital camera and a computer was used to evaluate the Energy Dispersive X-ray spectrometry (EDX) for the solution annealed and the control samples. The EDX examination of the solution annealing heat treatment of stage 3 was carried out at the Experimental Materials Mechanics laboratory, Helmholtz Zentrum Geesthacht, Germany. The EDX result is presented in Figure 4.1a.-4.1b and Appendix B.

3.7: Hardness Testing

In order to examine the effect of solution annealing heat treatment temperature and holding time on the mechanical properties of the steel, the hardness test was carried out according to standard ASTM A384/89 (1990), BAS EN ISO 6 507-1/ 2007 and EN ISO 6 508-1/ 2007 BAS (Gigovic-Gekic et al., 2011; Elki et al., 2017). The samples were prepared to give it a flat, smooth and polished to mirror like surface. The hardness measurement was performed using Vickers Microhardness Testing Machine with microhardness scale of HV 0.02, a test force from a diamond pyramid of 0.1961N and with a dwell time of 10 (ten) seconds. The indentation was taken over the entire sample surface which cut across the Parent Material (PM), Heat Affected Zone (HAZ) and the Welded Zone (WZ). The indentation image is presented in Figure 3.8. A camera was swung over the square impression produced by the diamond pyramid, the diagonals were measured between knife edges, and the reading taken with the aid of a digital counter. The hardness values are obtained from the hardness testing machine which is equipped with electronic sensor that permits the direct readout digitally from the machine. The microhardness testing was carried out at the Experimental Materials Mechanics laboratory, Helmholtz Zentrum Geesthacht, Germany. The results from the hardness test are presented in Figure 4.2a – 4.2j and Appendix B.

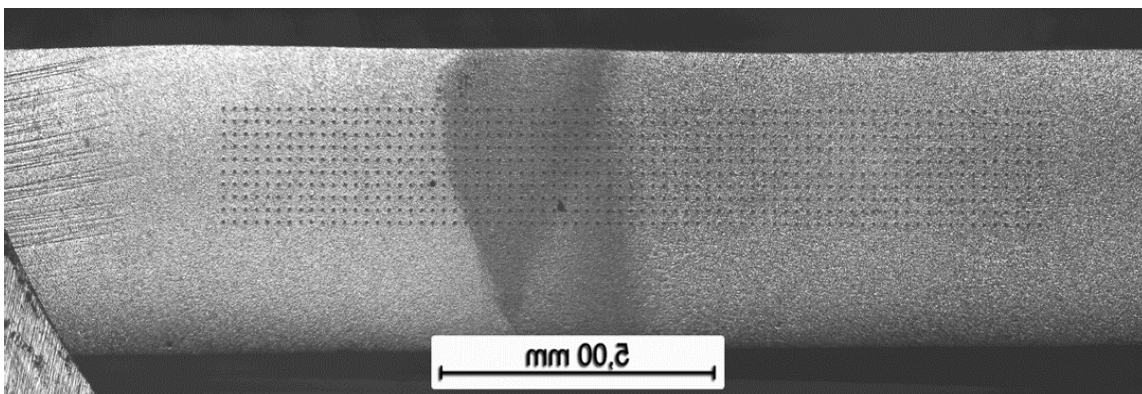


Figure 3.7: Indentation Image of the hardness sample

3.8: Environment Preparation

The corrosion environment was prepared by weighing 58.44g of sodium chloride salt dissolved in 1000ml of deionized or distilled water and stored in a 20 litre gallon and labeled. The environment was prepared at the Chemistry Department laboratory of the University of Benin.

3.9: Corrosion Characterizations

3.9.1 Electrochemical Corrosion Measurement Evaluation

The electrochemical corrosion susceptibility of the examined steel was investigated using potentiodynamic methods. A potentiostat/galvanostat (VoltaLab) with VersaSTAT 4 software for data gathering and to analyze the corrosion were used for the electrochemical measurements after the tool was properly calibrated. The measurements were done with three-electrode cell where a platinum electrode acted as the counter electrode and the reference electrode is a saturated (Ag/AgCl) calomel electrode (SCE). The samples acting as the working electrodes were properly sealed in epoxy resin. For each of the experiment, the samples (working electrode) was wet ground and polished with a 1.5 μm diamond paste, properly washed in 95.6% ethanol and distilled water and air dried. Silica gel sealant were used to seal the interfaces between the samples and the resin in order to prevent crevice corrosion, and air dried. The exposed surface area of the working electrode was 1 cm^2 . Polarization investigation were done at a scan rate of 0.5 mV/s in 1.0M NaCl solution (electrolyte) at room temperature ($26 \pm 1^\circ\text{C}$). All the corrosion susceptibility was examined after 1 hr of immersion. The corrosion susceptibility was examined by open circuit potential (OCP) monitoring for 1 hr. The corrosion software was used to evaluate the Tafel area so as to be able to obtain important corrosion parameters. Linear polarization examination was done in 1.0M NaCl solution at ± 20 mV from corrosion potential E_{corr} . The electrochemical impedance spectroscopy (EIS) evaluation was done at open circuit potential (OCP), by the application of sinusoidal perturbation of 10 mV with a frequency variation from 100 kHz to 0.01 Hz. The impedance data was evaluated and fitted to suitable equivalent electrical circuit using the

software. The electrochemical noise (EN) measurement was done under OCP and result evaluated by the software. All of these measurements is in accordance with (Hidenori et al., 2011; Kciuk and Kurc-Lisiecka., 2012; Ihsan-ul-Haq, 2014; Yanjun et al., 2014; Rosemann et al., 2015; Elki et al., 2017). The electrochemical measurement was carried out at the corrosion laboratory of the Metallurgical and Materials Engineering Department, Federal University of Technology, Akure (FUTA).

3.9.1.1 Statistical Analysis of Electrochemical Noise

The statistical analysis of electrochemical noise (EN) corrosion measurement technique has been regarded as suitable for giving information about the nature and rate of the corrosion processes taking place in the specimen. Having obtained the electrochemical noise records, many statistical methods can be utilized to analyze and evaluate the data obtained. Standard deviation and Skewness were adopted for this study because of its simplicity.

i. Standard Deviation (σ). This helps us to determine the rate and the type of corrosion (general, pitting and crevice) taking place in the specimen (Da-Hai-Xia et al., 2019).

$$\sigma = \left(\frac{\sum (x - \bar{x})^2}{n-1} \right)^{1/2} \quad (3.1)$$

ii. Skewness (Skew). This is a statistical third-order, and is used to determine unidirectionality of the signals (Mansfeld, 2005).

$$Skew = \frac{\sum_{k=1}^N (x[k] - \bar{x})^3}{(N-1) \overline{(x[k]^2)}^{3/2}} \quad (3.2)$$

3.9.2: Determination of Corrosion Penetration Rate from Gravimetric Measurement

According to Sodile (2002) and Adebisi et al (2003) who reported that among the commonly used corrosion evaluation techniques, weight loss measurement was preferred due to its simplicity. The technique involves intermittent weight loss measurement. The samples which were sectioned into parent metal (PM), heat affected zone (HAZ) and welded zone (WZ) were weighed before immersion in the environment. On each day of monitoring, samples were taken from the environments with the help of a tong thereafter the samples were appropriately washed in distilled water, rinsed in acetone and then dried. The dried corrosion samples were weighed with a digital chemical weighing balance and the value recorded. This took place at regular intervals of twenty (20) days. Data obtained are presented in Tables 4.7a -4.7c.

The corrosion rate was determined using equation 3.3 ((Fontana, 1986; Oloruntoba, 2002; Ogunleye et al., 2011 and Awheme, et al., 2018):

$$CPR = \frac{W}{Ax(\frac{T}{365})} \quad (\text{mg/cm}^2/\text{yr}) \quad (3.3)$$

Where, $W = W_0 - W_f$

W = Weight loss (mg)

W_0 = Initial weight

W_f = Final weight of each day of monitoring

$T/365$ = Exposure time in days extrapolated to a year

A = total surface area (cm^2)

$A = 2\pi r(r+L)$ due to the cylindrical shape of the samples

Where: r = Radius of samples (cm)

L = Length of samples (cm)

The gravimetric measurement was carried out at the Metallurgy Laboratory of the Department of Mechanical Engineering, University of Benin.

3.9.3: Determination of Corrosion Penetration Rate from Specific Metal Loss (S.M.L)

Specific metal loss denotes a ratio of the weight loss (W) to the total surface area (A) of the sample which is in accordance with ASTM G31 standard practice. The specific metal loss (mg/day) for the various samples was determined as a ratio of weight loss to time of exposure (t) as presented in Equation 3.4:

$$S.M.L = \frac{W}{A} \quad (3.4)$$

Where W = Weight loss in (mg)

A = Area of sample exposed to corrosion (cm²)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Microscopic Examination Results

The microscopic examination results are as listed.

4.1.1 Micrograph of Solution Annealing Heat Treatment Stage 1

The photomicrographs of the solution annealed 0.36%C steel with varied holding time are shown in Plates 4.1a – 4.1u respectively.

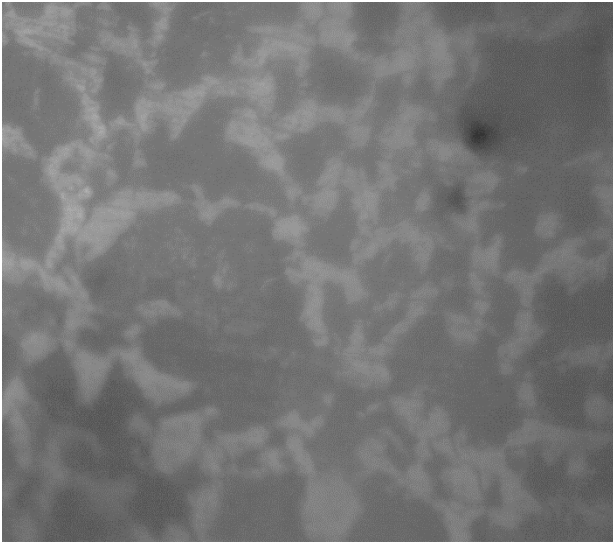


Plate 4.1a: Optical Micrograph of the Control Un-Welded Zone of 0.36%C Steel at X1000. The structure shows carbide (dark) uniformly dispersed in the matrix of ferrite (light).

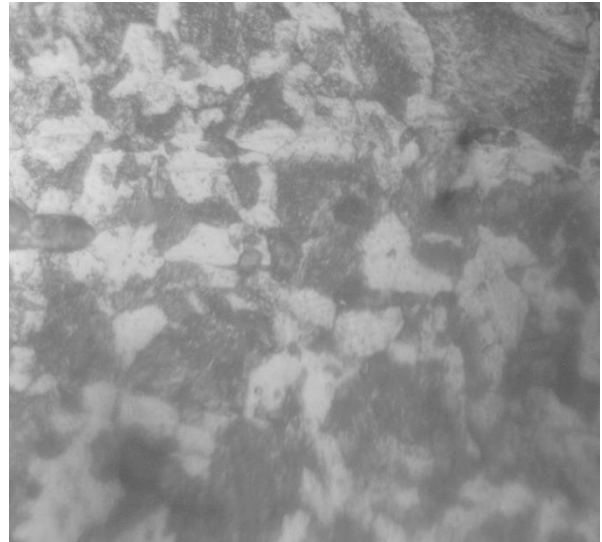


Plate 4.1b: Optical Micrograph of the Control Heat Affected Zone (HAZ) of 0.36%C Steel at X1000. Structure shows more coarse carbide in the ferrite matrix.

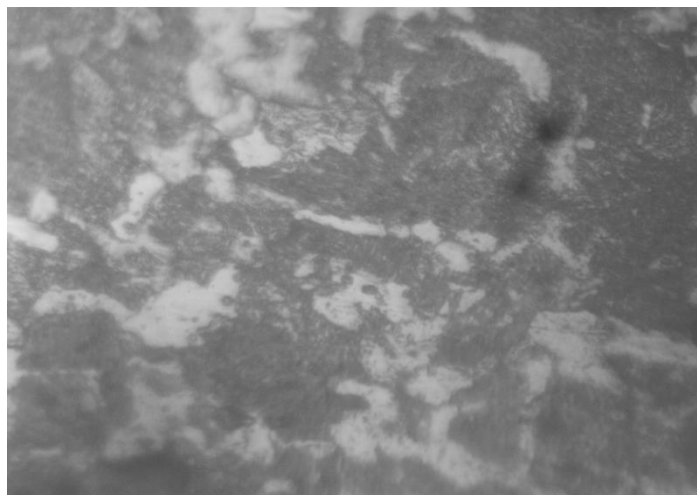


Plate 4.1c: Optical Micrograph of the Control Welded Zone of 0.36%C Steel at X1000. The structure shows coarser carbide dispersion in the ferrite matrix.

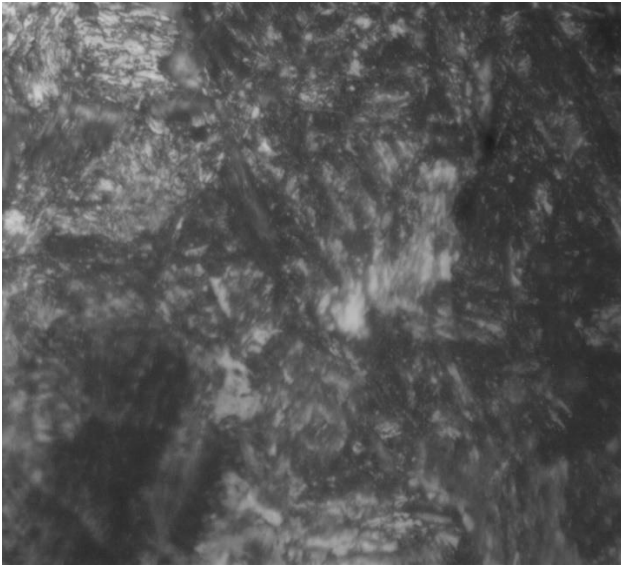


Plate 4.1d: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 860 °C for 1hr at X1000. Structure shows martensite lath with traces of retained austenite appearing white.

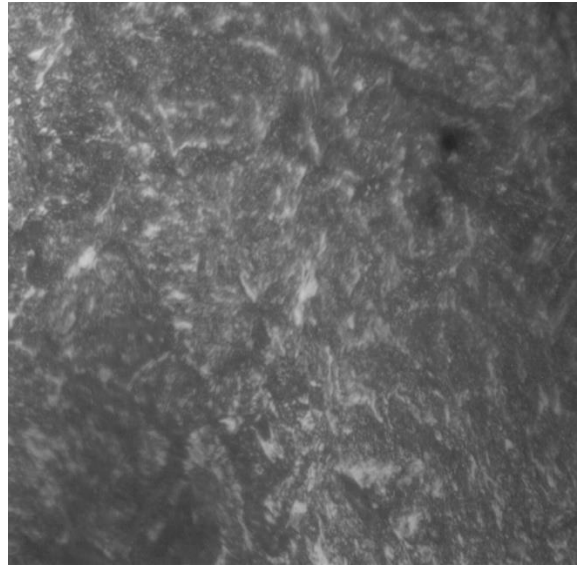


Plate 4.1e: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 860 °C for 1hr at X1000. Structure shows martensite with little traces of retained austenite appearing white.

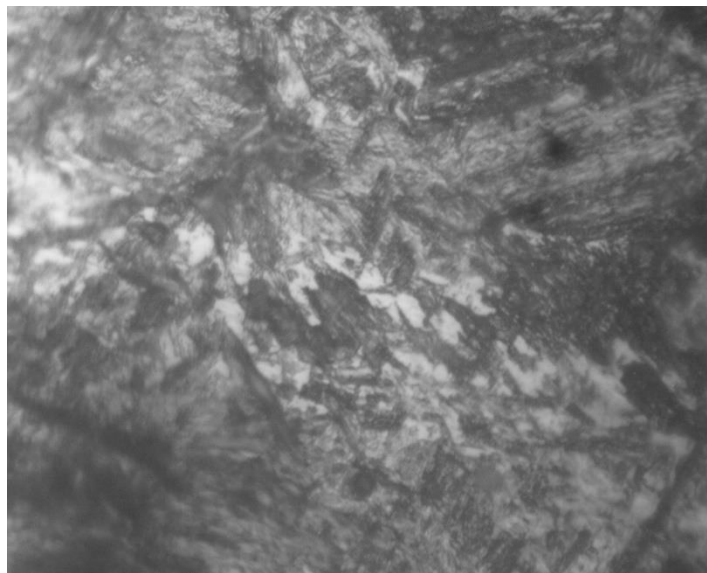


Plate 4.1f: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 1hr at X1000. The structure shows uniformly dispersed ferrite, martensite with large traces of retained austenite appearing white.

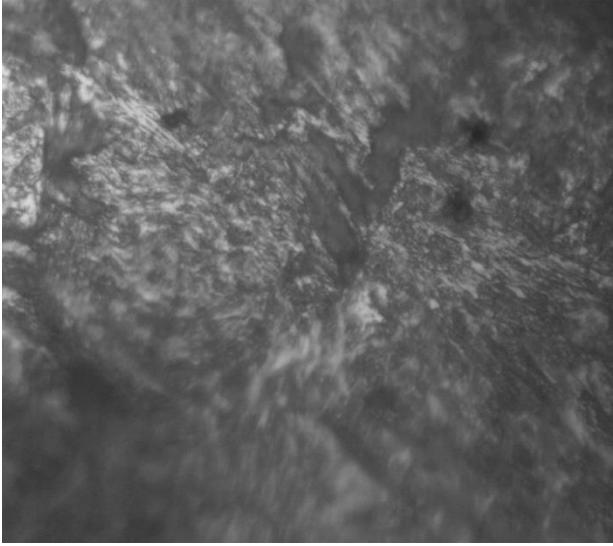


Plate 4.1g: Optical Micrograph of the Parent Material of 0.36%C Steel annealed at 860 °C for 1hr 30min at X1000. Structure shows block martensite lath with little traces of retained austenite appearing white in martensite grains.

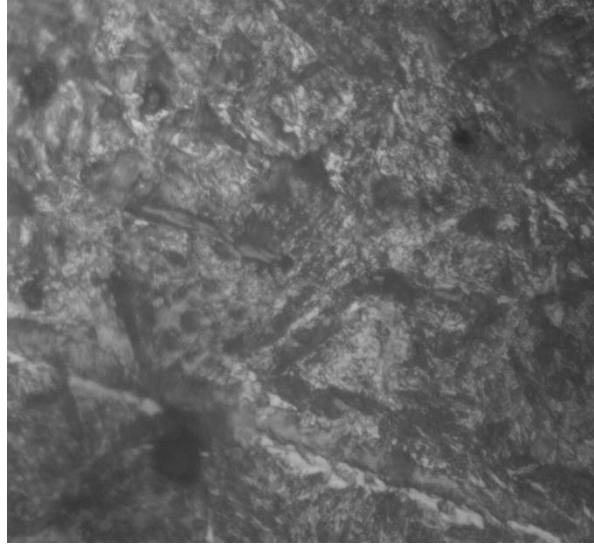


Plate 4.1h: Optical Micrograph of the Heat Affected Zone (HAZ) of the 0.36%C Steel annealed at 860 °C for 1hr 30min at X1000. Structure shows martensite lath with more traces of austenite appearing white in martensite grains.

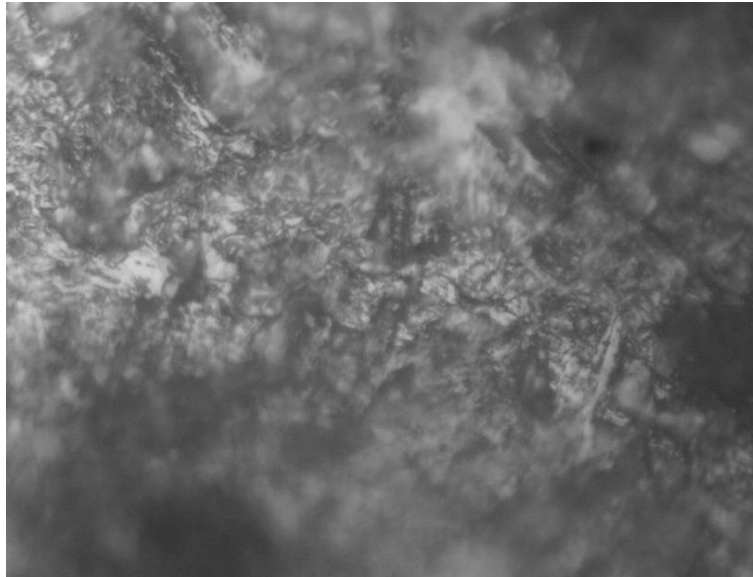


Plate 4.1i: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 1hr 30min at X1000. Structure shows uniformly dispersed ferrite, martensite and little retained austenite grains.

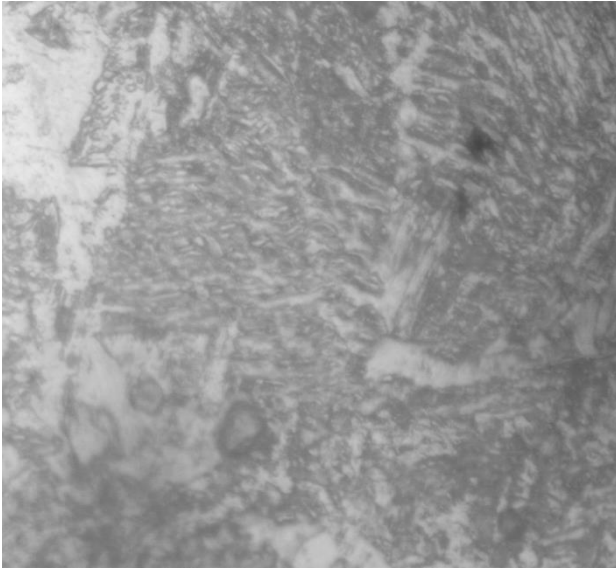


Plate 4.1j: Optical Micrograph of the Parent Metal of 0.36%C Steel solution annealed at 860 °C for 2hr at X1000. Structure shows martensite lath with little traces of retained austenite grains appearing as white.

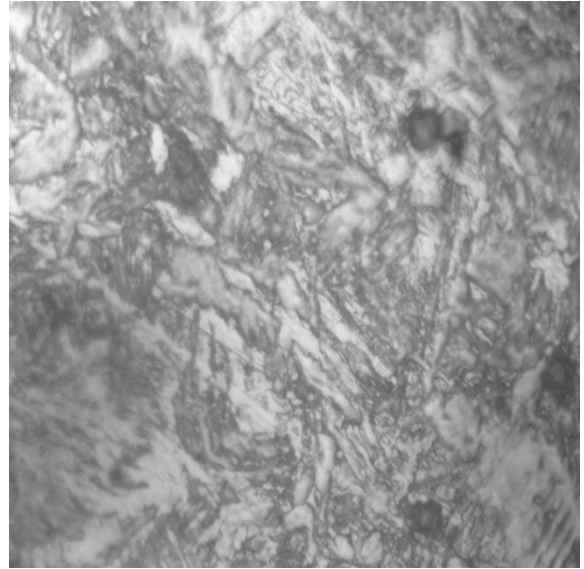


Plate 4.1k: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel solution annealed at 860 °C for 2hr at X1000. Structure shows martensite lath with more traces of retained austenite appearing white.

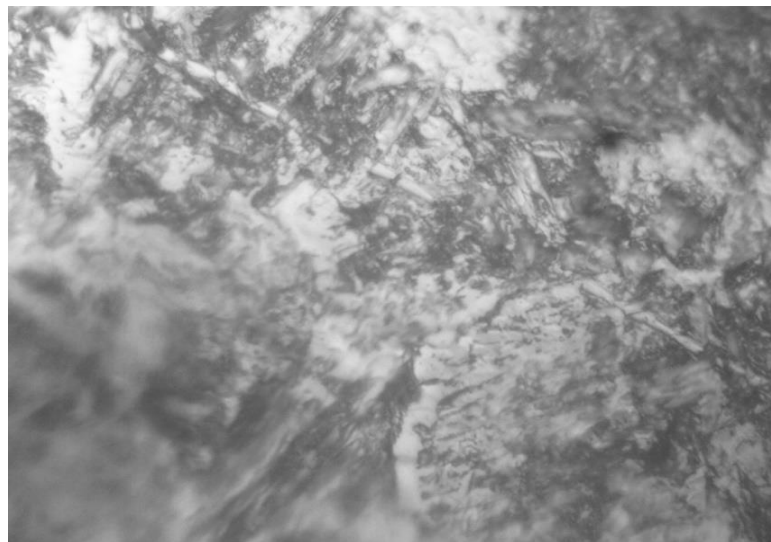


Plate 4.1l: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 2hr at X1000. Structure Shows martensite lath with coarse retained austenite grains.



Plate 4.1m: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 860 °C for 2hr 30min at X1000. Structure shows packet and block martensite lath with very little patches of retained austenite grains.

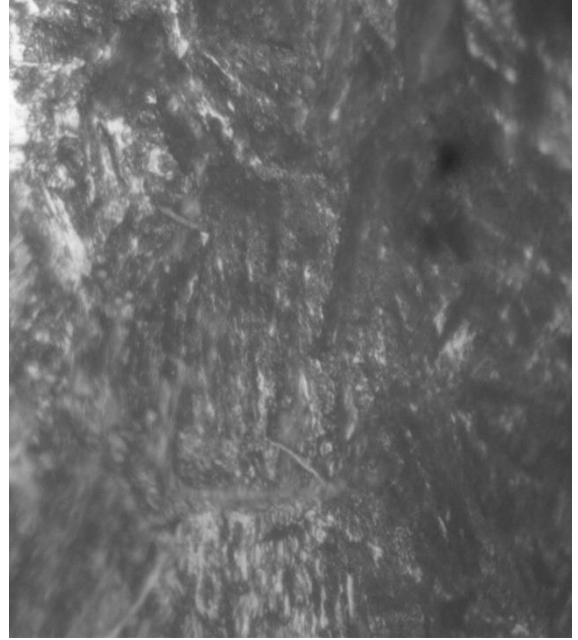


Plate 4.1n: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 860 °C for 2hr 30min at X1000. Structure shows more block martensite lath with few dispersed retained austenite.

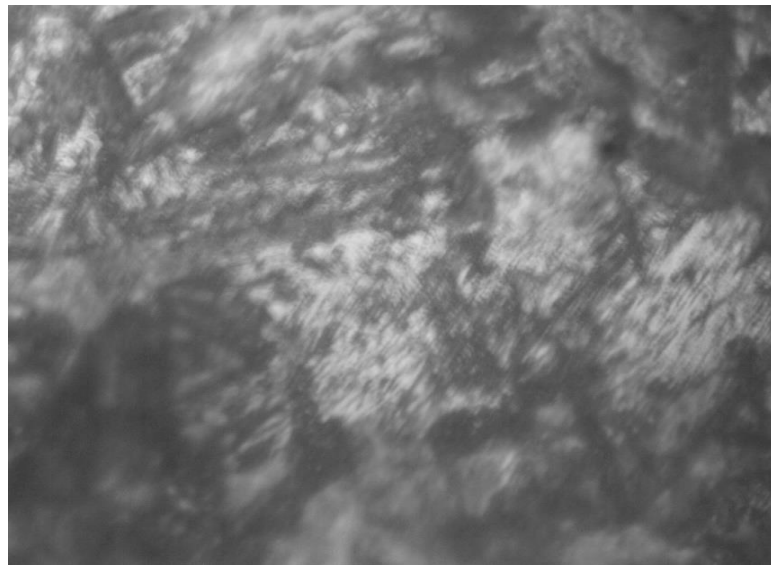


Plate 4.1o: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 2hr 30min at X1000. Structure shows distribution of martensite with some retained austenite.

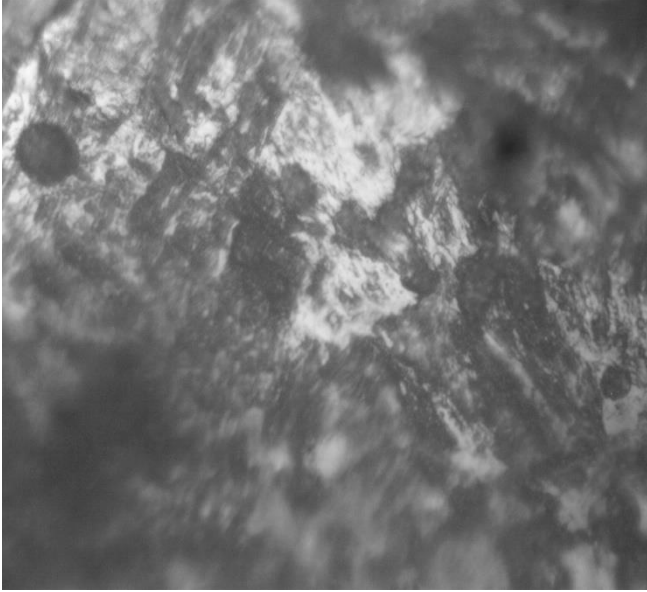


Plate 4.1p: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 860 °C for 3hr at X1000. Structure shows distribution of retained austenite with predominant martensite lath

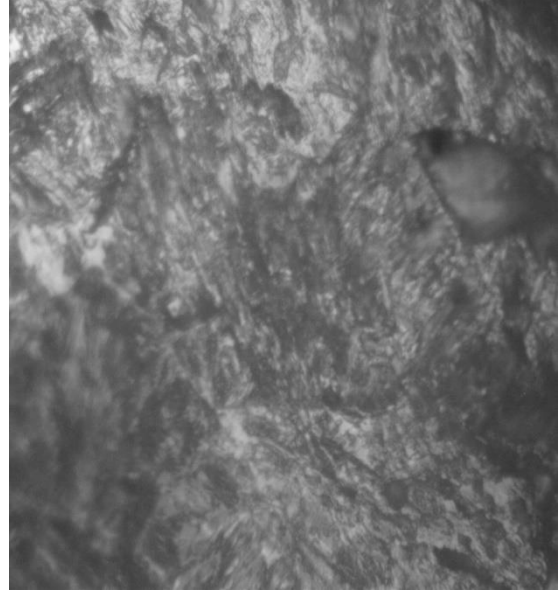


Plate 4.1q: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 860 °C for 3hr at X1000. Structure shows uniform distribution of retained austenite and martensite lath.

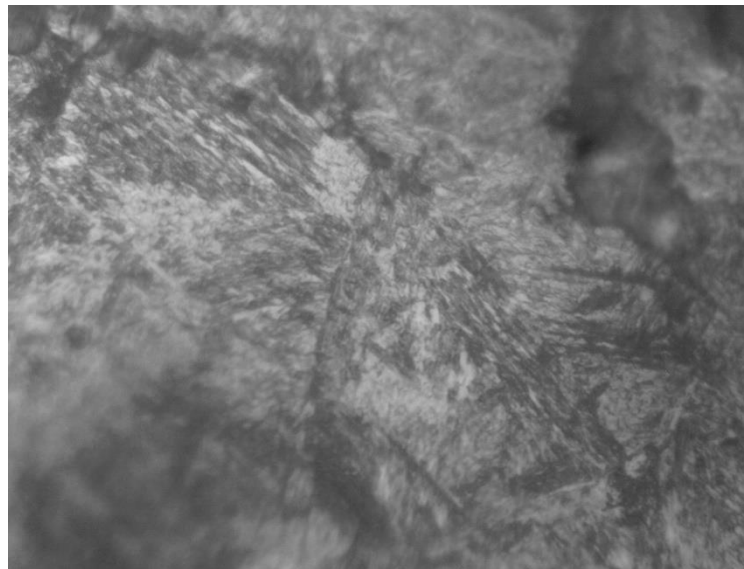


Plate 4.1r: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 3hr at X1000. Structure Shows retained austenite with more martensite grains.

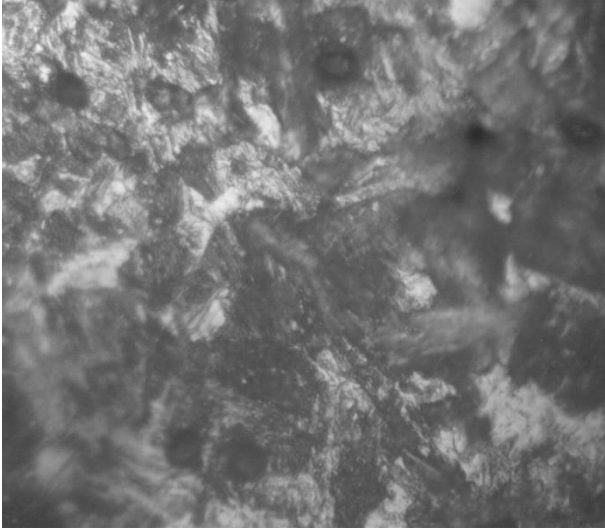


Plate 4.1s: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 860 °C for 3hr 30min at X1000. Structure shows predominant martensite lath with little patches of retained austenite.

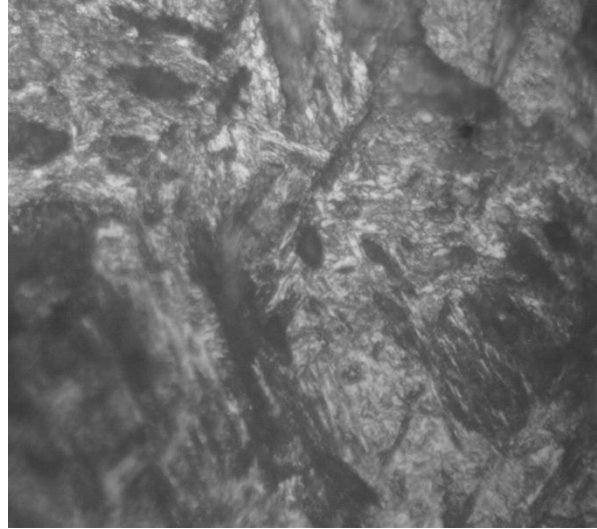


Plate 4.1t: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 860 °C for 3hr 30min at X1000. Structure shows distribution of block martensite lath with little traces of retained austenite.



Plate 4.1u: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 860 °C for 3hr 30min at X1000. Structure shows packet and block of martensite lath with traces of retained austenite.

The solution annealing holding time used in this research gave different microstructure as seen in Plate 4.1a – 4.1u. The micrographs of the control samples examined at the un-welded zone, heat affected zone (HAZ), and welded zone are presented in Plate 4.1a – 4.1c. It was observed that the welded zone structure shows coarser carbide dispersion in the ferrite matrix and this is followed by the heat affected zone (HAZ), with the un-welded zone revealing the least coarse carbide in the matrix of ferrite. This can be attributed to the different rate of cooling across the welded material and the loss of quenching elements from the welded zone. The welded zone takes a longer time to solidify thereby promoting grain growth to give a coarser carbide in the ferrite matrix compared to the HAZ and the parent metal as observed in this research. This finding is in agreement with (Blondeau, 2008; Lippold, 2015). Plate 4.1d – 4.1u are the microstructure photographs of the solution annealed heat treated samples at different holding time examined at the parent material (PM), heat affected zone (HAZ) and welded zone (WZ). Martensite with traces of retained austenite were formed as a result of the rapid cooling from the austenite temperature of 860 °C. The photomicrographs displayed numerous martensite structure after holding for 1hr, 1hr 30min, 2hr, 2hr 30min, 3hr and 3hr 30min. This could be attributed to the increased austenite nucleation at higher temperature, hence the structure became very enriched with more martensite on quenching (Ikpeseni et al., 2015). Zhuang et al., (2015) stated that it is likely that the equilibrium/optimum austenite fraction would be attained for reasonable holding time, irrespective of the heat treatment temperature. Though they did not give the exact holding time, their observation helped us to arrive at a holding time of 2hr and this could possibly be attributed to the presence of a carbon enriched retained austenite in the structure. This trend was also seen for samples heat treated at 920 °C and 1000 °C respectively and the result can be seen in appendices A₁ and A₂.

4.1.2: Micrograph of Solution Annealing Heat Treatment Stage 2

The photomicrographs of the solution annealed 0.36%C steel with varied solution annealing temperature are shown in Plate 4.2a – 4.2r respectively.

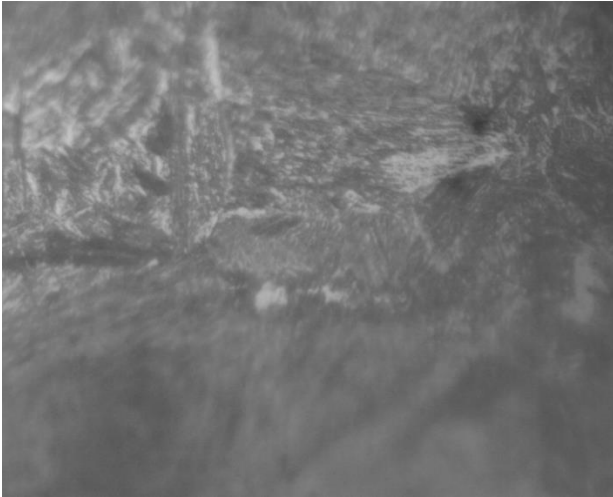


Plate 4.2a: Optical Micrograph of the Parent Metal of 0.36%C Steel solution annealed at 840 °C for 2hr at X1000. Structure shows predominant martensite lath with little patches of retained austenite.

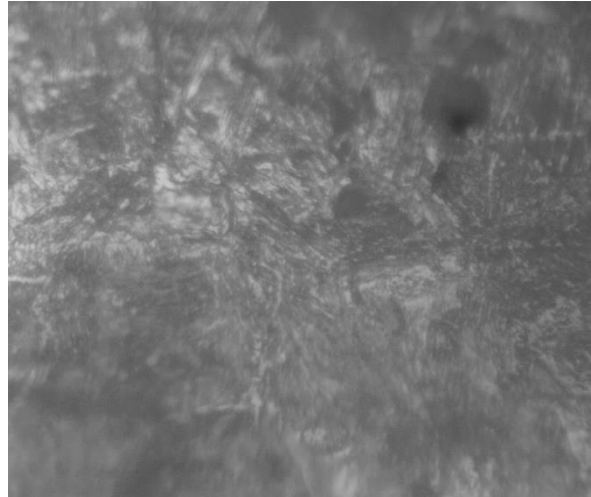


Plate 4.2b: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel solution annealed at 840 °C for 2hr at X1000. Structure shows predominant martensite lath with little traces of retained austenite.

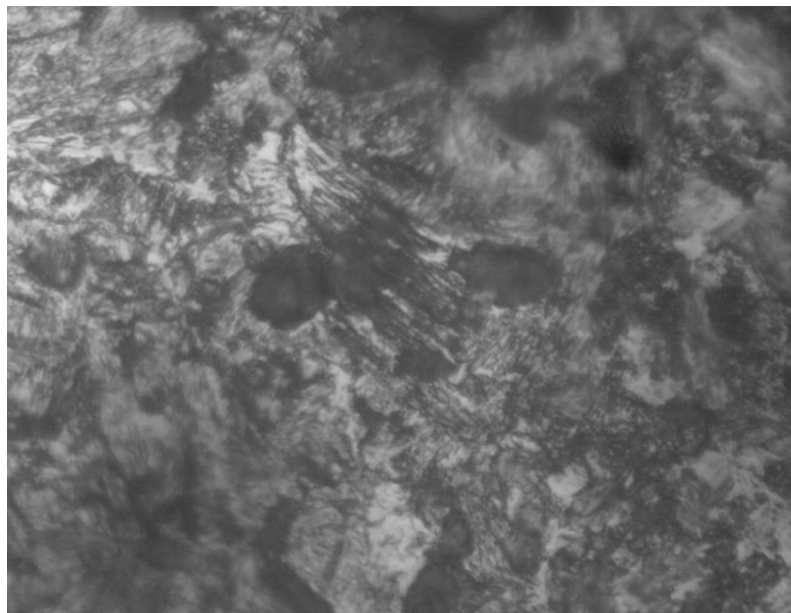


Plate 4.2c: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 840 °C for 2hr at X1000. Structure Shows martensite lath distribution with more retained austenite.

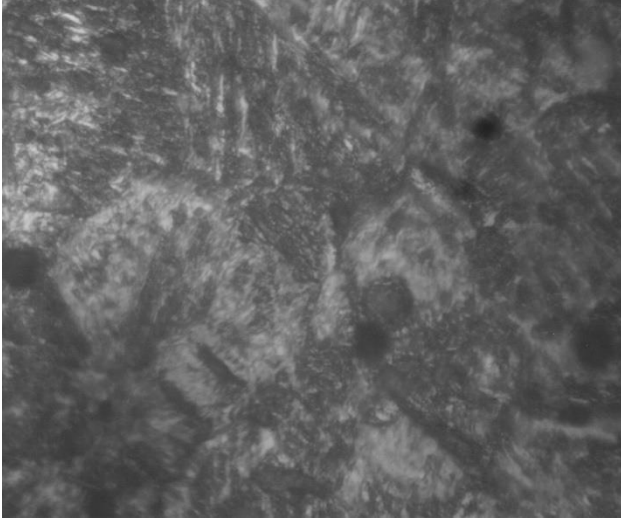


Plate 4.2d: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 890 °C for 2hr at X1000. Structure shows martensite dispersion with traces of retained austenite.

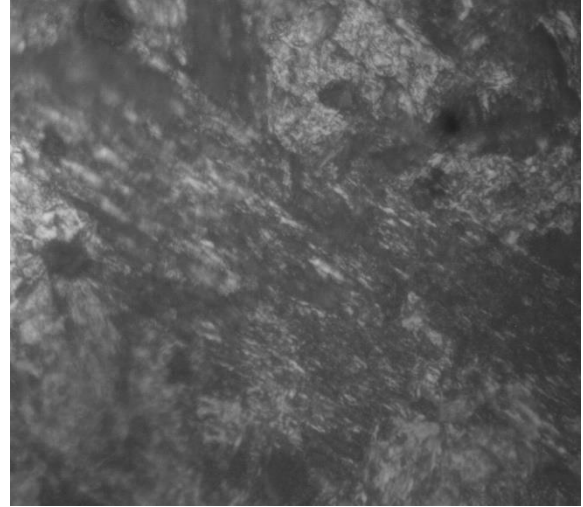


Plate 4.2e: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 890 °C for 2hr at X1000. Structure shows martensite distribution with more traces retained austenite

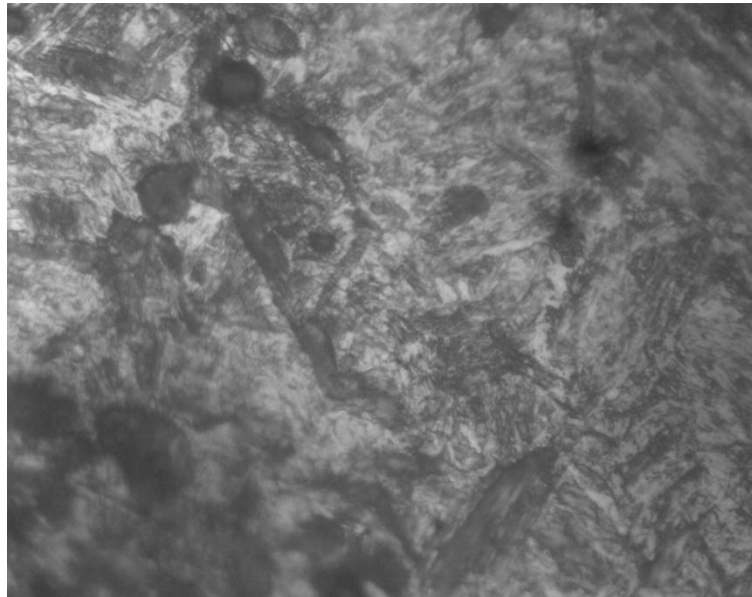


Plate 4.2f: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 890 °C for 2hr at X1000. Structure Shows martensite distribution, inclusions, cracks with more retained austenite.

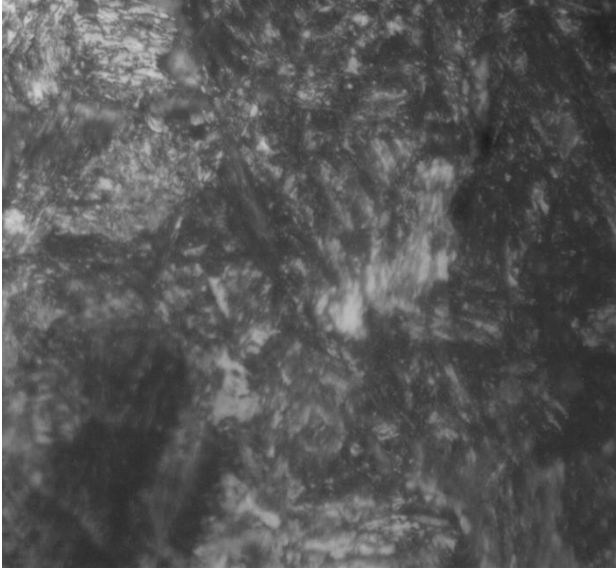


Plate 4.2g: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 940 °C for 2hr at X1000. Structure shows martensite lath with traces of retained austenite.

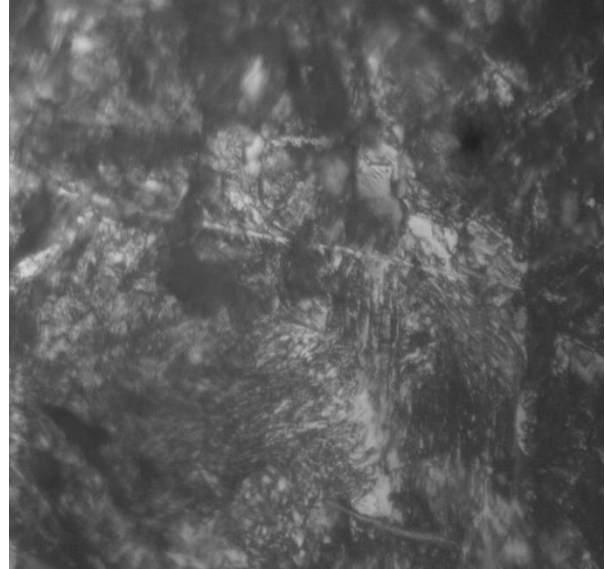


Plate 4.2h: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 940 °C for 2hr at X1000. Structure shows martensite lath with more traces of retained austenite

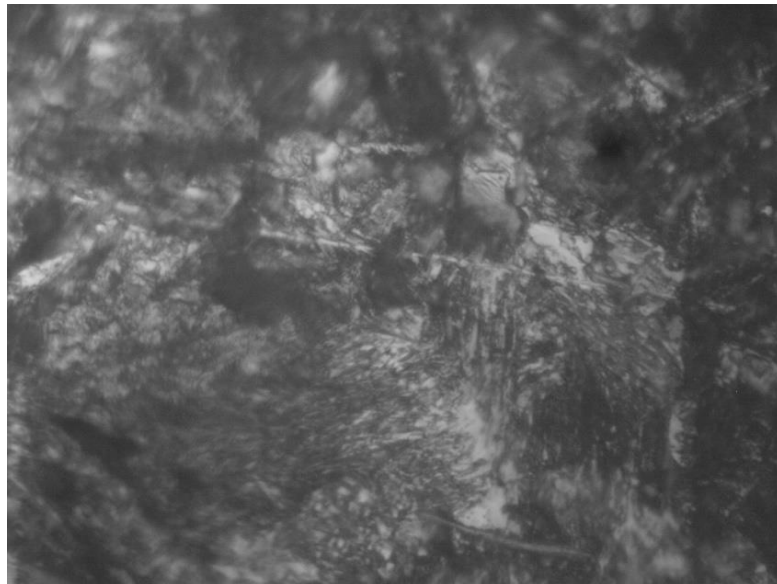


Plate 4.2i: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 940 °C for 2hr at X1000. Structure Shows martensite lath with coarse traces of retained austenite.

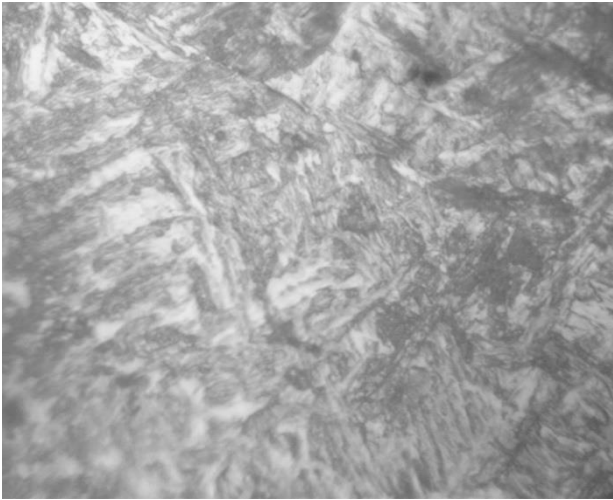


Plate 4.2j: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure shows martensite dispersion with traces of retained austenite.

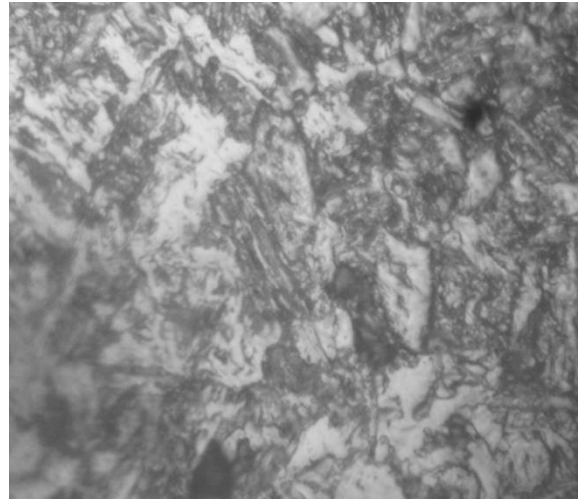


Plate 4.2k: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure shows martensite distribution with more traces of coarse retained austenite

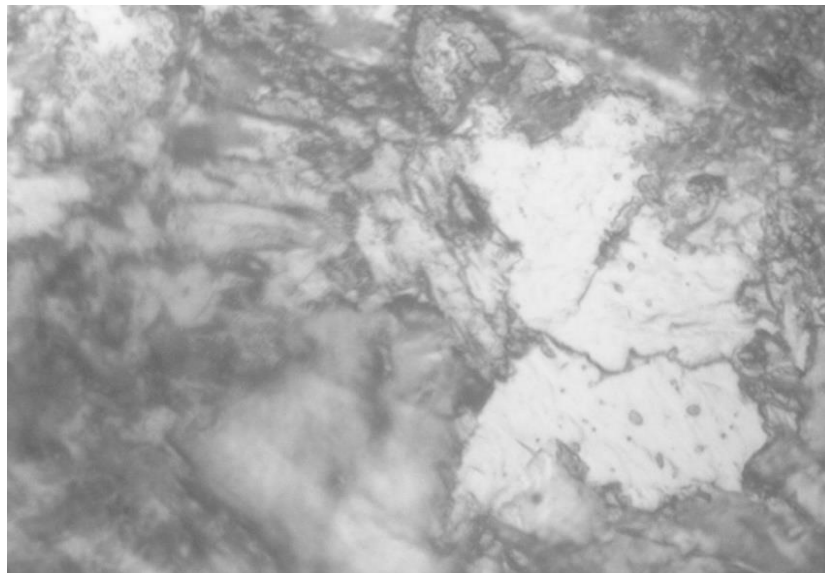


Plate 4.2l: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure Shows martensite lath distribution with coarser retained austenite.

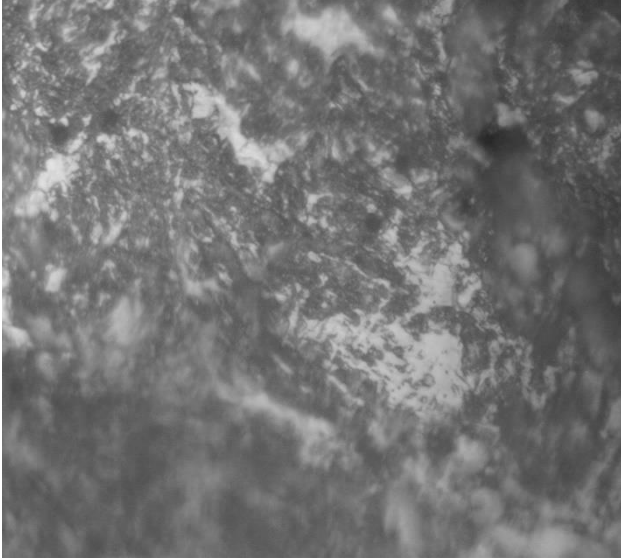


Plate 4.2m: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1040 °C for 2hr at X1000. Structure shows martensite distribution with traces of retained austenite.

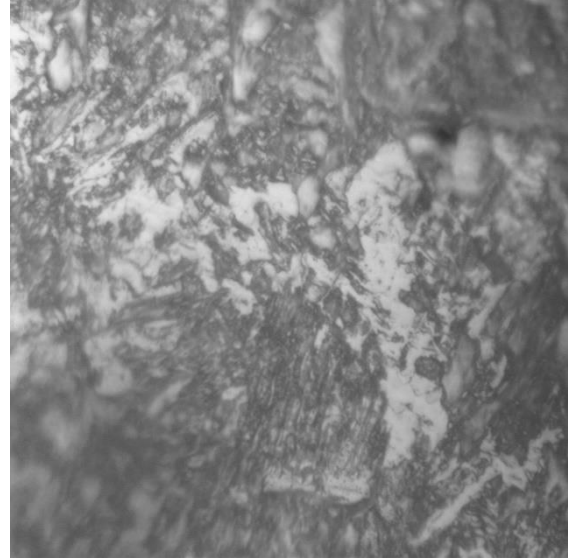


Plate 4.2n: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1040 °C for 2hr at X1000. Structure shows quasi martensite distribution with traces of retained austenite

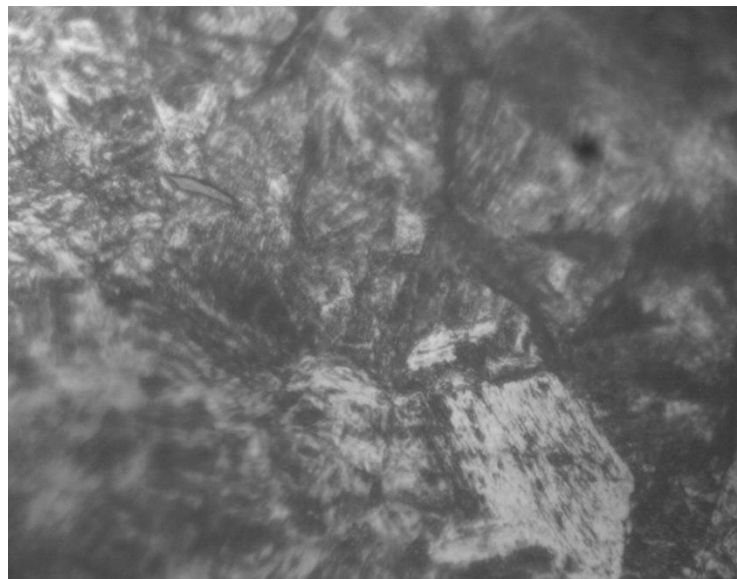


Plate 4.2O: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1040 °C for 2hr at X1000. Structure Shows martensite lath distribution with coarser retained austenite.

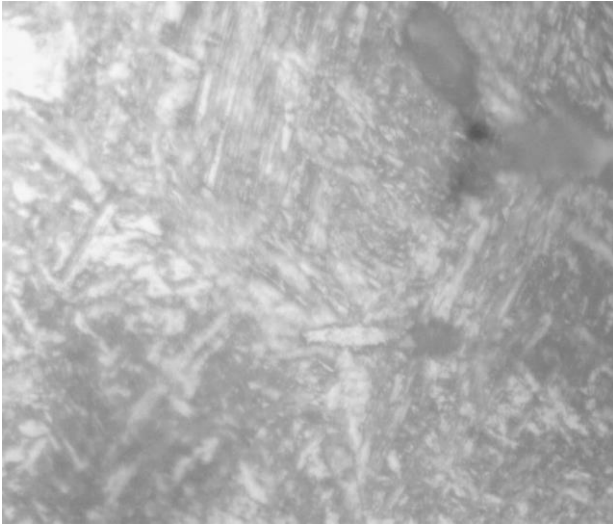


Plate 4.2p: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1090 °C for 2hr at X1000. Structure shows martensite lath with more traces of retained austenite.

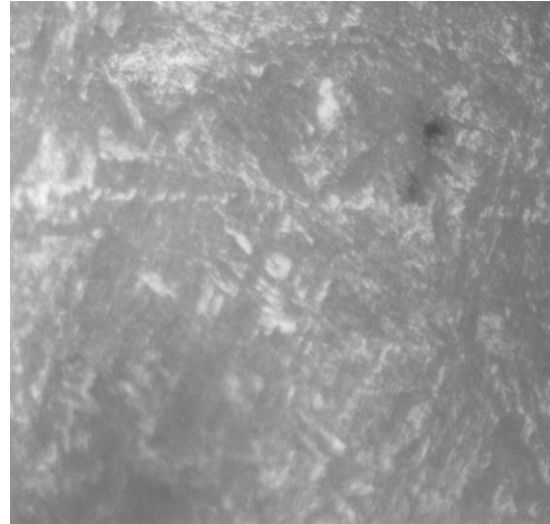


Plate 4.2q: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1090 °C for 2hr at X1000. Structure shows martensite lath with traces of retained austenite

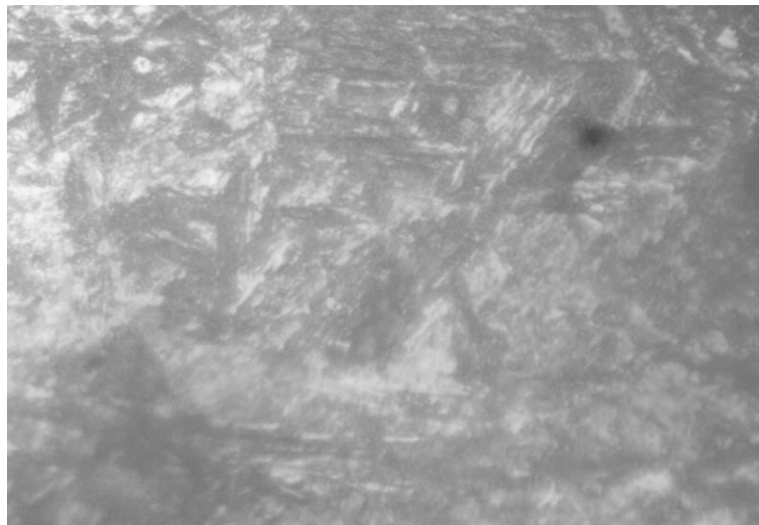


Plate 4.2r: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1090 °C for 2hr at X1000. Structure Shows martensite lath with traces of coarse retained austenite.

Plate 4.2a – 4.2r are the micrographs of the solution annealed heat treated samples at different solution annealing temperatures with a holding time of 2hr examined at the parent material (PM), heat affected zone (HAZ) and welded zone (WZ). The micrographs obtained revealed that the structures consist of martensite lath with traces of retained austenite in the matrix after heating for 840 °C, 890 °C, 940 °C, 990 °C, 1040 °C and 1090 °C. This could be attributed to the increased austenite nucleation at higher temperature, hence the structure became very enriched with more martensite on quenching as reported by Ikpeseni et al., (2015). Traces of retained austenite were evident as a result of the rapid cooling from the austenite temperatures. This was more evident at the solution annealing temperature of 990 °C, as the carbide were observed to have been homogenously dissolved in the matrix of the steel. This finding is in close agreement with (Villalobos-Vera and Mendoza-Bravo, 2019; Pacyna and Rozniata, 2007; Rosemann et al., 2013; Ihsan-ul-Haq, 2014; Yanjun et al., 2014; Soon-Hyeok et al., 2013; and Tukur et al., 2014).

4.1.3 Micrograph of Solution Annealing Heat Treatment Stage 3

The photomicrographs of 0.36%C steel samples annealed at 990 °C with a holding time of 2hr are shown in Plate 4.3a – 4.3f respectively.

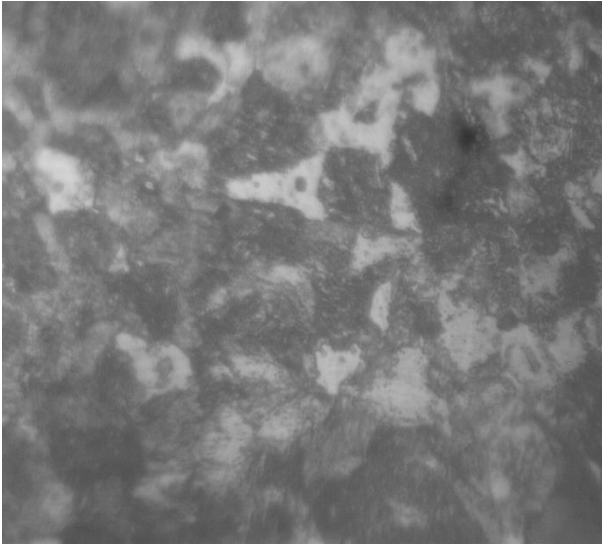


Plate 4.3a: Optical Micrograph of the Control Un-Welded Zone of 0.36%C Steel at X1000. The structure shows uniform distribution of carbide (dark) in the matrix of ferrite (light).

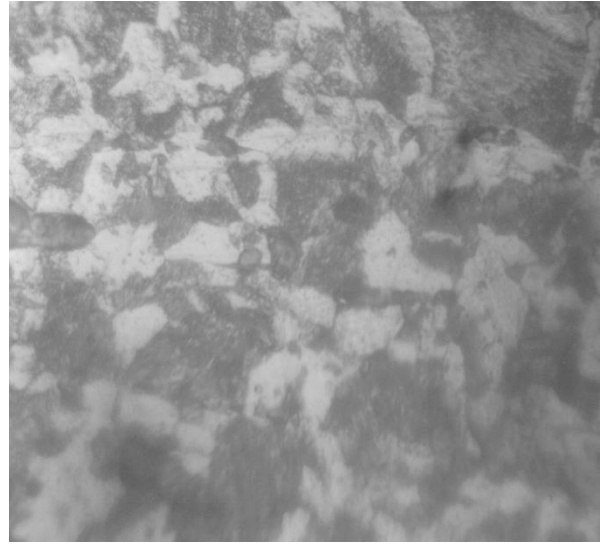


Plate 4.3b: Optical Micrograph of the Control Heat Affected Zone (HAZ) of 0.36%C Steel at X1000. The Structure shows coarse carbide in the ferrite matrix

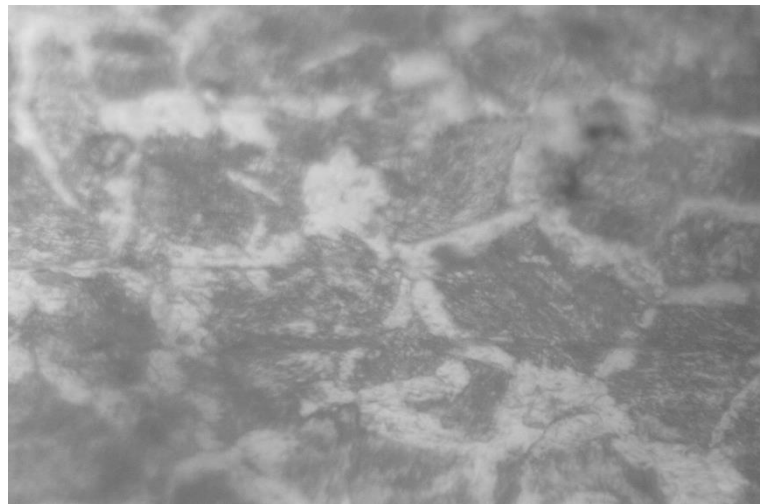


Plate 4.3c: Optical Micrograph of the Control Welded Zone of 0.36%C Steel at X1000. The structure shows coarser carbide dispersion in the ferrite matrix

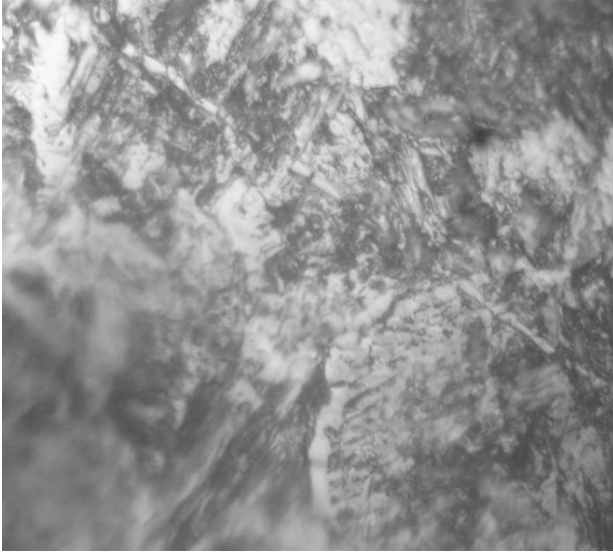


Plate 4.3d: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure shows uniform dispersion of martensite with more traces of retained austenite.

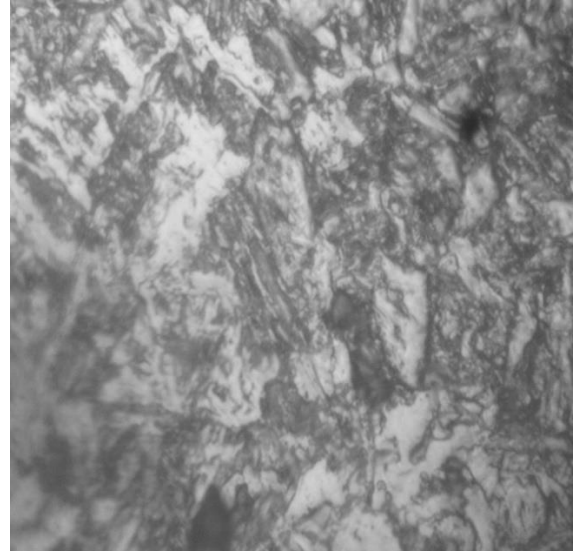


Plate 4.3e: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure shows martensite distribution with more traces of coarse retained austenite

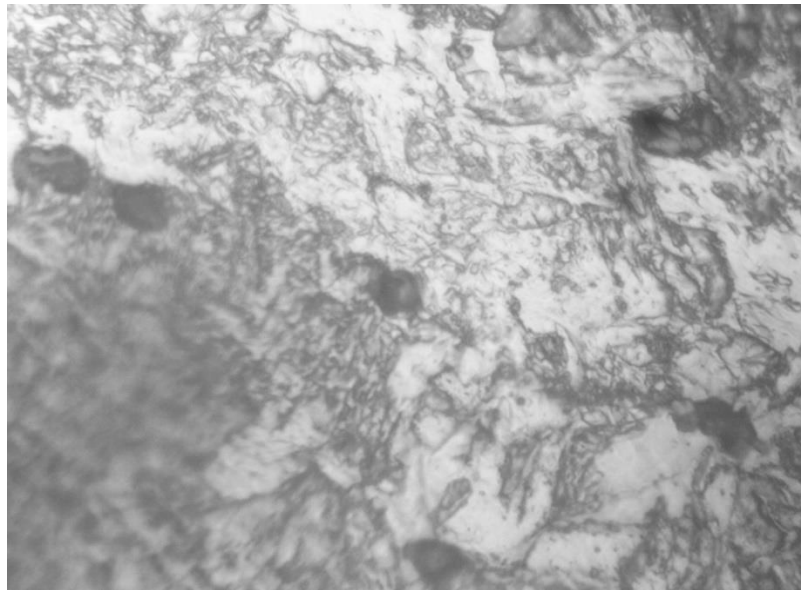


Plate 4.3f: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 990 °C for 2hr at X1000. Structure Shows martensite distribution with coarser retained austenite.

Rajan et al., (1988) reported that the grain growth of austenite is mainly controlled by the growth of the initial formed austenite grains and thereafter by the growth of the newly formed austenite nuclei. This process tends to continue until the upper critical temperature is reached. They also reported that the primary austenite grains grow at the expense of the proeutectoid ferrite.

The micrographs examination of the solution annealed samples obtained after this treatment is presented in Plate 4.3d - 4.3f. The structures show martensite distribution with major traces of retained austenite and this could be a result of the long isothermal soaking time in the course of austenization. Yang and Chen, (1991) reported that the initiation of austenite precipitation and the suppression of recrystallization are linked to the attractive interaction that exist between manganese, chromium and carbon atoms, which are simply segregated along the grain boundaries in the course of annealing at high temperature.

4.2 SEM-EDX Analysis

The graphs of the SEM-EDX analysis of the solution annealed and un-heat treated samples are shown in Figures 4.1a and 4.1b respectively. The data obtained from the SEM-EDX analysis of the solution annealed and un-heat treated samples which was used for plotting the figures are presented in Table B.1 of Appendix B.

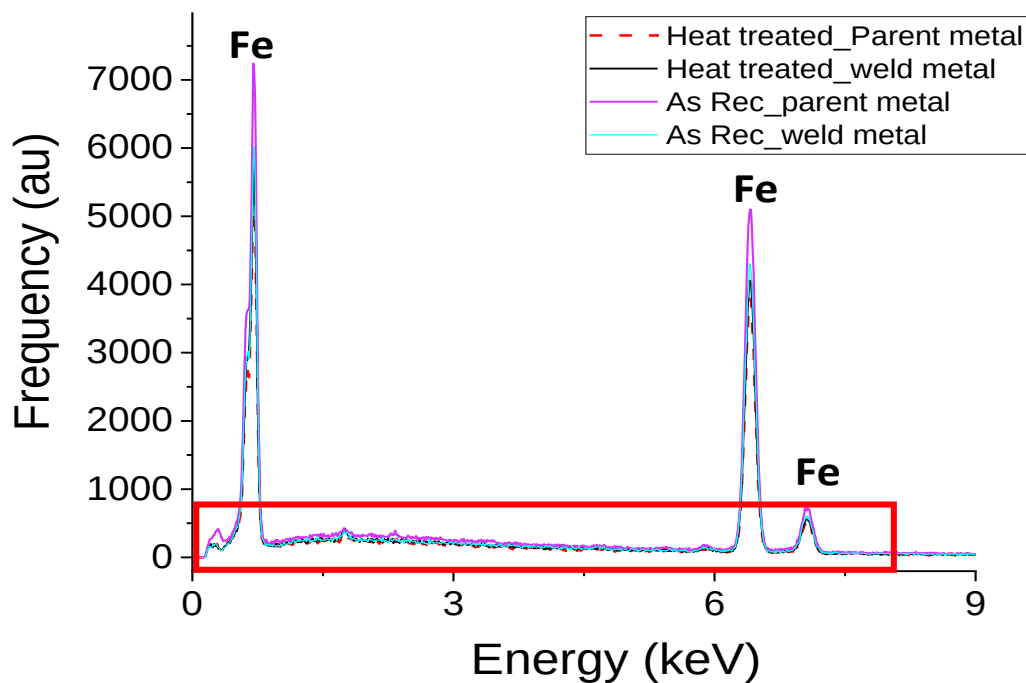


Figure 4.1a: EDX Spectrum of Welded 0.36%C Steel Solution Annealed and Un-Heat Treated Parent Metal and Weld Metal of the Samples

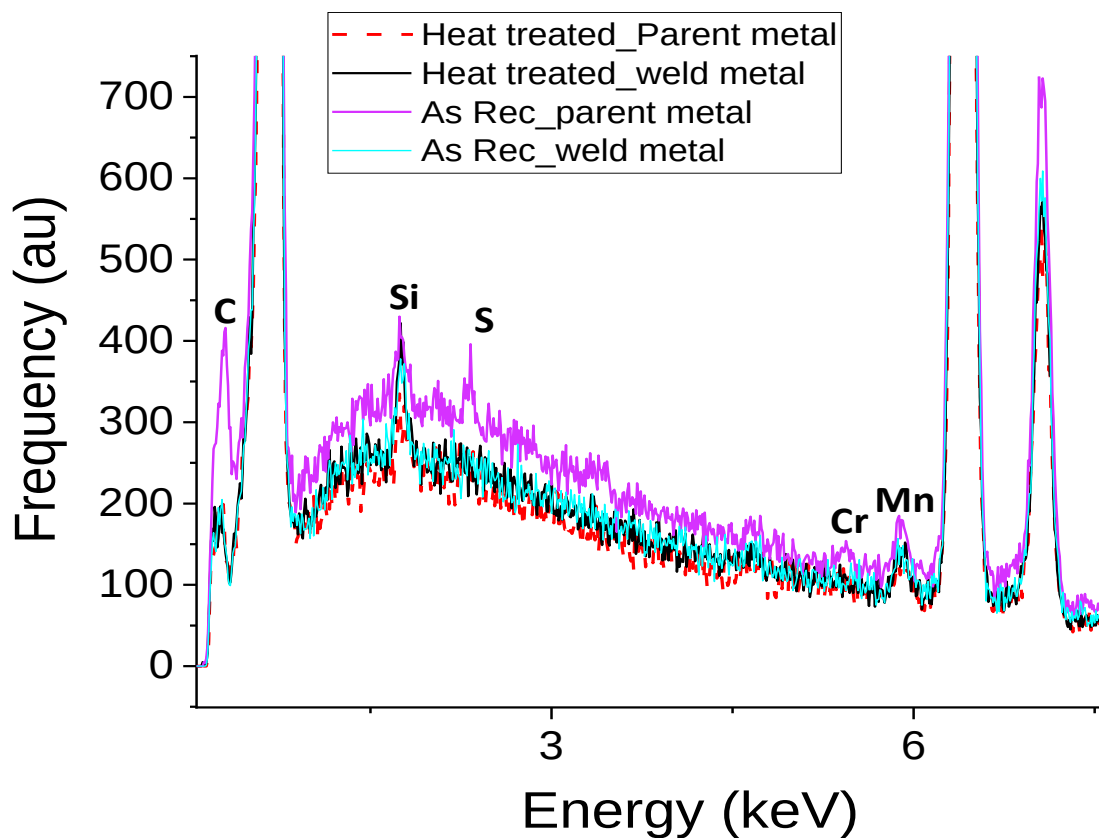


Figure 4.1b: Extrapolated EDX Spectrum of Welded 0.36%C Steel Solution Annealed and Un-Heat Treated Parent Metal and Weld Metal of the Samples

Figure 4.1a and b shows the result of SEM-EDX of 0.36%C steel solution annealed and un-heat treated parent metal and weld metal of the samples. It is found that Fe concentration gave a very high spectra indicating that it is the predominant element for both the solution annealed heat treated and the un-heat treated samples. The extrapolated Figure 4.1b showed a remarkable difference between the solution annealed and un-heat treated samples. It was observed in the un-heat treated samples from the parent to the weld metal zones that there are spikes of alloying elements C, Si, S, Cr, Mn indicating that the alloying elements are not homogeneously dispersed in the matrix of the samples, while in the solution annealed samples there were no spikes of alloying elements indicating that the alloying elements are homogeneously dispersed in the matrix of the samples. It was also observed in the solution annealed samples that the carbon is fully solutionized in the matrix of the samples which is one of the major reason of solution annealing heat treatment and this finding is in good agreement with Anburaj et al., (2012); Elki et al., (2017); Yanjun et al., (2014). They observed in their studies that solution annealing is effective in causing the dissolution of precipitated intermetallic phase (Fe_3C phase).

4.3 Hardness Testing Evaluation

The hardness test results are presented in this section. Figures 4.2a – 4.2i shows the hardness results of the solution annealed and un-heat treated samples. The results showed that the hardness increases from the welded zone, heat affected zone to the parent metal. The hardness test data obtained from this research which was used for plotting the Figures are shown in Table B.2 – B.3 of Appendix B.

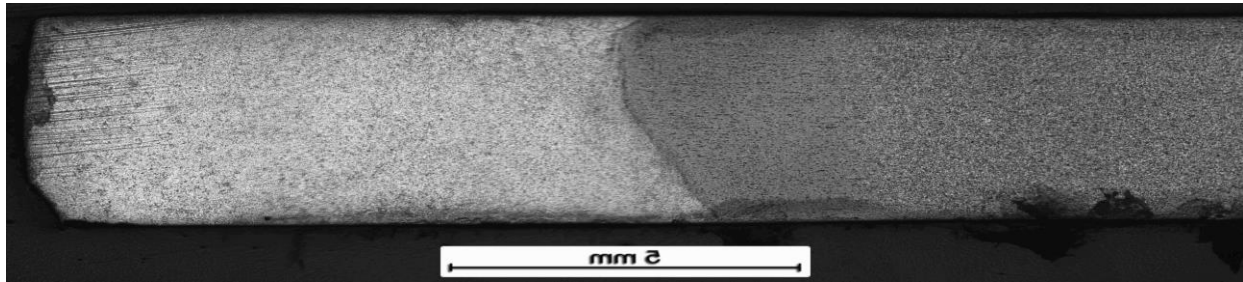


Figure 4.2a: Hardness Crop Image of the Un-Heat Treated Sample

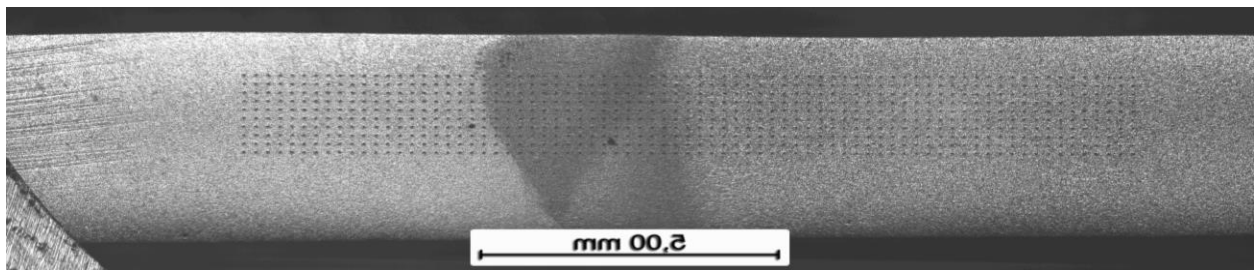


Figure 4.2b: Hardness Indents Image of the Un-Treated Sample

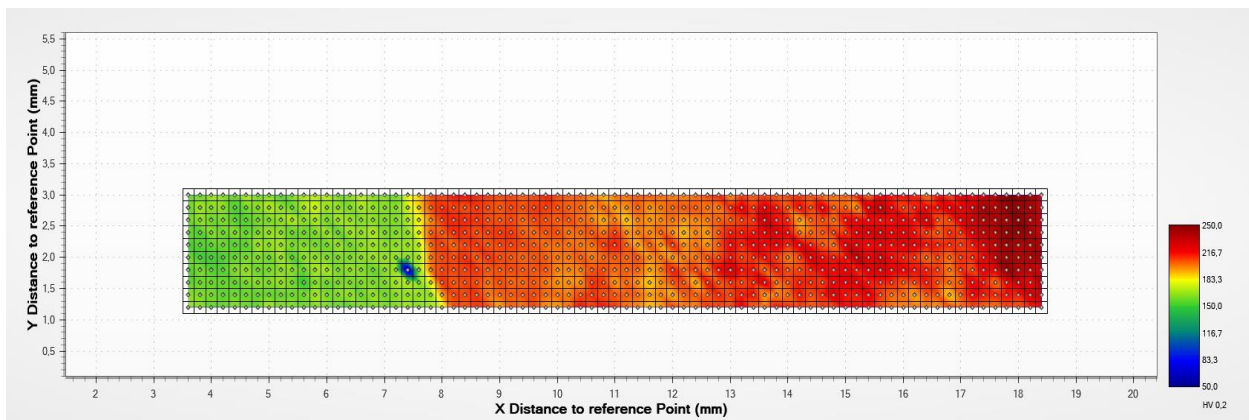


Figure 4.2c: Hardness Raw Plot Indents Image of the Un-Treated Sample

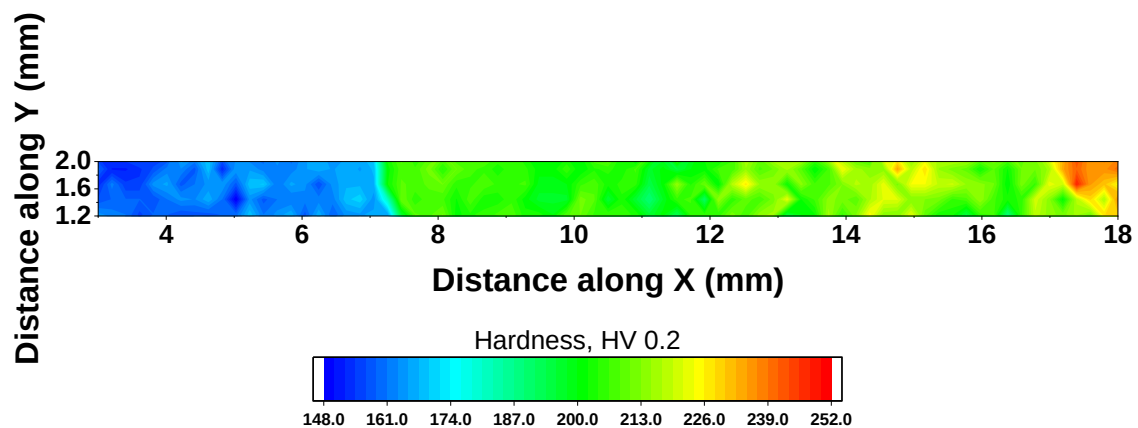


Figure 4.2d: Hardness Spectrum of the Un-Heat Treated Sample

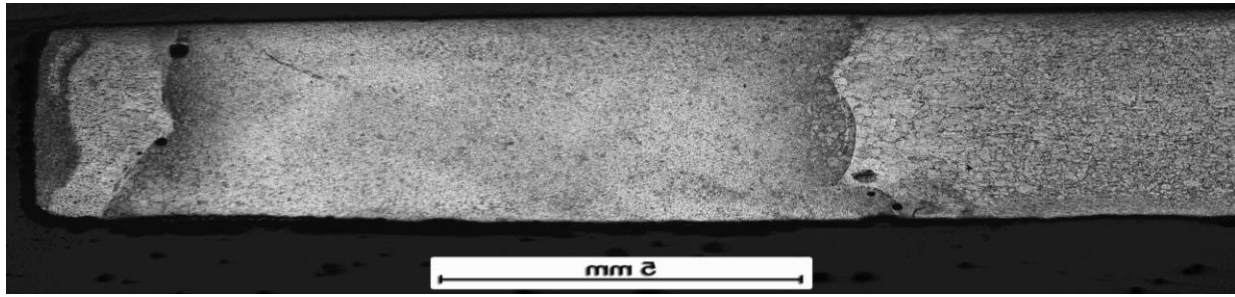


Figure 4.2e: Hardness Crop Image of the Solution Annealed Treated Sample

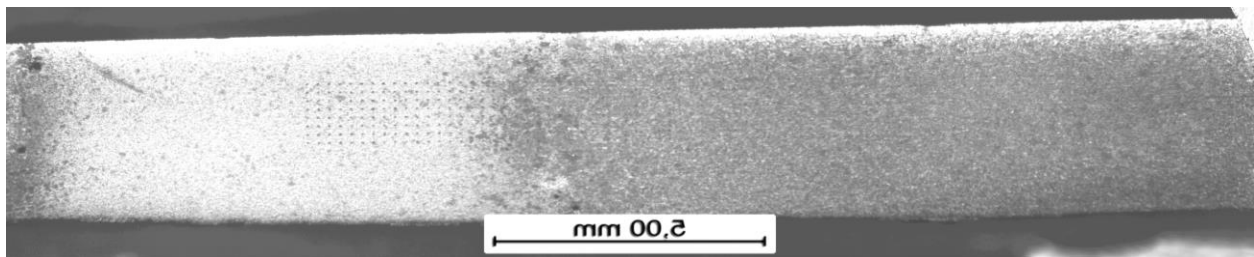


Figure 4.2f: Hardness Indents Image of the Solution Annealed Treated Sample

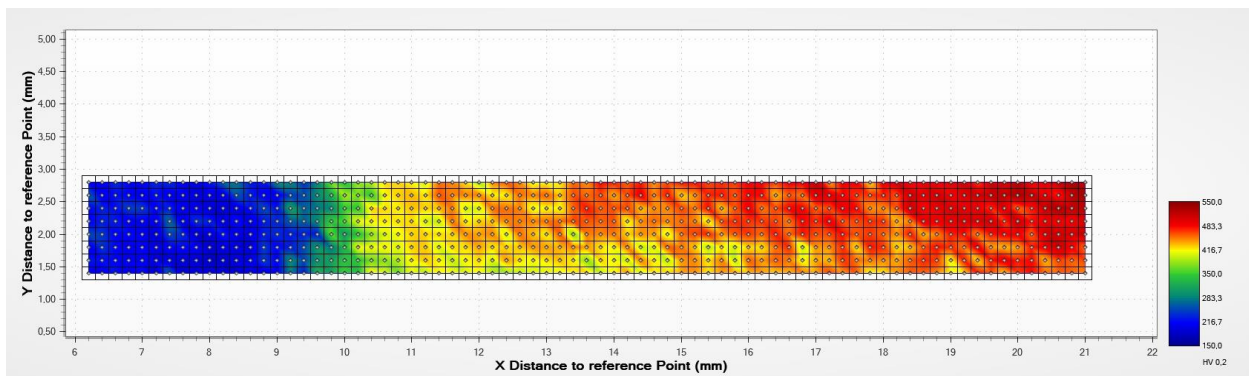


Figure 4.2g: Hardness Raw Plot Indents Image of the Solution Annealed Treated Sample

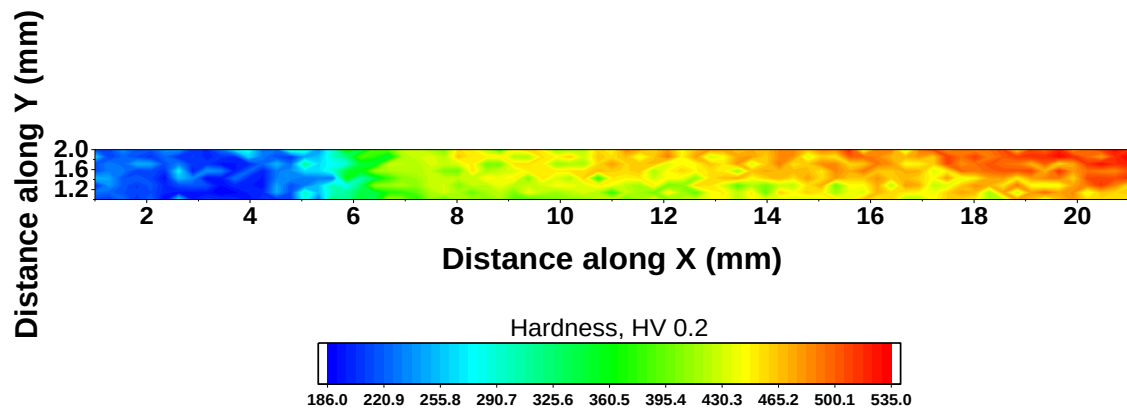


Figure 4.2h: Hardness Spectrum of the Solution Annealed Treated Sample

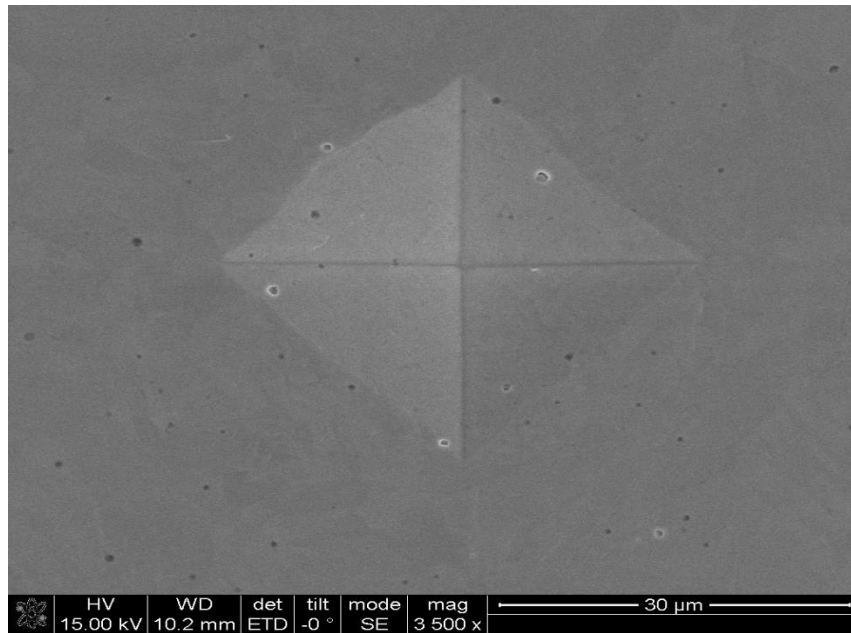


Figure 4.2i: SEM Indent Image of the Samples

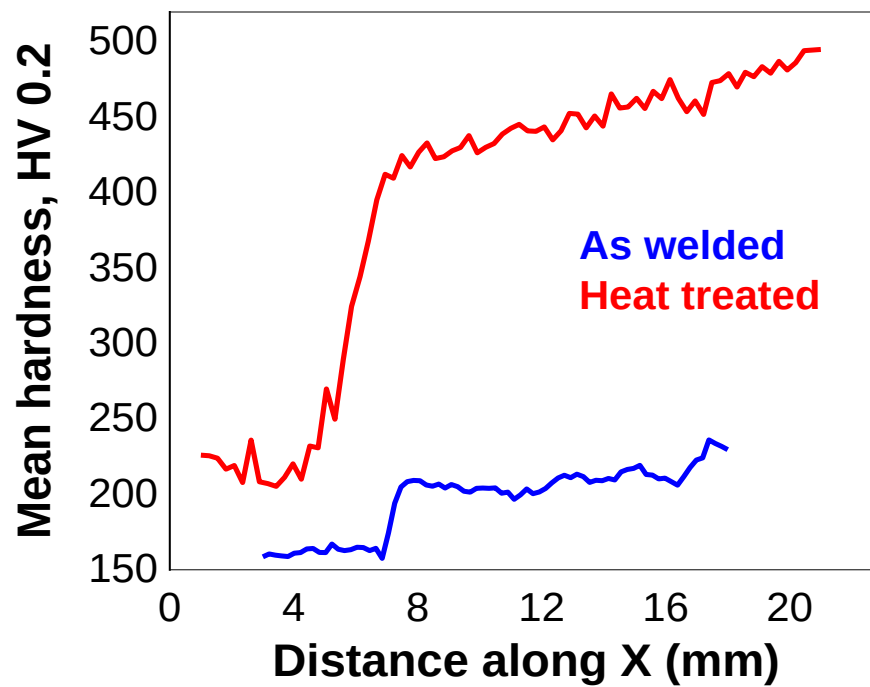


Figure 4.2j: Hardness Plot of the Solution Annealed Treated and Un-Treated Samples

4.3.1 Effect of Solution Annealing on Microstructural Evolution and Hardness Property of the Different Regions of the Welded Steel.

The hardness distribution in the different regions of the un-heat treated and solution annealed samples is shown in Figure 4.2j. The results showed that the hardness increases from the welded zone (WZ), heat affected zone (HAZ) to the parent metal (PM) for both the samples. This variation in properties across the welded samples could be attributed to the microstructure of the samples (Raghavan,1989) as shown in Plate 4.3a – 4.3f. It can be seen from the microstructure that the grain size across the different regions of the samples increases from the parent metal (PM) to the welded zone (WZ), which in turn resulted in the increase in the hardness from the welded zone (WZ), heat affected zone (HAZ) and the parent metal (PM) across the samples. This could be attributed to the different rate of cooling across the sample. These findings correspond with Sathiya et al., (2007), Raghavan, (1989) and Adedayo et al., (2010). The welded metal was observed to have the lowest hardness value and this finding aligns with Xin et al., (2016), and this could be attributed to the loss of quenching elements from the weld zone (WZ), their coarse structure (Blondeau.,2008; Lippold., 2015; Nandan et al., 2008) and also due to grain growth (Dodo et al., 2016). The occurrence of coarse grain size in the welded zone (WZ) can also be attributed to the heat cycle, low dislocation density and dissolution of precipitation (Ueji et al., 2006). The parent metal (PM) was observed to have the maximum hardness for both samples and this finding aligns with Xin et al., (2016). These could be attributed to the finer grain size (Sathiya et al., 2007; Nandan et al., 2008). The solution annealed samples showed higher hardness than the un-heat treated samples. This implies that the carbides dissolution in the matrix of the solution annealed samples has helped to stretch the matrix of the steel resulting in volumetric expansion with martensite formation and also impede dislocation movement which resulted to increased hardness of the solution annealed samples. This finding is in close agreement with Tukur et al., (2014); Marcuci et al., (2014); Martin et al., (2009); Choi et al., (2015); Hoyos et al., (2015); Krauss,

(1999) and Zhang et al., (2018). Ndaliman, (2006); DZU et al., (2002); Baker, (1991) and Garcia et al., (1992, 1996) also reported that hardening mechanism in steel is due to the martensitic structure (phase). The higher hardness associated with the solution annealed samples over the as welded samples can also be attributed to the existence of retained austenite in the structure. This finding aligns with Adedayo et al., (2010); Ragunathan et al., (2015). Handoko et al., (2018). They observed that retained austenite enhanced hardness property as it prevented the generation of pitting holes at the grain boundary.

4.4 Corrosion Characterization

The results obtained from the corrosion test after exposure to the chloride environment are presented in this section.

4.4.1 Electrochemical Corrosion Measurement Evaluation

The electrochemical corrosion measurements were used to determine the corrosion rate, corrosion current (density) and corrosion potential from the Tafel slope, linear polarization resistance (PR), open circuit potential (OCP), electrochemical noise (EN), and electrochemical impedance spectroscopy (EIS). The results obtained are presented as follows:

4.4.1.1 Corrosion Evaluation from Tafel Slope and Linear Polarization Resistance (R_p)

The Tafel and polarization resistance (R_p) results obtained from electrochemical corrosion analysis of the solution annealed and un-heat treated samples are shown in Table 4.1, while the data used for plotting the graphs in Figures 4.3a – 4.3c are presented in Tables B.4 –B.6 of Appendix B respectively.

Table 4.1: Electrochemical Corrosion Parameters obtained from Tafel and Linear Polarization of the Control and Solution Annealed Steel Samples Immersed in 1.0M NaCl Environment

<u>Samples</u>	<u>Corrosion Potential</u> <u>E_{corr} (mV)</u>	<u>Corrosion Current</u> <u>I_{corr} (μA.cm⁻²)</u>	<u>Polarization Resistance</u> <u>R_p (Ω.cm²)</u>	<u>Corrosion Rate</u> <u>(mm/yr)</u>
CPM	-464.741	144.198	269.867	1.673
SAPM	-455.552	50.928	786.061	0.591
CHAZ	-481.118	270.825	61.263	3.143
SAHAZ	-462.632	87.668	180.452	1.017
CWZ	-473.451	416.569	41.133	4.832
SAWZ	-464.671	276.492	54.483	3.207

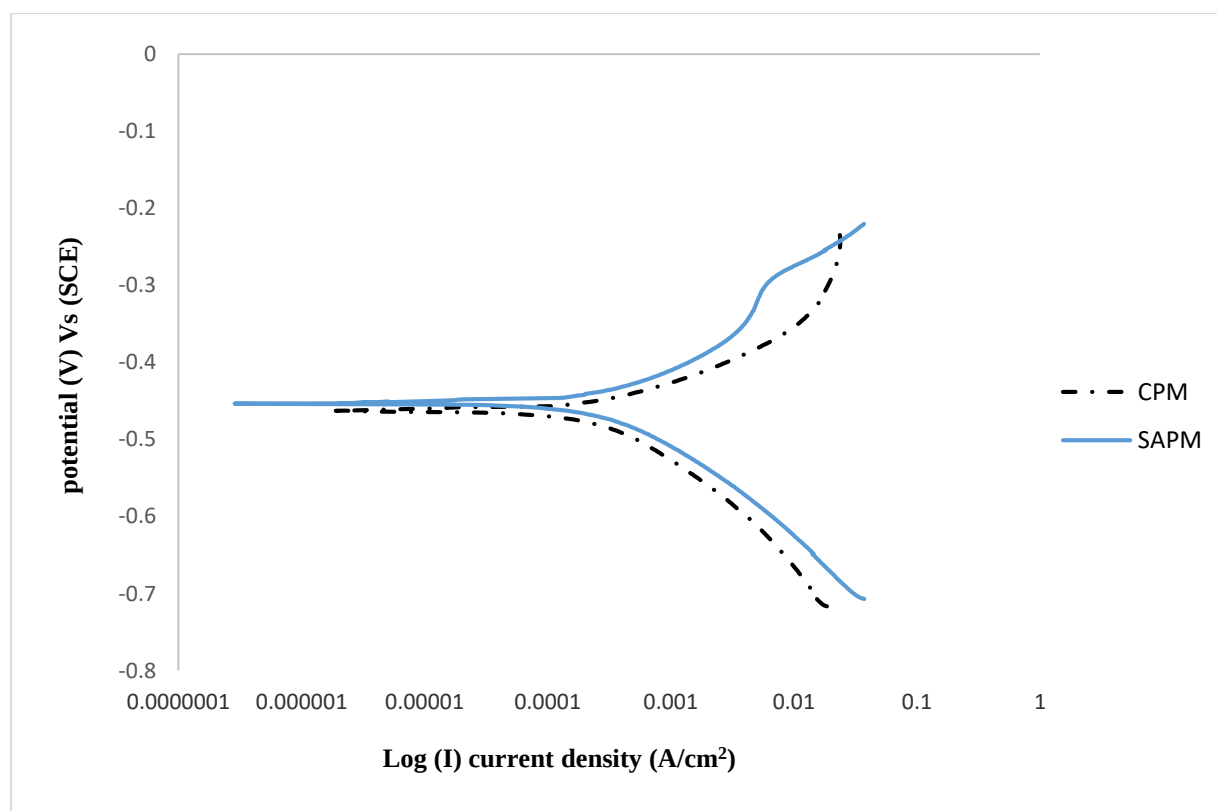


Figure 4.3a: Tafel Polarization Curves of the Control and Solution Annealed Parent Metal of the Samples Immersed in 1.0M NaCl Environment

The tafel plot in Figure 4.3a, shows that the anodic current of the control parent metal (CPM) samples gave the highest anodic potential of -0.72V (SCE) compared to the solution annealed parent metal (SAPM) sample that gave an anodic potential of -0.70V (SCE). This depicts that the control samples are corroding more than solution annealed sample.

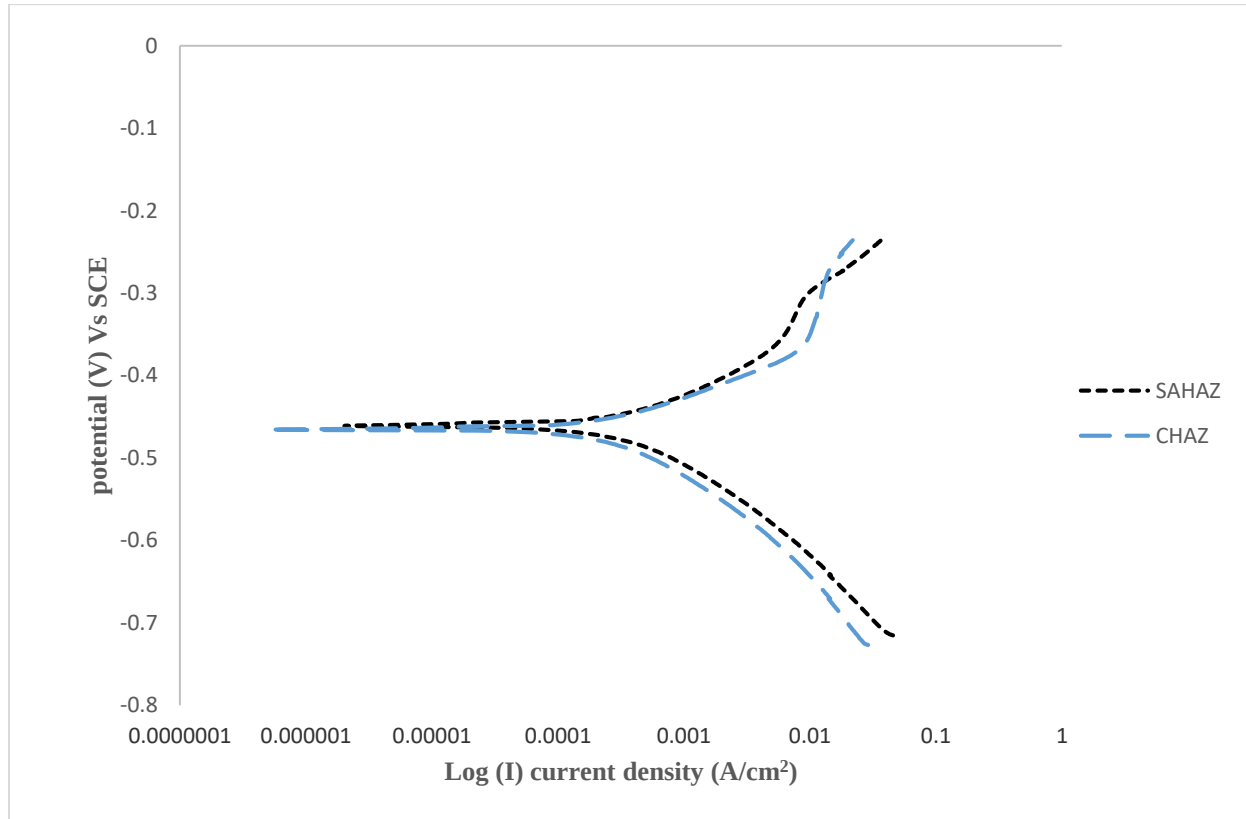


Figure 4.3b: Tafel Polarization Curves of the Control and Solution Annealed Heat Affected Zone of the Samples Immersed in 1.0M NaCl Environment

The tafel plot in Figure 4.3b, shows that the anodic current of the control heat affected zone sample gave the highest anodic potential of -0.73V (SCE) compared to the solution annealed heat affected zone sample that gave an anodic potential of -0.71V (SCE). This depicts that the control heat affected zone samples are corroding more than solution annealed heat affected samples.

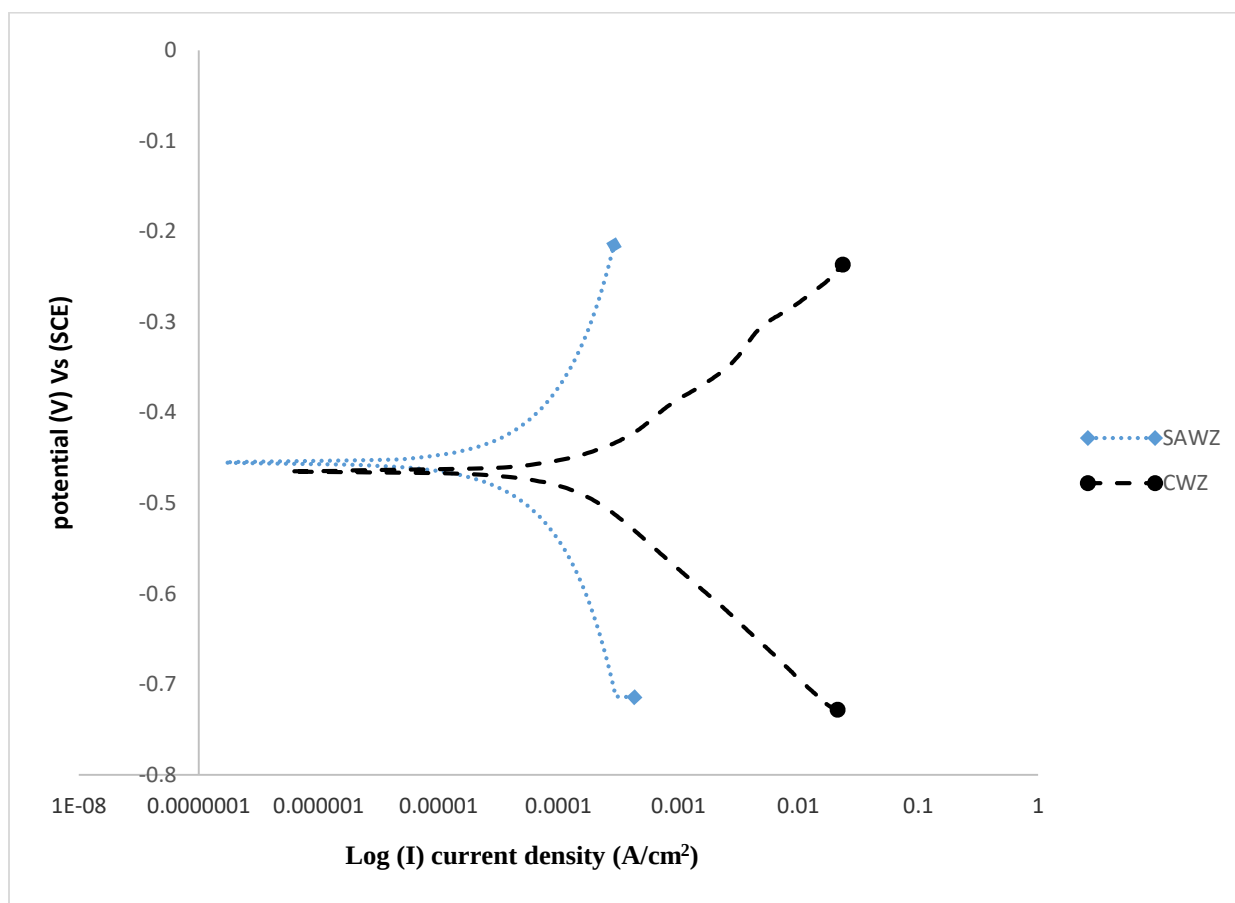


Figure 4.3c: Tafel Polarization Curves of the Control and Solution Annealed Welded Zone of the Samples Immersed in 1.0M NaCl Environment

The tafel plot in Figure 4.3c, shows that the anodic current of the control welded zone (CWZ) of the samples gave the highest anodic potential of -0.73V (SCE) compared to the solution annealed welded zone (SAWZ) samples that gave an anodic potential of -0.71V (SCE). This depicts that the control welded zone samples are corroding more than solution annealed welded zone (SAWZ) samples.

4.4.1.1.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Tafel Slope and Polarization Resistance

Kato et al., (1978), in their investigation reported that electrochemical difference (potential) between the parent metal (PM), heat affected zone (HAZ) and weld zone (WZ) results in selective corrosion. Rothwell and Turner, (1989), also reported that the differences in local galvanic potential between the parent metal (PM), heat affected zone (HAZ) and the welded zone (WZ) are responsible for corrosion attack and these findings were observed in Figure 4.3a to 4.3c. These figures show the Tafel plot of electrode potential against the current density for the control and solution annealed samples in 1.0M NaCl environment. The Tafel plot in Figure 4.3a, show that the anodic current of the control parent metal (CPM) samples gave the highest anodic potential of -0.72V (SCE), lower polarization resistance R_p of $269.867 \Omega \cdot \text{cm}^2$ and higher corrosion rate of 1.673 mm/yr compared to the solution annealed parent metal (SAPM) sample that gave an anodic potential of -0.70V (SCE), higher polarization resistance R_p of $786.061 \Omega \cdot \text{cm}^2$ and a lower corrosion rate of 0.591 mm/yr as seen in Table 4.1. This finding depicts that the solution annealed samples are more noble and that the control samples are corroding more than the solution annealed sample. This finding could be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed parent metal (SAPM), which resulted in its low anodic potential, higher polarization resistance and lower corrosion rate. This is in accordance with the findings of Hilbert, (1984), who reported that low anodic potential results in low corrosion rates and that high anodic potential result in an increase in the corrosion rate in chloride medium. Fontana (1974) and Scully (1975) also reported that low anodic potential favored corrosion rate reduction.

The Tafel plot in Figure 4.3b, shows that the anodic current of the control heat affected zone sample gave the highest anodic potential of -0.73 V (SCE), lower polarization resistance of $61.263 \Omega \cdot \text{cm}^2$ and a higher corrosion rate of 3.143 mm/yr compared to the solution annealed heat affected zone sample that gave an anodic potential of -0.71V (SCE), higher polarization resistance of $180.452 \Omega \cdot \text{cm}^2$ and with a lower corrosion rate of 1.017 mm/yr as seen in Table 4.1. This finding

depicts that the solution annealed samples are more noble and that the control heat affected zone sample are corroding more than the solution annealed heat affected samples. This finding can be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed samples which is in agreement with Anburaj et al., (2012), and also to the presence of carbides at the grain boundaries in the heat affected zone (HAZ) of the control samples. This finding aligns with Vignal et al., (2015), they reported that the presence of carbides at the grain boundaries in the heat affected zone (HAZ) was responsible for its high susceptibility to corrosion. Kato et al., (1978) also reported that the accelerated corrosion rates of the (HAZ) was due to massive grain growth. The Tafel plot in Figure 4.3c, shows that the anodic current of the control welded zone (CWZ) samples gave the highest anodic potential of -0.73V (SCE), lower polarization resistance of 41.133 $\Omega \cdot \text{cm}^2$ and with a higher corrosion rate of 4.832 mm/yr compared to the solution annealed welded zone (SAWZ) samples that gave an anodic potential of -0.71V (SCE), higher polarization resistance of 54.483 $\Omega \cdot \text{cm}^2$ and with a lower corrosion rate of 3.207 mm/yr as seen in Table 4.1. This finding depicts that the solution annealed samples are more noble and that the control welded zone sample are corroding more than the solution annealed welded zone (SAWZ) samples. This finding can be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed samples which is in agreement with Rosemann et al., (2015). The welded zone was observed to have the highest corrosion rate for both samples and this can be attributed to the presence of manganese sulphide (MnS) inclusion in the welded zone (WZ) (Kato et al., 1978). Nejihashi et al., (1988) reported that the MnS are developed in the weld by fast reprecipitation of the manganese sulphide after dissolution during welding. They also reported that the weld area is anodic when compared to the base metal, hence, resulting in the formation of a macro-cell between the weld area (smaller portion) and the parent metal resulting in its high corrosion rate. The higher

corrosion rate observed in the welded zone can be attributed to the dissolution or removal of MnS inclusion, thus revealing more MnS inclusion available for more corrosion attack. Nejhashi et al., (1988) also reported that the application of heat treatment could help to lower the S-enriched zone around the manganese sulphide inclusion, reduce the electrochemical difference between the weld and the parent metal, and reduce the formation of macro-cell, thus, lowering the corrosion rate which was obtained by the solution annealing heat treatment in this study.

In summary, the welded zone (WZ) was observed to produce the lowest polarization resistance R_p values with highest corrosion rates as seen in Table 4.1. This finding correspond with Gulbrandsen et al., (2002), where they reported that preferential corrosion occurs more in the welded zone (WZ) of steels. The HAZ gave a moderate corrosion rate with the parent metal displaying the least corrosion rate as seen in Table 4.1, and this finding aligns with Abdurrahim et al., (2003).

4.4.1.2 Corrosion Evaluation from Open Circuit Potential (OCP)

The corrosion potentials (OCP) results obtained from electrochemical corrosion analysis of the solution annealed and un-heat treated samples immersed in 1M NaCl environment are presented in Figures 4.4a – 4.4c, while the data used for plotting the graphs are presented in Tables B.7-B.9 of Appendix B respectively.

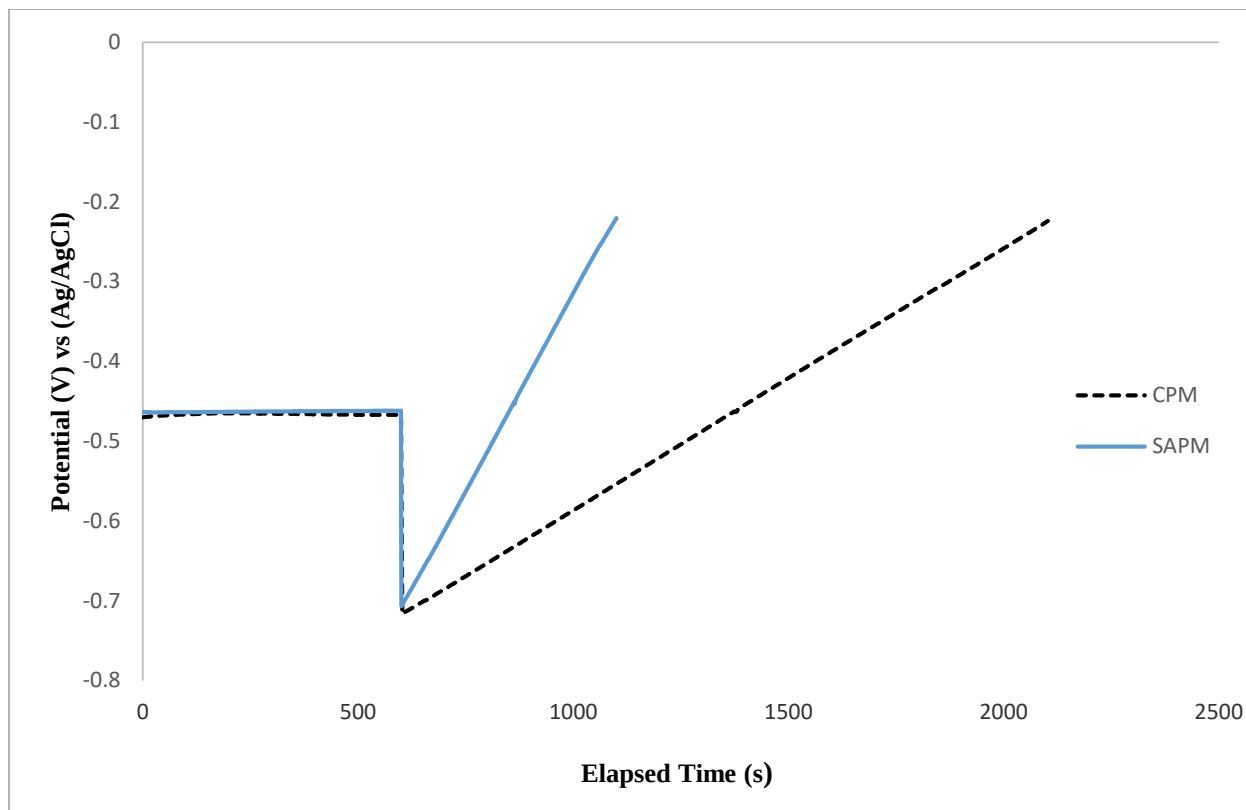


Figure 4.4a: OCP Plots for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1.0M NaCl Environment

The OCP plot in Figure 4.4a, show that there was a stable corrosion potential for both the control and solution annealed samples at about 600 seconds, and a sharp decrease in corrosion potential of all the samples followed by a progressive increase in the corrosion potential for the remaining period of exposure time. The control parent metal (CPM) samples gave the highest corrosion potential of -0.72V (Ag/AgCl) compared to the solution annealed parent metal (SAPM) sample that gave a corrosion potential of -0.70V (Ag/AgCl). This depicts that the control samples are corroding more than solution annealed samples.

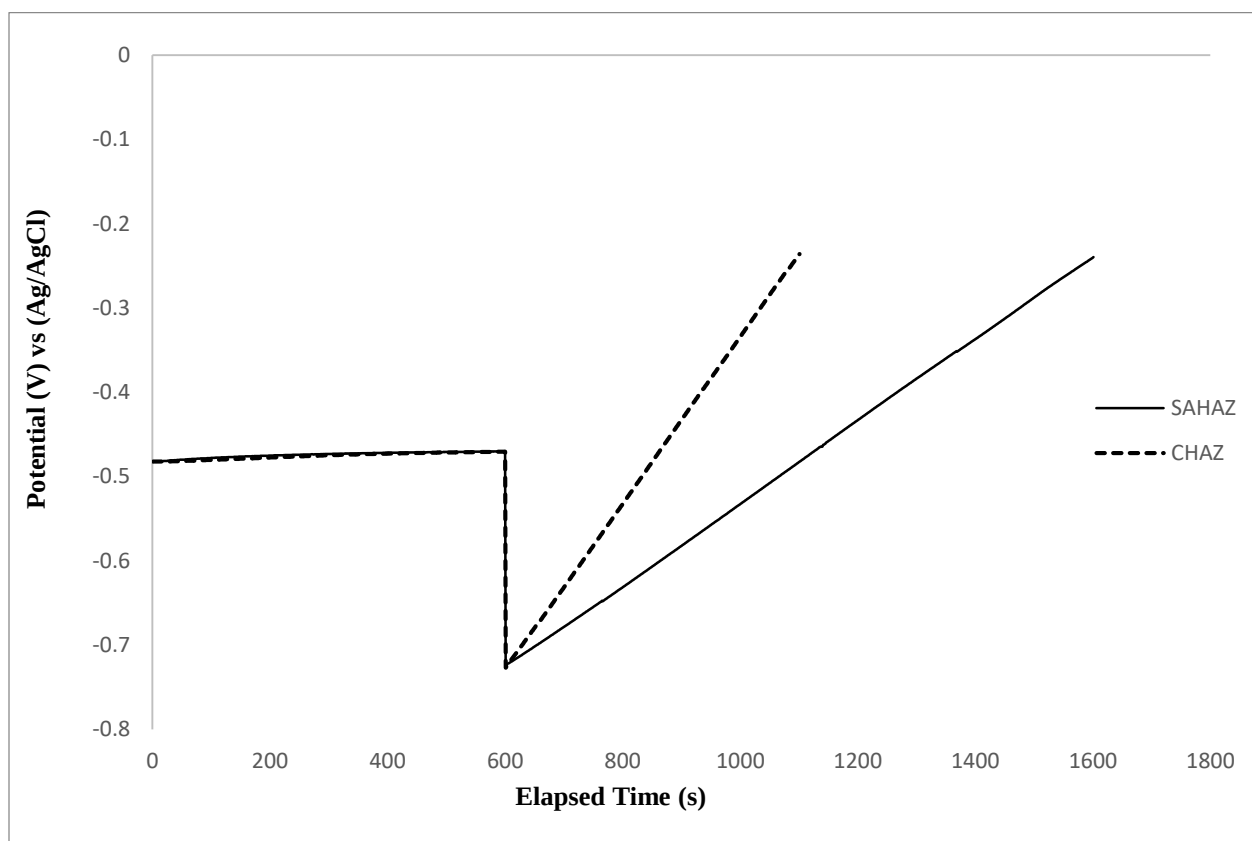


Figure 4.4b: OCP Plots for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1.0M NaCl Environment

The OCP plot in Figure 4.4b, show that there was a stable corrosion potential for both the control and solution annealed samples at about 600 seconds, and a sharp decrease in corrosion potential of all the samples followed by a progressive increase in the corrosion potential for the remaining period of exposure time. The control heat affected zone (CHAZ) samples gave the highest corrosion potential of -0.73V (Ag/AgCl) compared to the solution annealed heat affected zone (SAHAZ) sample that gave a corrosion potential of -0.71V (Ag/AgCl). This depicts that the control samples are corroding more than solution annealed samples.

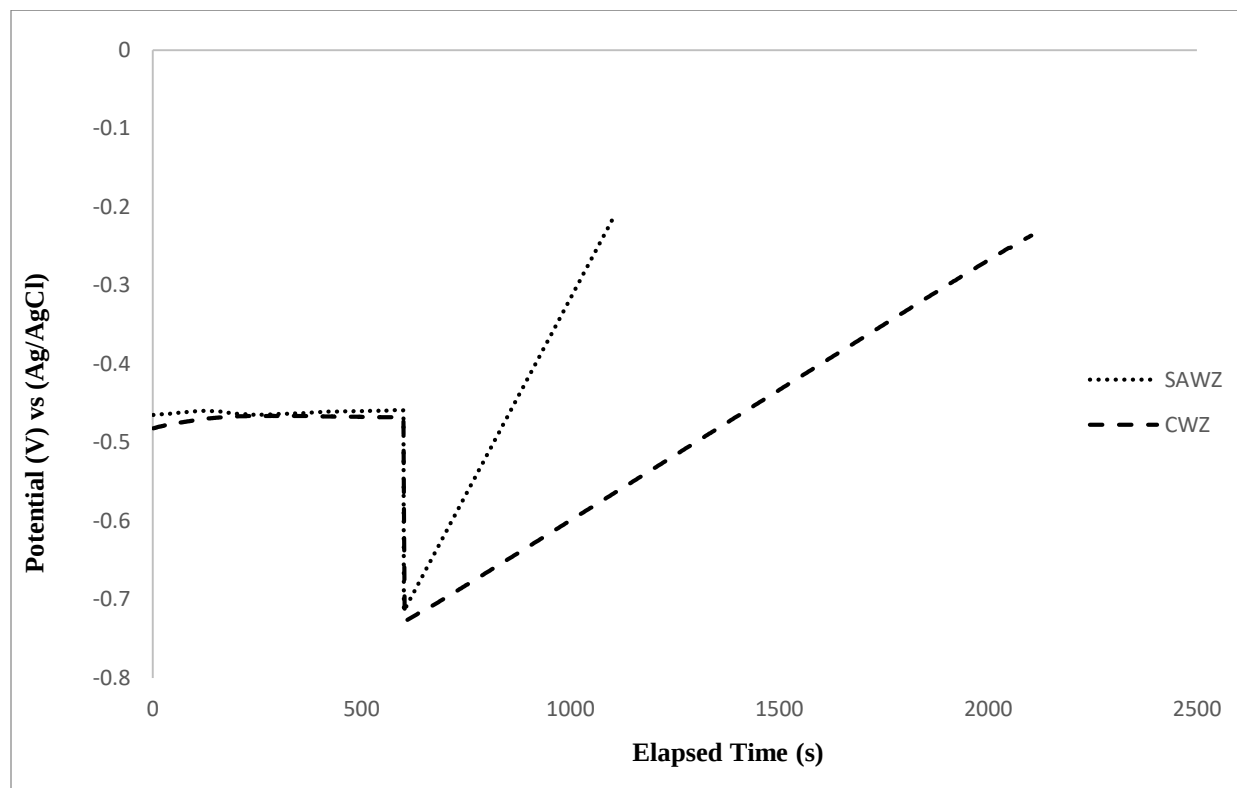


Figure 4.4c: OCP Plots for the Control and Solution Annealed Welded Zone of the Samples Immersed in 1.0M NaCl Environment

The OCP plot in Figure 4.4c, show that there was a stable corrosion potential for both the control and solution annealed samples at about 600 seconds, and a sharp decrease in corrosion potential of all the samples followed by a progressive increase in the corrosion potential for the remaining period of exposure time. The control welded zone (CWZ) samples gave the highest corrosion potential of -0.74V (Ag/AgCl) compared to the solution annealed welded zone (SAWZ) sample that gave a corrosion potential of -0.72V (Ag/AgCl). This depicts that the control samples are corroding more than solution annealed samples.

4.4.1.2.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Open Circuit Potential (OCP)

Kato et al., (1978), in their investigation reported that electrochemical difference (potential) between the parent metal (PM), heat affected zone (HAZ) and weld zone (WZ) results to selective corrosion and these findings was observed in Figure 4.4a to 4.4c. These figures show the OCP plot of electrode potential (V) vs (Ag/AgCl) against the elapsed time (s) for the control and solution annealed samples in 1.0M NaCl environment. The OCP plot in Figure 4.4a, shows that after about 600 seconds of immersion the control and solution annealed samples had attained a stable corrosion potential. It was observed from the graph that there was a sharp decrease (drop) in the corrosion potential between 600 and 700 seconds of immersion, followed by a progressive increase in the corrosion potential values for the remaining period of exposure time. This sharp drop in corrosion potential can be attributed to the damage of the shielding (passive) oxide film of the corrosion product and this is in agreement with the observation of Uhlig (2000), Silverman (2003) and Ikpeseni (2008, 2012) who reported from their investigations that chloride ions have more capability of damaging the protective oxide film formed on the metal/solution interface. They also reported that the damage of the protective oxide film exposes new surface of the steel to the environment which ultimately increased the current density in the system and results to an increase in the corrosion rate. Brandi, (1992) reported that the driving force of film formation (surface oxide) on steel is the free energy of the reaction that occurs between the metal and the corroding medium in the course of the open circuit process (OCP). The progressive increase in the corrosion potential of the samples can be attributed to rebuilding of the passive film on the surface of the steel samples. The control parent metal (CPM) samples gave the highest corrosion potential of -0.72V (SCE) which is equivalent to anodic potential from the Tafel slope shown in Figure 4.3a, when compared to the solution annealed parent metal (SAPM) sample that gave a corrosion potential of -0.70V (SCE) which is equivalent to the anodic potential from the Tafel slope shown

in Figure 4.3a. This finding depicts that the solution annealed samples are more noble (cathodic) and that the control samples are corroding more than the solution annealed sample. This observation could be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed parent metal (PM), which resulted in its low corrosion potential, anodic potential, and corrosion rate. This is in agreement with the findings of Hilbert, (1984), who reported that low anodic potential results in low corrosion rates and that high anodic potential result in an increase in the corrosion rate in chloride medium. Fontana (1974) and Scully (1975) also reported that low anodic potential favored corrosion rate reduction.

The OCP plot in Figure 4.4b, show that there was a stable corrosion potential for both the control and solution annealed samples at about 600 seconds, and a sharp decrease in corrosion potential of all the samples followed by a progressive increase in the corrosion potential for the remaining period of exposure time. The control heat affected zone (CHAZ) samples gave the highest corrosion potential of -0.73V (Ag/AgCl) which is equivalent to anodic potential from the tafel slope shown in Figure 4.3b, when compared to the solution annealed heat affected zone (SAHAZ) sample that gave a corrosion potential of -0.71V (Ag/AgCl) which is equivalent to anodic potential from the tafel slope shown in Figure 4.3b. This depicts that the control samples are corroding more than solution annealed sample. This finding can be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed samples which is in agreement with Anburaj et al., (2012), and also to the presence of carbides in the grain boundaries of the heat affected zone (HAZ) of the control sample. This finding agrees with Vignal et al., (2015).

The OCP plot in Figure 4.4c, show that there was a stable corrosion potential for both the control and solution annealed samples at about 600 seconds, and a sharp decrease in corrosion potential of all the samples followed by a progressive increase in the corrosion potential for the remaining period of exposure time. The control welded zone (CWZ) samples gave the highest corrosion

potential of -0.74V (Ag/AgCl) which is equivalent to anodic potential from the tafel slope shown in Figure 4.3c when compared to the solution annealed welded zone (SAWZ) sample that gave a corrosion potential of -0.72V (Ag/AgCl) which is equivalent to anodic potential from the Tafel slope shown in Figure 4.3c. This depicts that the control samples are corroding more than solution annealed sample. This finding can be attributed to the homogenous dissolution of the carbides in the matrix of the solution annealed samples which is in agreement with Rosemann et al., (2015). In summary, the results obtained from this investigation showed that the protective capabilities of the passive film on the investigated steel improved with the solution annealed samples than the control samples. The OCP of the different regions of the welded steel showed that the parent metal (PM) is more noble (cathodic) than the heat affected zone (HAZ) and the weld zone (WZ).

4.4.1.3 Corrosion Evaluation from Electrochemical Noise (EN)

The statistical electrochemical current noise (ECN) results obtained from electrochemical corrosion analysis of the solution annealed and un-heat treated samples are shown in Table 4.2, while the data used for plotting the graphs in Figures 4.5a – 4.5c are presented in Tables B.10-B.12 of appendix B respectively.

Table 4.2: Statistical Values Computed for Electrochemical Current Noise (ECN) Signals for the Control and Solution Annealed Steel Samples Immersed in 1.0M NaCl Environment

<u>Samples</u>	σ_I (A)	<u>Skewness</u>
<u>CPM</u>	<u>4.6169E-08</u>	<u>0.0691</u>
<u>SAPM</u>	<u>1.5476E-08</u>	<u>0.3920</u>
<u>CHAZ</u>	<u>4.6281E-08</u>	<u>0.0146</u>
<u>SAHAZ</u>	<u>3.5358E-08</u>	<u>0.0356</u>
<u>CWZ</u>	<u>4.9072E-08</u>	<u>0.0132</u>
<u>SAWZ</u>	<u>4.0104E-08</u>	<u>0.0261</u>

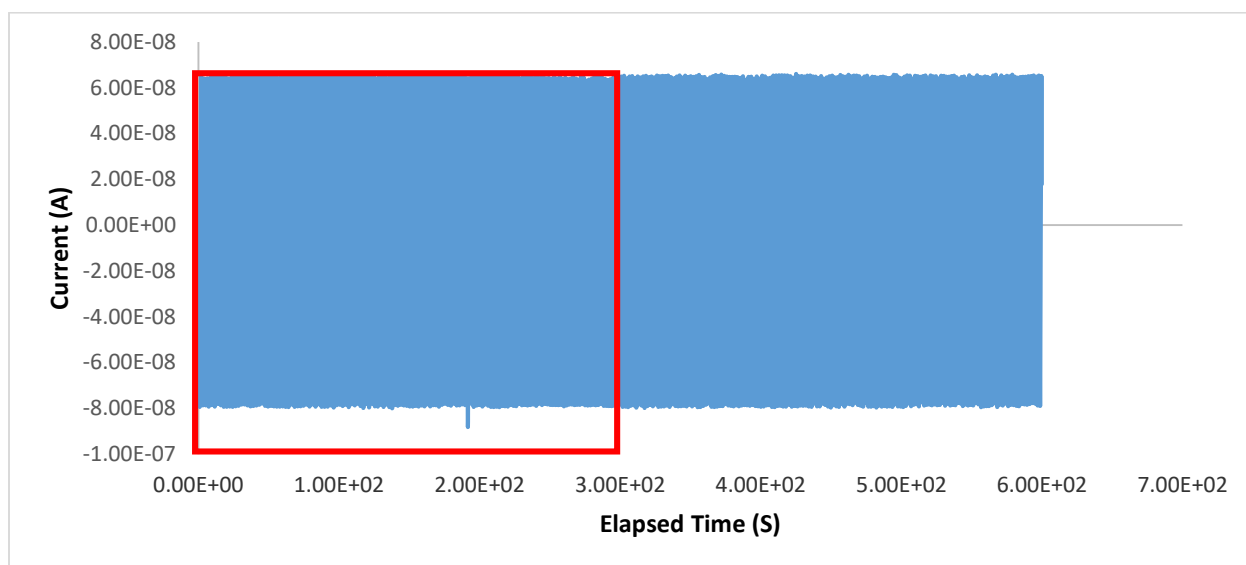


Figure 4.5a: Electrochemical Current Noise (ECN) Plots for the Control Parent Metal (PM) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

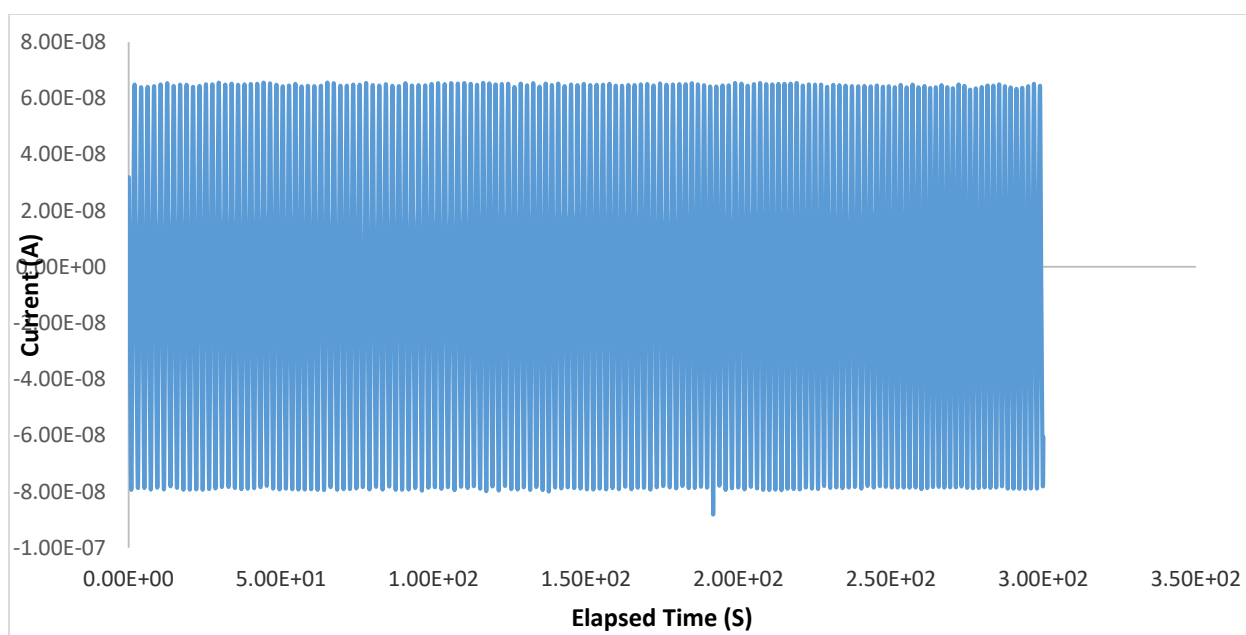


Figure 4.5a1: Extrapolated Electrochemical Current Noise (ECN) Plots for the Control Parent Metal (PM) of the Samples After 600 Seconds of Immersion in 1M NaCl Environment

The extrapolated ECN plot in Figure 4.5a1, shows that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with peak spike at 191.7 seconds of immersion at a current of -8.815×10^{-8} (A). This peak fluctuation indicated that an active corrosion is taking place as a result of film failure and hence fresh sample surface is exposed to further corrosion until a passive film is formed. This peak fluctuation also indicated that there is a tendency of pitting corrosion taking place in the sample.

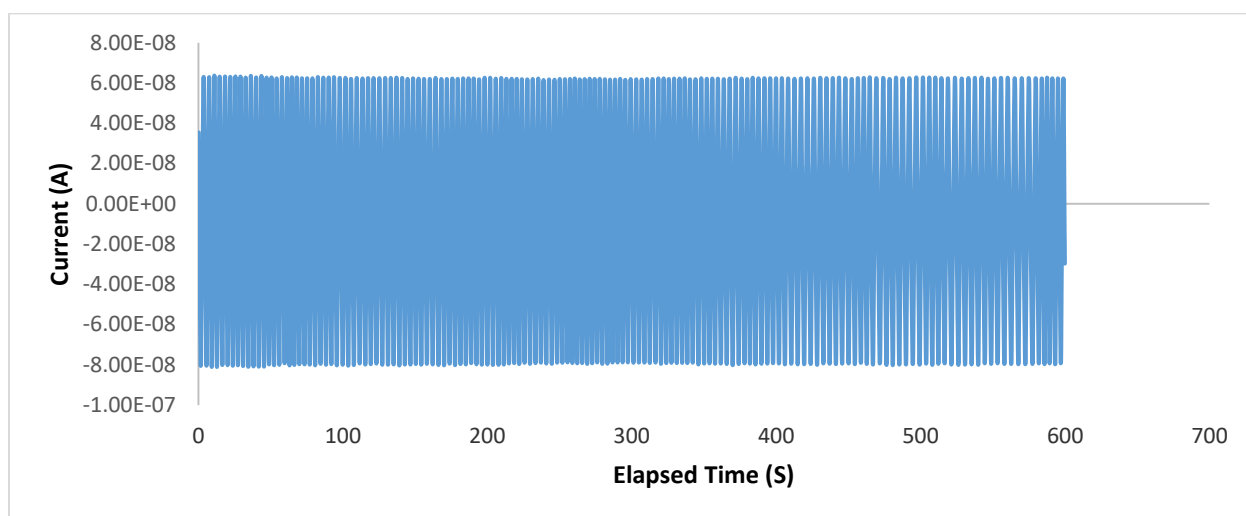


Figure 4.5aa: Electrochemical Current Noise (ECN) Plots for the Solution Annealed Parent Metal (PM) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

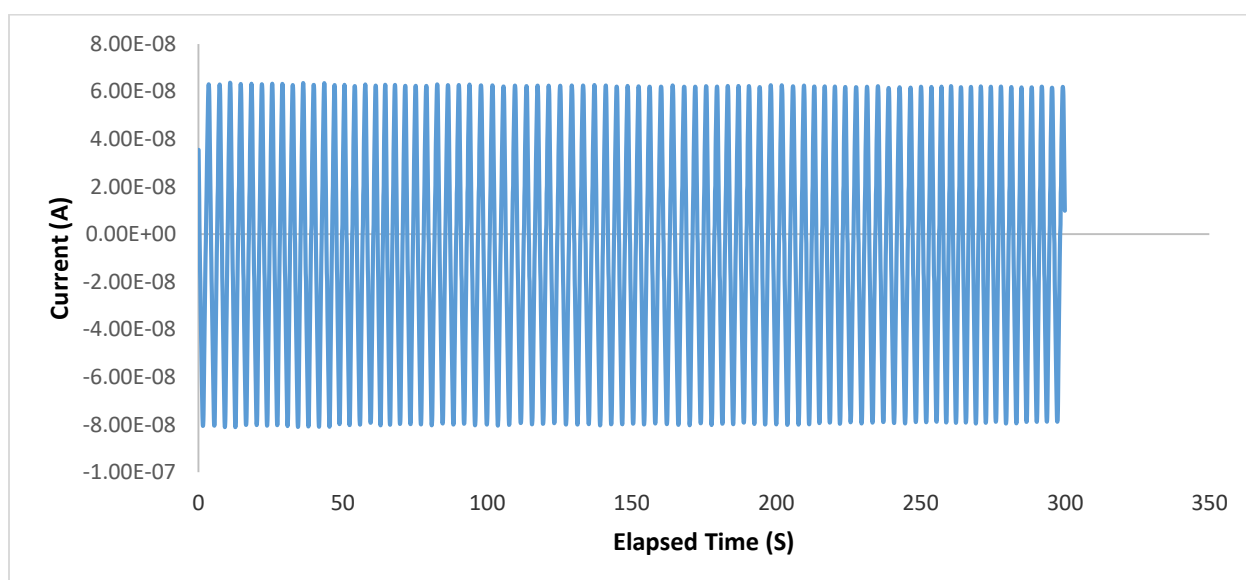


Figure 4.5aa1: Extrapolated Electrochemical Current Noise (ECN) Plots for the Solution Annealed Parent Metal (PM) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

The extrapolated ECN plot in Figure 4.5aa1, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with no apparent significant peak spike throughout period of exposure. This steady fluctuation indicated a uniform corrosion with no tendency for pitting corrosion occurring in the sample.

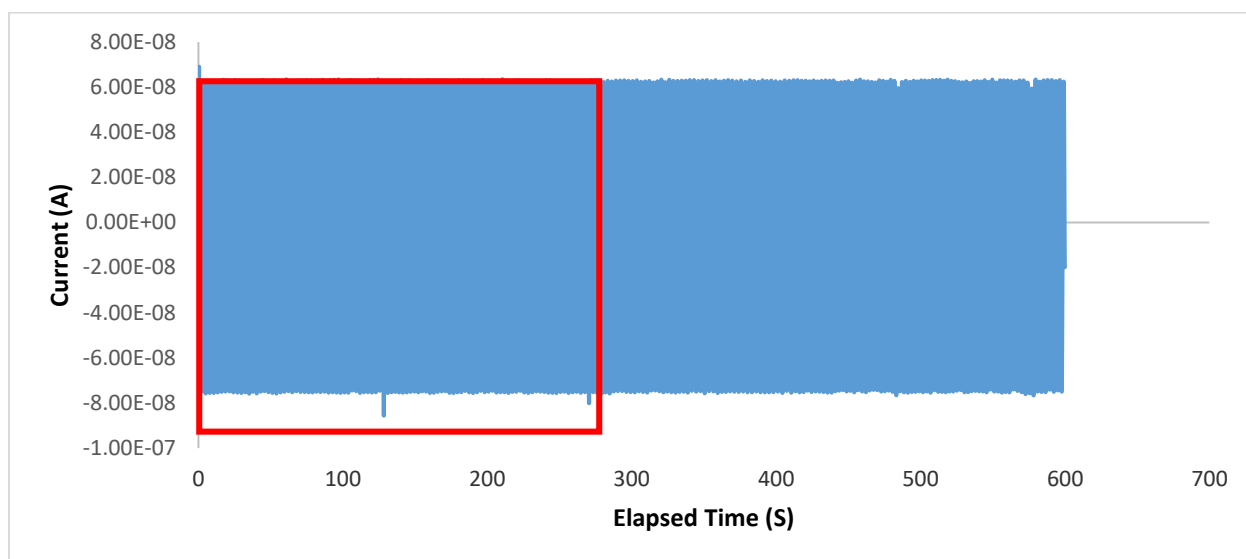


Figure 4.5b: Electrochemical Current Noise (ECN) Plots for the Control Heat Affected Zone (HAZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

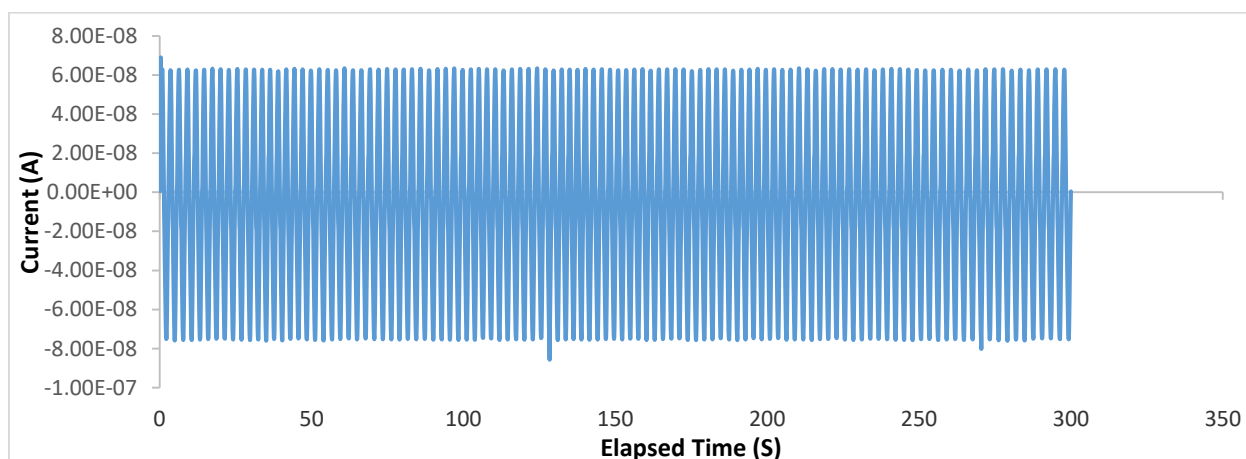


Figure 4.5b1: Extrapolated Electrochemical Current Noise (ECN) Plots for the Control Heat Affected Zone (HAZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

The extrapolated ECN plot in Figure 4.5b₁, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with peak spikes at 128.4 and 270.5 seconds of immersion at a current of -8.5628E-08 and -8.0112E-08 (A). These peak fluctuations indicated that an active corrosion is taking place as a result of film failure and hence fresh sample surface is exposed to further corrosion until a passive film is formed. This peak fluctuation also indicated that there is a tendency of pitting corrosion taking place in the sample.

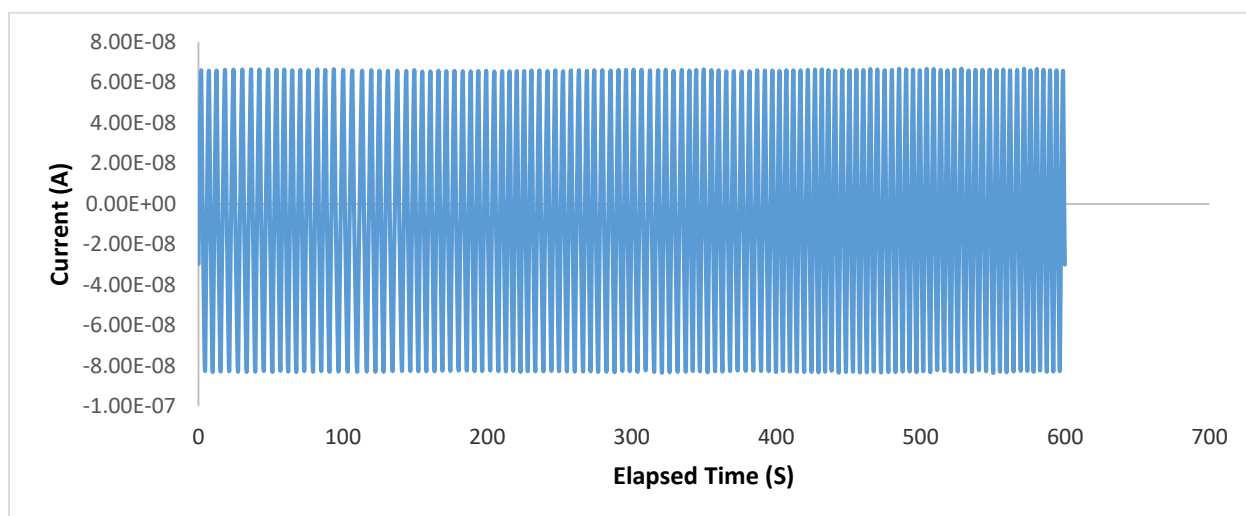


Figure 4.5bb: Electrochemical Current Noise (ECN) Plots for the Solution Annealed Heat Affected Zone (HAZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

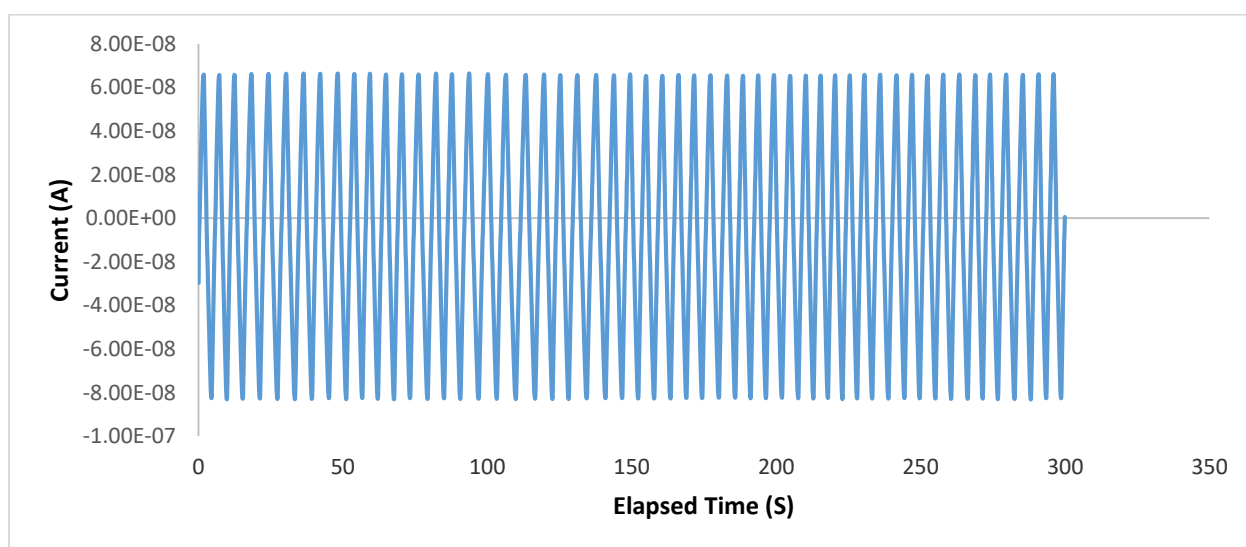


Figure 4.5bb1: Extrapolated Electrochemical Current Noise (ECN) Plots for the Solution Annealed Heat Affected Zone (HAZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

The extrapolated ECN plot in Figure 4.5bb₁, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with no apparent significant peak spike throughout period of exposure. This steady fluctuation indicated a uniform corrosion with no tendency for pitting corrosion occurring in the sample.

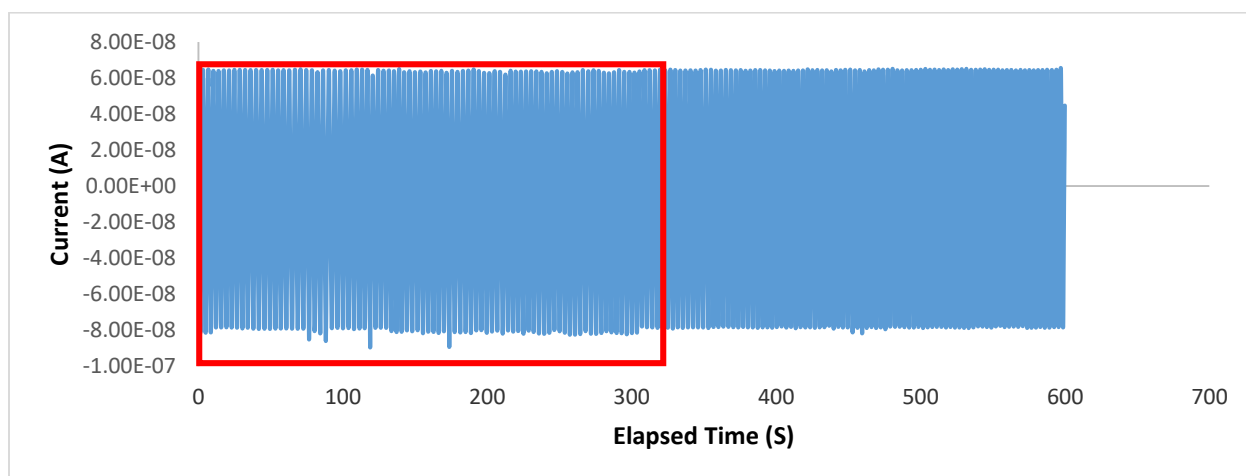


Figure 4.5c: Electrochemical Current Noise (ECN) Plots for the Control Welded Zone (WZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

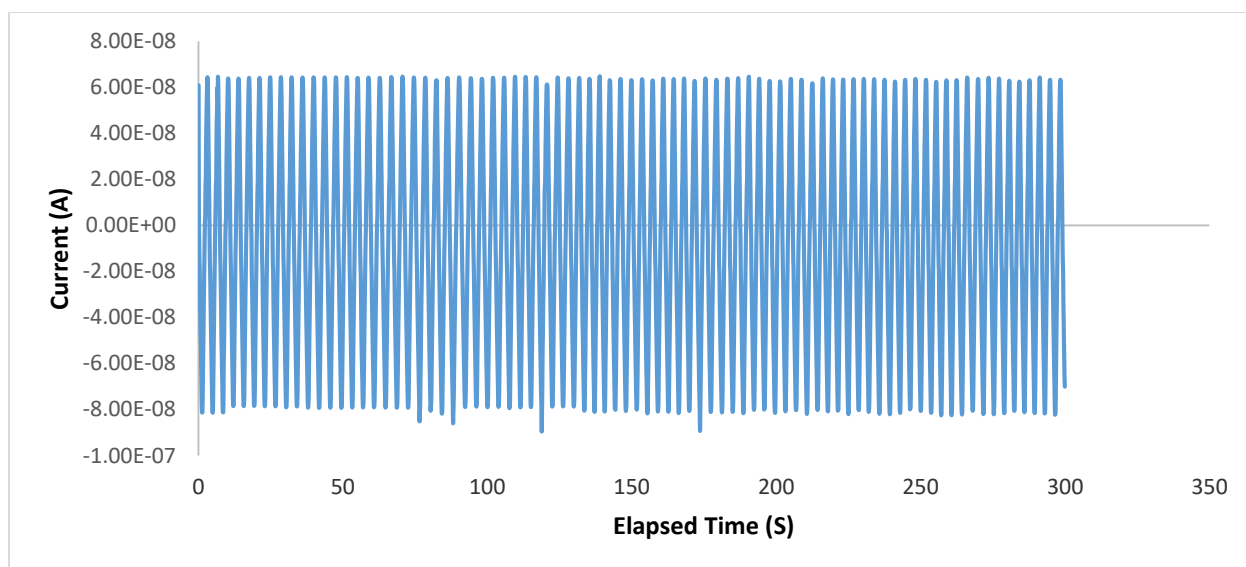


Figure 4.5c₁: Extrapolated Electrochemical Current Noise (ECN) Plots for the Control Welded Zone (WZ) of the Samples After 600 Seconds of Immersion in 1M NaCl Environment

The extrapolated ECN plot in Figure 4.5c₁, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface displayed a non-uniform fluctuation with peak spikes at 76.6, 88.2, 118.9, and 173.7 seconds of immersion at a current of -8.5191E-08, -8.6038E-08, -8.9615E-08, and -8.9334E-08 (A). These peak fluctuations indicated that an active corrosion is taking place as a result of film failure and hence fresh sample surface is exposed to further corrosion until a passive film is formed. This peak fluctuation also indicated that the welded zone is more susceptible to pitting failure than uniform corrosion failure.

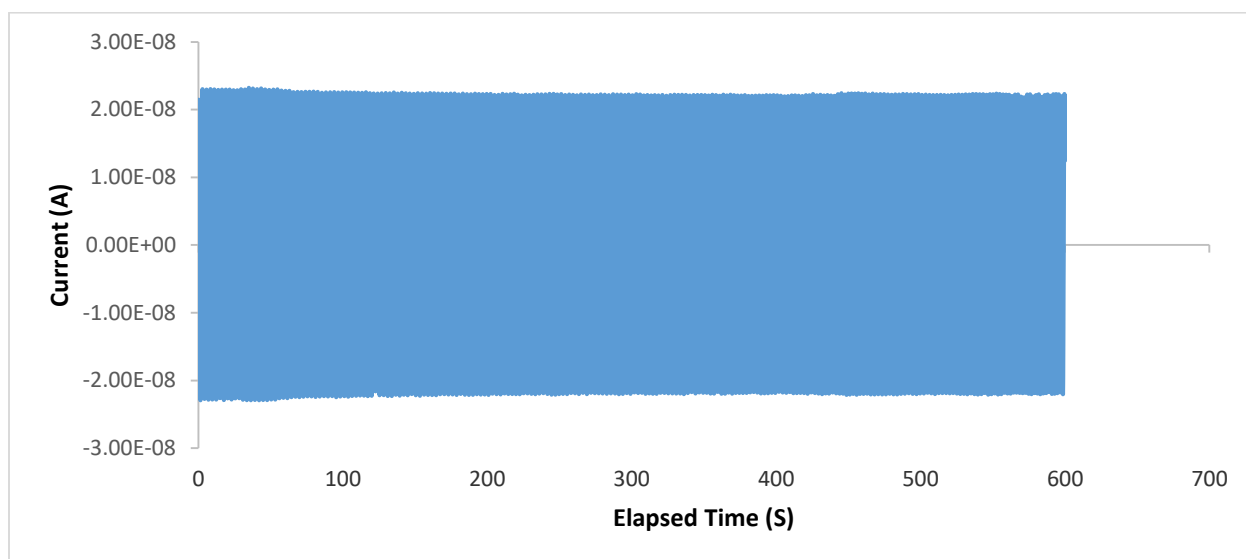


Figure 4.5cc: Electrochemical Current Noise (ECN) Plots for the Solution Annealed Welded Zone (WZ) of the Samples After 600 Seconds of Immersion in 1M NaCl Environment

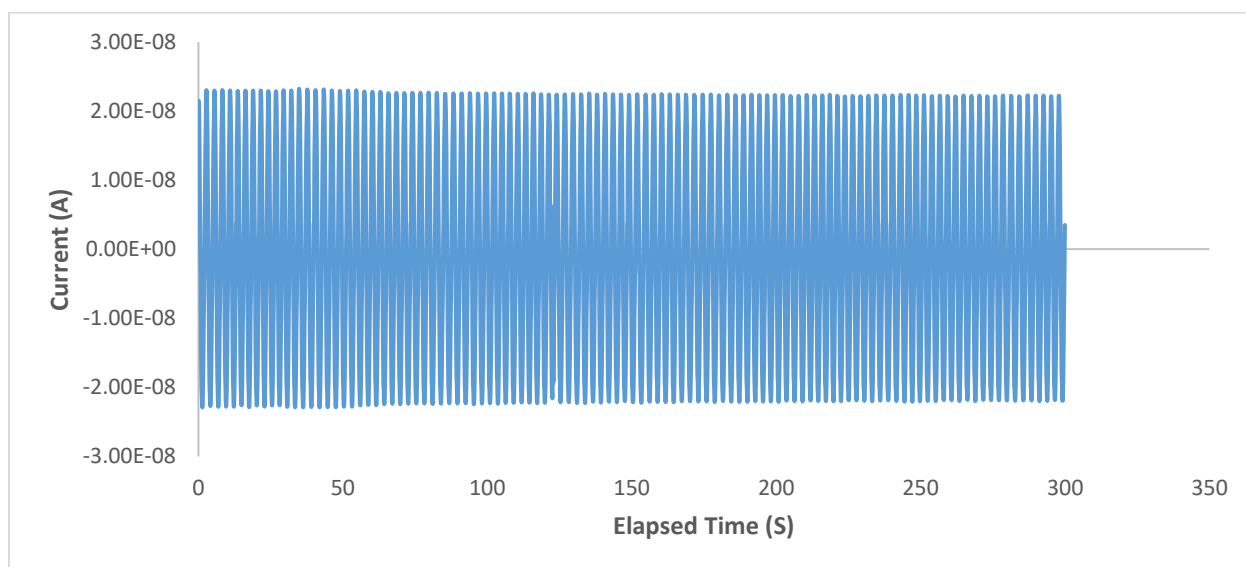


Figure 4.5cc₁: Extrapolated Electrochemical Current Noise (ECN) Plots for the Solution Annealed Welded Zone (WZ) of the Samples After 600 Seconds of Immersion in 1.0M NaCl Environment

The extrapolated ECN plot in Figure 4.5cc₁, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with no apparent significant peak spike throughout period of exposure. This steady fluctuation indicated a uniform corrosion with no tendency for pitting corrosion occurring in the sample.

4.4.1.3.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Electrochemical Current Noise (ECN)

Zheng et al., (2020), in their investigation reported that ECN is an effective technique that is closely related to corrosion rate. This finding was observed in Figure 4.5a -4.5c which show the electrochemical current noise (ECN) plots for the control and solution annealed parent metal (PM), heat affected zone (HAZ) and the welded zone (WZ) of the samples after 600 Seconds of immersion in 1.0M NaCl Environment. The extrapolated ECN plot in Figure 4.5a₁ of the control parent metal (PM) sample, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with peak spike at 191.7 seconds of immersion at a current of $-8.815\text{E}-08$ (A) and thereafter a steady state fluctuation signals was observed with exposure time. This peak fluctuation observed in this study can be attributed to pitting corrosion taking place as a result of film failure and hence fresh sample surface were exposed to further corrosion until a passive film was formed. This finding is in agreement with Obot et al., (2019) who in their investigation reported that sudden peak amplitude of electrochemical current noise (ECN) signals depicts pitting corrosion. This finding is also in agreement with Loto (2012) who also observed that pitting corrosion was initiated by sharp fluctuation of current noise signals. This observation is also in strong agreement with Arellano-Perez et al., (2019), they observed that pitting corrosion is considered to occur when isolated signals or events of high peak spike amplitude occur. This peak fluctuation indicated that there is a tendency of pitting corrosion taking place in the control sample. This finding can be credited to the presence of carbides precipitate at the grain boundaries of the samples. This observation is in good agreement with Vignal et al., (2015), they reported that the presence of carbides at the grain boundaries was responsible for the high susceptibility of the samples to corrosion as the passive film are easily ruptured at this region leading to the formation of pit. The film failure observed in this study could be due to chloride ions in the environment. This finding is in agreement with Zhu

et al., (2020), who reported that chloride ion induced corrosion led to passive film failure and repair on steel surface. The steady state fluctuation later observed could be attributed with the electrochemical events associated with regular and synchronized depassivation and repassivation of brownish iron oxide film formation on the sample surfaces. This finding is in strong agreement with Loto (2018). The extrapolated ECN plot in Figure 4.5aa₁ of the solution annealed parent metal (PM) sample, show that the spontaneous fluctuation with time of the electrochemical current noise passing through the sample surface maintained a steady state fluctuation with no apparent significant peak spike throughout period of exposure. The steady fluctuation observed in this study can be attributed to uniform corrosion. This finding correspond with Arellano-Perez et al., (2019), who in their research reported that uniform corrosion is considered to occur when the instantaneous fluctuation signals are uniform and continuous. This steady fluctuation can be attributed to the homogeneous dissolution of the carbides in the matrix of the solution annealed parent metal (PM) sample. This finding is in good alignment with Shoushtari et al., (2013), who in their research found out that homogeneous carbide distribution in the matrix of the sample obtained during heat treatment remarkably lead to reduced carbide at the grain boundaries which ultimately resulted to an increase in corrosion resistance of the samples. The increase in the corrosion resistance can be attributed to the reduced carbides and nonmetallic inclusion at the grain boundaries which could have been selectively removed from the samples.

The extrapolated ECN plot in Figure 4.5b₁ and 4.5c₁ of the control heat affected zone (HAZ) and the welded zone (WZ), were observed to follow the same pattern of corrosion tendencies as observed with the (PM) with more increased peak spikes from the (HAZ) to the (WZ). The extrapolated plot in Figure 4.5bb₁ and 4.5cc₁ of the solution annealed heat affected zone (HAZ) and the welded zone (WZ) were also observed to follow the same pattern of corrosion tendencies as observed with the (PM). Pit initiation associated with sudden high peak current signals and

reparation of metastable film was not observed on the solution annealed steel samples in the chloride environment. This observation is in strong agreement with Tan et al., (2009), Hamada et al., (2006) and Ebrahimi et al., (2012), from their investigation they reported that solution annealing spontaneously passivated their samples hence resulted to an increased in the resistance of the samples to pitting corrosion. This observation is in good agreement with Afolabi and Peleowo, (2011) who in their research observed that solution annealing increased the resistance of their samples to pitting corrosion as a result of the dissolution of carbides and secondary phases in the matrix of the steel which would have been precipitated at grain boundaries.

In summary, from the electrochemical current noise (ECN) investigation carried out, the control samples were observed to be more susceptible to pitting and uniform corrosion while the solution annealed samples were observed to be only susceptible to uniform corrosion. These findings can be attributed to the homogeneous dissolution of the carbide in the matrix of the solution annealed samples and the presence of carbides at the grain boundaries of the control samples. These findings are in strong agreement with Shoushtari et al., (2013) and Vignal et al., (2015). Greene and Fontana, (1958), reported that pitting corrosion damage is considered more catastrophic than uniform corrosion damage due to the difficulty in detecting, predicting and designing against it. They also observed that a small pit with negligible metal loss can result to a complete engineering system failure.

4.4.1.3.2 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Statistical Evaluation of Electrochemical Current Noise (ECN)

Table 4.2 show the statistical analysis for electrochemical current noise (ECN) signals for the control and solution annealed steel samples immersed in 1M NaCl environment. To qualitatively analyze the symmetrical distribution on the positive /negative direction and the amplitude of the current signals respectively, the skewness and standard deviation of the electrochemical current noise signals for each group of samples were considered which is in accordance with Mansfeld,

(2005) and Da-Hia-Xia et al., (2019). From Table 4.2, it was observed that the values obtained by standard deviations of the electrochemical current noise signals arising from the control samples were higher than that of the ECN signals from the solution annealed samples. This observable difference in standard deviation can be credited to the higher amplitude of signals obtained from the control samples and this finding is in accordance with Pistorius, (1997) and Shahidi et al., (2012). The symmetrical distribution on the positive /negative direction i.e the unidirectionality of the ECN signals of the samples obtained by the skewness, show that the signals of the solution annealed samples have a higher skewness than the control samples. This observation suggests that the signals obtained from the solution annealed samples in the chloride environment are more unidirectional than the control samples. This finding can be attributed to stable oxide film formation on the solution annealed samples and this is in agreement with the result obtained from Figure 4.5a-4.5c respectively.

4.4.1.4 Corrosion Evaluation from Electrochemical Impedance Spectroscopy (EIS)

The EIS results obtained from electrochemical corrosion analysis of the solution annealed and un-heat treated samples are presented in this section. Tables 4.3 -4.5 data were used to plot the graphs in Figures 4.6a – 4.6c.

Table 4.3: Electrochemical Impedance Spectroscopy (EIS) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1.0M NaCl Environment

CPM		SAPM	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
3.79E+00	9.86E-02	1.17E+01	3.04E-01
3.79E+00	1.20E-01	1.17E+01	3.70E-01
3.80E+00	1.46E-01	1.17E+01	4.50E-01
3.81E+00	1.77E-01	1.18E+01	5.47E-01
3.82E+00	2.15E-01	1.18E+01	6.65E-01
3.83E+00	2.62E-01	1.18E+01	8.09E-01
3.84E+00	3.18E-01	1.19E+01	9.84E-01
3.86E+00	3.87E-01	1.19E+01	1.20E+00
3.88E+00	4.71E-01	1.20E+01	1.45E+00
3.90E+00	5.72E-01	1.21E+01	1.77E+00
3.93E+00	6.95E-01	1.21E+01	2.15E+00

CPM		SAPM	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
3.97E+00	8.45E-01	1.23E+01	2.61E+00
4.01E+00	1.03E+00	1.24E+01	3.17E+00
4.07E+00	1.25E+00	1.26E+01	3.86E+00
4.13E+00	1.52E+00	1.28E+01	4.69E+00
4.21E+00	1.85E+00	1.30E+01	5.70E+00
4.31E+00	2.24E+00	1.33E+01	6.93E+00
4.43E+00	2.72E+00	1.37E+01	8.42E+00
4.58E+00	3.31E+00	1.42E+01	1.02E+01
4.77E+00	4.02E+00	1.47E+01	1.24E+01
5.00E+00	4.88E+00	1.54E+01	1.51E+01
5.28E+00	5.93E+00	1.63E+01	1.83E+01
5.63E+00	7.19E+00	1.74E+01	2.22E+01
6.07E+00	8.72E+00	1.88E+01	2.69E+01
6.62E+00	1.06E+01	2.05E+01	3.27E+01
7.31E+00	1.28E+01	2.26E+01	3.96E+01
8.19E+00	1.55E+01	2.53E+01	4.79E+01
9.31E+00	1.87E+01	2.88E+01	5.79E+01
1.07E+01	2.26E+01	3.32E+01	6.99E+01
1.26E+01	2.73E+01	3.89E+01	8.42E+01
1.50E+01	3.28E+01	4.63E+01	1.01E+02
1.81E+01	3.93E+01	5.59E+01	1.21E+02
2.21E+01	4.69E+01	6.84E+01	1.45E+02
2.74E+01	5.56E+01	8.47E+01	1.72E+02
3.43E+01	6.56E+01	1.06E+02	2.03E+02
4.32E+01	7.66E+01	1.34E+02	2.37E+02
5.46E+01	8.85E+01	1.69E+02	2.73E+02
6.90E+01	1.01E+02	2.13E+02	3.11E+02
8.66E+01	1.13E+02	2.67E+02	3.48E+02
1.07E+02	1.23E+02	3.32E+02	3.80E+02
1.31E+02	1.31E+02	4.06E+02	4.05E+02
1.57E+02	1.36E+02	4.86E+02	4.19E+02
1.84E+02	1.36E+02	5.69E+02	4.20E+02
2.11E+02	1.32E+02	6.51E+02	4.09E+02
2.35E+02	1.25E+02	7.26E+02	3.87E+02
2.57E+02	1.15E+02	7.94E+02	3.56E+02
2.75E+02	1.04E+02	8.51E+02	3.21E+02
2.90E+02	9.16E+01	8.97E+02	2.83E+02
3.03E+02	7.96E+01	9.35E+02	2.46E+02
3.12E+02	6.83E+01	9.64E+02	2.11E+02
3.19E+02	5.81E+01	9.87E+02	1.79E+02
3.25E+02	4.90E+01	1.00E+03	1.51E+02
3.29E+02	4.11E+01	1.02E+03	1.27E+02
3.33E+02	3.43E+01	1.03E+03	1.06E+02

CPM		SAPM	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
3.35E+02	2.86E+01	1.04E+03	8.83E+01
3.37E+02	2.37E+01	1.04E+03	7.33E+01
3.39E+02	1.97E+01	1.05E+03	6.07E+01
3.40E+02	1.63E+01	1.05E+03	5.03E+01
3.41E+02	1.34E+01	1.05E+03	4.15E+01
3.42E+02	1.11E+01	1.06E+03	3.43E+01
3.42E+02	9.16E+00	1.06E+03	2.83E+01

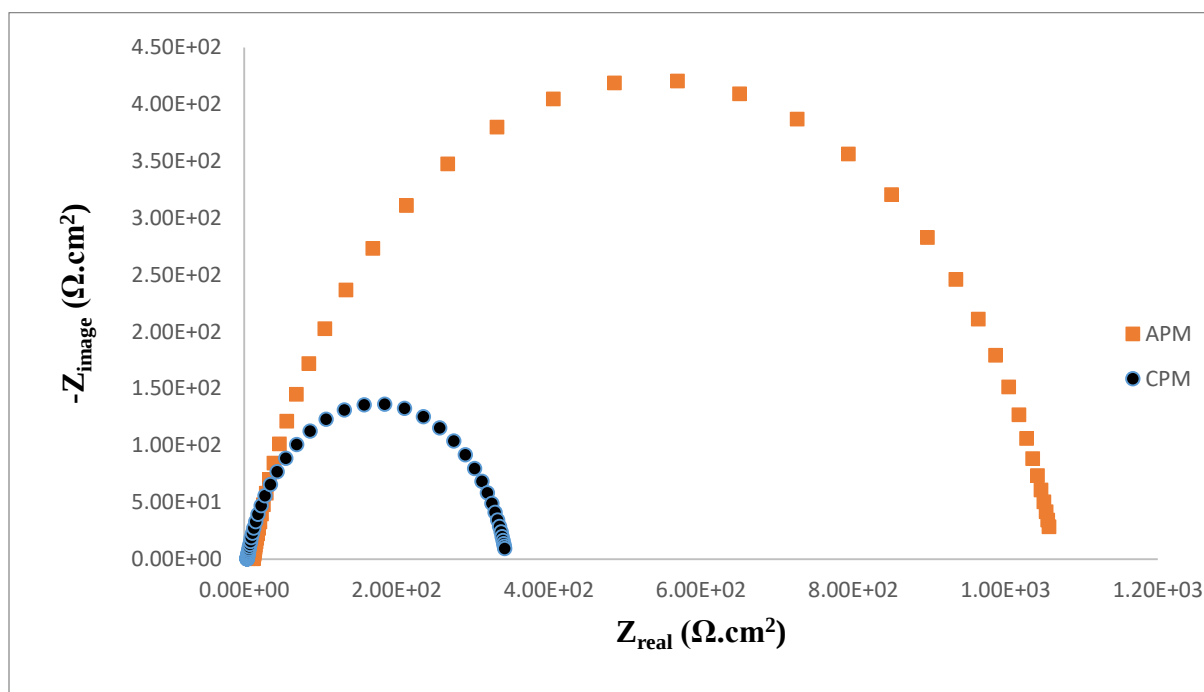


Figure 4.6a: Nyquist Plots for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1.0M NaCl Environment

The Nyquist plots of the EIS spectra obtained at OCP for the control and solution annealed parent metal (PM) are presented in Figure 4.6a. It shows high frequency semicircles capacitive arc with the solution annealed sample displaying a bigger capacitive arc when compared to the control sample. The substantial difference between the capacitive arc indicated the effectiveness of solution annealing heat treatment (SAHT) toward corrosion protection. Thus, the solution annealed sample offer better corrosion resistance than the control sample.

Table 4.4: Electrochemical Impedance Spectroscopy (EIS) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1.0M NaCl Environment

CHAZ		SAHAZ	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
2.46E+00	6.41E-02	3.71E+00	9.65E-02
2.47E+00	7.79E-02	3.71E+00	1.17E-01
2.47E+00	9.47E-02	3.72E+00	1.43E-01
2.47E+00	1.15E-01	3.73E+00	1.74E-01
2.48E+00	1.40E-01	3.74E+00	2.11E-01
2.49E+00	1.70E-01	3.75E+00	2.57E-01
2.50E+00	2.07E-01	3.76E+00	3.12E-01
2.51E+00	2.52E-01	3.78E+00	3.79E-01
2.52E+00	3.06E-01	3.80E+00	4.61E-01
2.54E+00	3.72E-01	3.82E+00	5.60E-01
2.56E+00	4.52E-01	3.85E+00	6.81E-01
2.58E+00	5.50E-01	3.89E+00	8.28E-01
2.61E+00	6.68E-01	3.93E+00	1.01E+00
2.64E+00	8.12E-01	3.98E+00	1.22E+00
2.69E+00	9.87E-01	4.05E+00	1.49E+00
2.74E+00	1.20E+00	4.13E+00	1.81E+00
2.80E+00	1.46E+00	4.22E+00	2.20E+00
2.88E+00	1.77E+00	4.34E+00	2.67E+00
2.98E+00	2.15E+00	4.49E+00	3.24E+00
3.10E+00	2.61E+00	4.67E+00	3.94E+00
3.25E+00	3.17E+00	4.90E+00	4.78E+00
3.43E+00	3.85E+00	5.17E+00	5.80E+00
3.66E+00	4.68E+00	5.52E+00	7.04E+00
3.95E+00	5.67E+00	5.95E+00	8.54E+00
4.30E+00	6.87E+00	6.49E+00	1.04E+01
4.76E+00	8.33E+00	7.16E+00	1.25E+01
5.33E+00	1.01E+01	8.03E+00	1.52E+01
6.05E+00	1.22E+01	9.12E+00	1.84E+01
6.99E+00	1.47E+01	1.05E+01	2.22E+01
8.19E+00	1.77E+01	1.23E+01	2.67E+01
9.74E+00	2.13E+01	1.47E+01	3.21E+01
1.18E+01	2.55E+01	1.77E+01	3.85E+01
1.44E+01	3.05E+01	2.17E+01	4.59E+01
1.78E+01	3.62E+01	2.69E+01	5.45E+01
2.23E+01	4.26E+01	3.36E+01	6.42E+01
2.81E+01	4.98E+01	4.23E+01	7.51E+01
3.55E+01	5.75E+01	5.35E+01	8.67E+01
4.48E+01	6.55E+01	6.76E+01	9.86E+01
5.63E+01	7.31E+01	8.48E+01	1.10E+02

CHAZ		SAHAZ	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
6.99E+01	7.99E+01	1.05E+02	1.20E+02
8.54E+01	8.51E+01	1.29E+02	1.28E+02
1.02E+02	8.81E+01	1.54E+02	1.33E+02
1.20E+02	8.85E+01	1.81E+02	1.33E+02
1.37E+02	8.61E+01	2.06E+02	1.30E+02
1.53E+02	8.14E+01	2.30E+02	1.23E+02
1.67E+02	7.50E+01	2.52E+02	1.13E+02
1.79E+02	6.75E+01	2.70E+02	1.02E+02
1.89E+02	5.95E+01	2.85E+02	8.97E+01
1.97E+02	5.17E+01	2.96E+02	7.79E+01
2.03E+02	4.44E+01	3.06E+02	6.69E+01
2.08E+02	3.77E+01	3.13E+02	5.69E+01
2.11E+02	3.18E+01	3.18E+02	4.80E+01
2.14E+02	2.67E+01	3.23E+02	4.03E+01
2.16E+02	2.23E+01	3.26E+02	3.36E+01
2.18E+02	1.86E+01	3.28E+02	2.80E+01
2.19E+02	1.54E+01	3.30E+02	2.32E+01
2.20E+02	1.28E+01	3.32E+02	1.93E+01
2.21E+02	1.06E+01	3.33E+02	1.59E+01
2.22E+02	8.74E+00	3.34E+02	1.32E+01
2.22E+02	7.22E+00	3.35E+02	1.09E+01
2.23E+02	5.95E+00	3.35E+02	8.97E+00

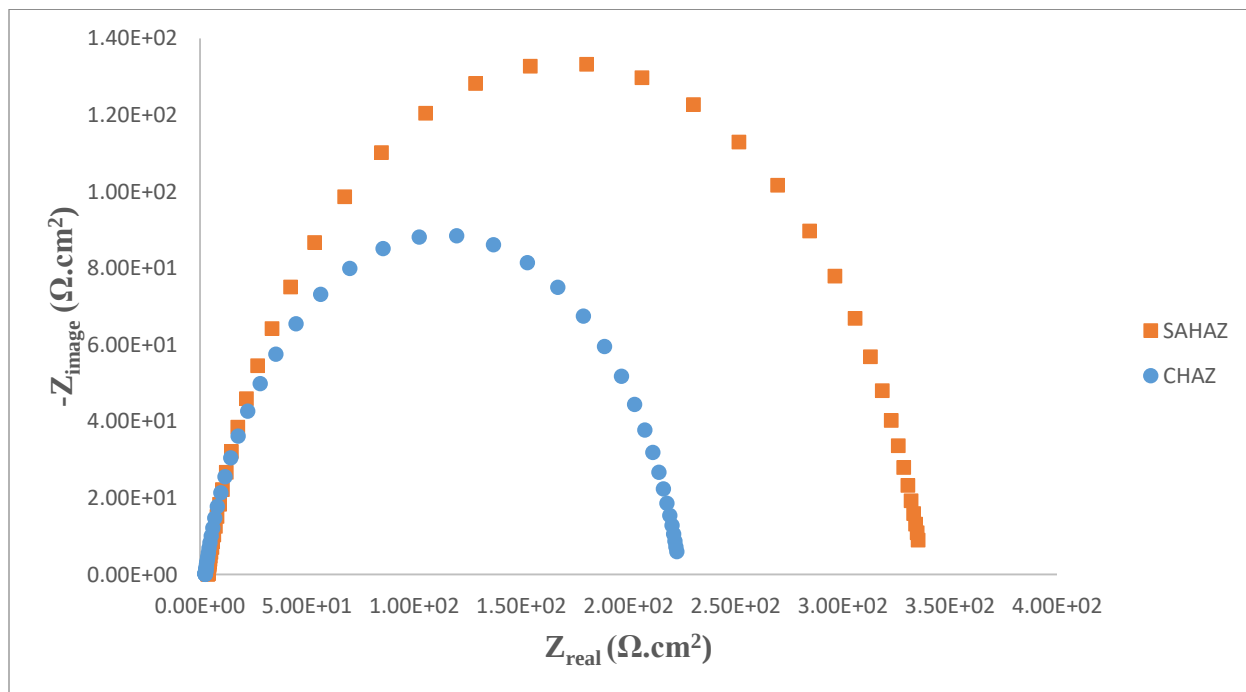


Figure 4.6b: Nyquist Plots for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1.0M NaCl Environment

The Nyquist plots of the EIS spectra obtained at OCP for the control and solution annealed heat affected zone (HAZ) are presented in Figure 4.6b. It shows high frequency semicircles capacitive arc with the solution annealed sample displaying a bigger capacitive arc when compared to the control sample. The substantial difference between the capacitive arc indicated the effectiveness of solution annealing heat treatment (SAHT) toward corrosion protection. Thus, the solution annealed sample offer better corrosion resistance than the control sample.

Table 4.5: Electrochemical Impedance Spectroscopy (EIS) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Welded Zone (WZ) of the Samples Immersed in 1.0M NaCl Environment

CWZ		SAWZ	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
7.113481	0.18513	20.14	0.52
7.123016	0.225089	20.17	0.64
7.134615	0.27367	20.20	0.77
7.148726	0.332734	20.24	0.94
7.165898	0.404542	20.29	1.15
7.186796	0.491841	20.35	1.39
7.212234	0.597971	20.42	1.69
7.243208	0.726989	20.51	2.06
7.280931	0.883825	20.61	2.50
7.326893	1.074469	20.74	3.04
7.382915	1.306195	20.90	3.70
7.451237	1.587836	21.10	4.50
7.534612	1.930115	21.33	5.46
7.636434	2.346044	21.62	6.64
7.760899	2.851408	21.97	8.07
7.913209	3.465341	22.40	9.81
8.099839	4.211025	22.93	11.92
8.328883	5.116521	23.58	14.49
8.6105	6.21576	24.38	17.60
8.957519	7.549717	25.36	21.38
9.386227	9.167791	26.58	25.96
9.917437	11.12941	28.08	31.51
10.57793	13.50585	29.95	38.24
11.40239	16.38234	32.28	46.38
12.43607	19.86024	35.21	56.23
13.73841	24.05942	38.90	68.12
15.38792	29.12033	43.57	82.45
17.48888	35.20569	49.52	99.68

CWZ		SAWZ	
$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$	$-Z_{\text{image}} (\Omega.\text{cm}^2)$	$Z_{\text{real}} (\Omega.\text{cm}^2)$
20.18021	42.50086	57.14	120.33
23.64721	51.21188	66.95	145.00
28.13655	61.55951	79.66	174.29
33.97457	73.76641	96.19	208.86
41.58788	88.03381	117.75	249.25
51.52309	104.5027	145.88	295.88
64.45881	123.194	182.50	348.80
81.19705	143.925	229.90	407.50
102.6143	166.2051	290.53	470.58
129.5482	189.1293	366.79	535.49
162.6022	211.3144	460.38	598.30
201.881	230.943	571.59	653.87
246.7254	245.9819	698.56	696.45
295.5771	254.5866	836.87	720.82
346.1055	255.5846	979.94	723.64
395.6261	248.8343	1120.15	704.53
441.6693	235.2708	1250.51	666.13
482.4566	216.6129	1365.99	613.30
517.1052	194.8902	1464.09	551.80
545.5487	172.0034	1544.63	487.00
568.2908	149.456	1609.02	423.16
586.1315	128.271	1659.53	363.18
599.9514	109.0349	1698.66	308.71
610.578	91.99808	1728.74	260.48
618.7232	77.18227	1751.81	218.53
624.9666	64.47034	1769.48	182.54
629.7634	53.67198	1783.07	151.96
633.4635	44.56721	1793.54	126.18
636.3319	36.93325	1801.66	104.57
638.5678	30.55953	1807.99	86.52
640.3207	25.25514	1812.96	71.51
641.7028	20.85161	1816.87	59.04
642.7983	17.20293	1819.97	48.71

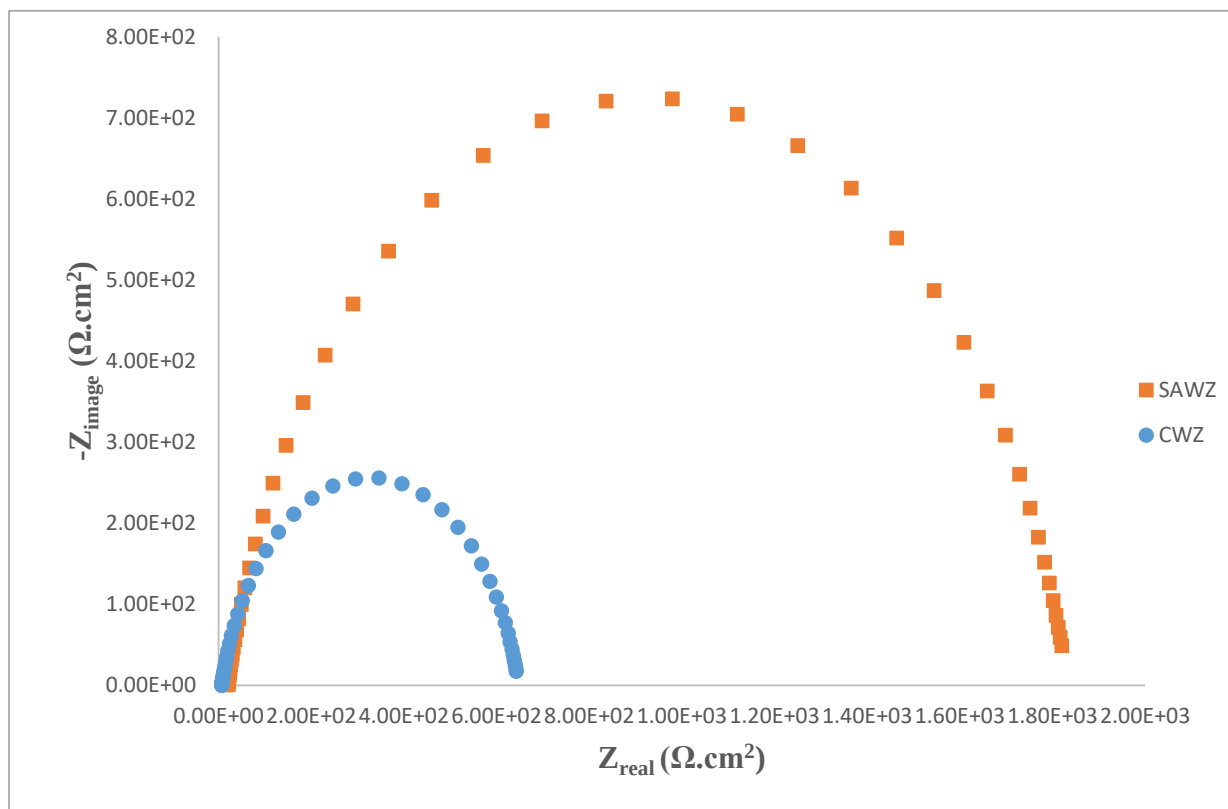


Figure 4.6c: Nyquist Plots for the Control and Solution Annealed Welded Zone (WZ) of the Samples Immersed in 1.0M NaCl Environment

The Nyquist plots of the EIS spectra obtained at OCP for the control and solution annealed heat affected zone (HAZ) are presented in Figure 4.6c. It shows high frequency semicircles capacitive arc with the solution annealed sample displaying a bigger capacitive arc when compared to the control sample. The substantial difference between the capacitive arc indicated the effectiveness of solution annealing heat treatment (SAHT) toward corrosion protection. Thus, the solution annealed sample offer better corrosion resistance than the control sample.

4.4.1.4.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Electrochemical Impedance Spectroscopy (EIS)

Studies by (Ihsan-ul-Haq, 2014; Pardo et al., 2008; Lucio-Garcia et al., 2009; and Gao et al., 2009), in their investigation reported that metal dissolution reaction is closely considered to be associated with the semicircle capacitive arc. They also reported that the diameter of each of the semicircle capacitive arc has a direct relationship with charge transfer resistance at the metal solution interface. In chloride solutions, the corrosion mechanism of steel is mostly accompanied by iron oxide film formation (Bertolini et al., 2004; Broomfield, 2007; Sherif et al., 2010 and Sherif et al., 2013). Thus, the increase in the impedance and also the semicircle capacitive arc diameter of the Nyquist EIS semicircle is attributed to iron oxide film growth. The decrease in the semicircle capacitive arc diameter indicates that the growth of the oxide film continues till a critical thickness, after which the oxide films crack and detached from the surface of the metal resulting in the decrease of the Nyquist EIS semicircle diameter arc (Lucio-Garcia et al., 2009). These findings were observed in Figure 4.6a - 4.6c, which show the electrochemical impedance spectroscopy (EIS) plots for the control and solution annealed parent metal (PM), heat affected zone (HAZ) and the welded zone (WZ) of the samples in 1M NaCl Environment. The Nyquist plots of the EIS spectra obtained at OCP for the control and solution annealed parent metal (PM) are presented in Figure 4.6a. It shows high frequency semicircles capacitive arc diameter with the solution annealed sample displaying a bigger semicircle capacitive arc diameter when compared to the control sample which displayed the smallest semicircle capacitive arc diameter. The semicircle capacitive arc diameter of the solution annealed sample was observed to be significantly bigger, therefore, indicating a reduced metal dissolution rates at the interface of the metal/solution for these samples. The bigger semicircle capacitive arc diameter of the solution annealed samples can also be said to be related to its increased charge transfer resistance at the interface of the metal/solution for these samples. These observations are in agreement with (Ihsan-ul-Haq, (2014); Pardo et al., (2008);

Lucio-Garcia et al., (2009); and Gao et al., 2009), which can be attributed to the homogeneous dissolution of the carbides in the matrix of the solution annealed samples and ultimately assisted in the suppression of the carbides species activity at the interface of the metal/solution. This corresponds to the observation of Ihsan-ul-Haq, (2014). The smaller semicircle capacitive arc diameter observed with the control samples can be related to increased metal dissolution rates and also to decreased charged transfer resistance at the interface of the metal/solution for these samples. These can be attributed to the presence of carbides precipitate at the grain boundaries of the samples which is in good agreement with Vignal et al., (2015).

Figure 4.6b and 4.6c of the control and solution annealed heat affected zone (HAZ) and the welded zone (WZ), was observed to follow the same pattern of corrosion tendencies as the (PM). Evidently, the substantial difference between the semicircle capacitive arc diameter of the solution annealed samples compared to the control samples indicated the effectiveness of solution annealing heat treatment (SAHT) toward corrosion protection. Thus, the solution annealed samples offer better corrosion resistant than the control samples.

4.5. Gravimetric Corrosion Measurement Evaluation

The gravimetric corrosion measurements were used to determine the corrosion penetration rate and specific metal loss. The results obtained are presented as follows:

4.5.1: Determination of Corrosion Penetration Rate from Gravimetric Measurement

The corrosion penetration rate results obtained from gravimetric corrosion analysis of the solution annealed and un-heat treated samples are presented in this section. Tables 4.6 -4.8 data were used to plot the graphs in Figures 4.7a – 4.7c.

Table 4.6: Corrosion Penetration Rate Results from Gravimetric Corrosion Measurement for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W ₀ (g)	W _f (g)	(W ₀ -W _f)g	(W ₀ -W _f)mg	CR (mg/cm ² /yr)
20	CPM	12.000	11.967	0.033	33	99.398
	SAPM	12.000	11.979	0.021	21	63.253
40	CPM	12.000	11.947	0.053	53	79.819
	SAPM	12.001	11.969	0.032	32	48.193
60	CPM	12.000	11.919	0.081	81	81.901
	SAPM	12.000	11.963	0.037	37	37.412
80	CPM	12.003	11.935	0.068	68	51.476
	SAPM	12.000	11.955	0.045	45	34.065
100	CPM	12.002	11.926	0.076	76	45.977
	SAPM	12.000	11.948	0.052	52	31.458

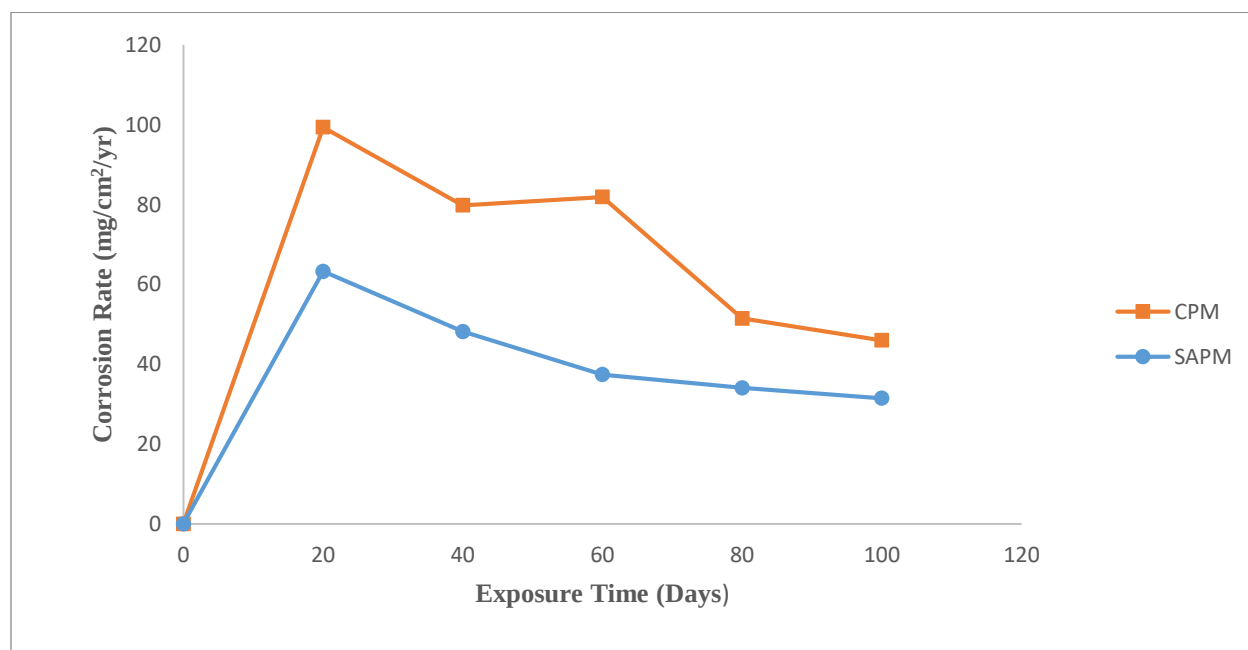


Figure 4.7a: Plot of Corrosion Rate Against Exposure Time for The Control and Solution Annealed Parent Metal (PM) of The Samples Immersed in 1.0M NaCl Environment.

Figure 4.7a show that there was a sharp increase in corrosion rate with exposure time in the 20th day of immersion for both the control and solution annealed samples respectively, with the solution annealed samples displaying the least corrosion rate and the control samples displaying the highest corrosion rate throughout the period of exposure time.

Table 4.7: Corrosion Penetration Rate Results from Gravimetric Corrosion Measurement for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W_0 (g)	W_f (g)	$(W_0 - W_f)$ g	$(W_0 - W_f)$ mg	CR ($\text{mg}/\text{cm}^2/\text{yr}$)
20	CHAZ	12.000	11.963	0.037	37	111.446
	SAHAZ	12.001	11.976	0.025	25	75.301
40	CHAZ	12.000	11.955	0.045	45	67.771
	SAHAZ	12.000	11.963	0.037	37	55.723
60	CHAZ	12.000	11.930	0.070	70	70.779
	SAHAZ	12.003	11.950	0.053	53	53.589
80	CHAZ	12.000	11.929	0.071	71	53.747
	SAHAZ	12.001	11.941	0.060	60	45.420
100	CHAZ	12.000	11.920	0.080	80	48.397
	SAHAZ	12.000	11.932	0.068	68	41.137

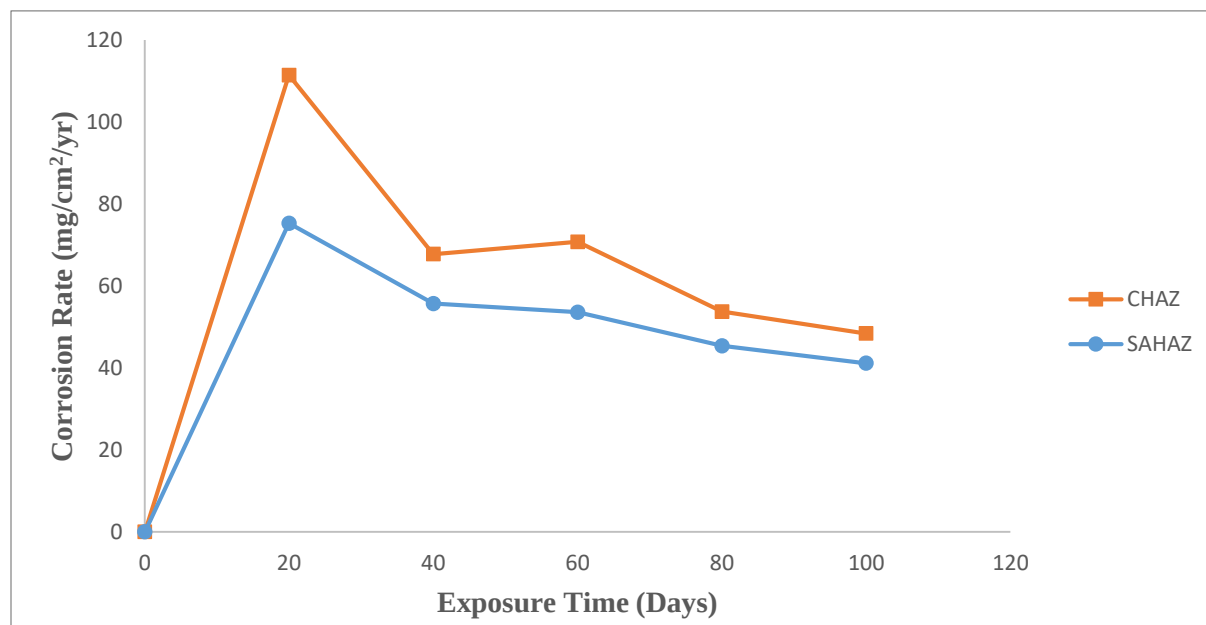


Figure 4.7b: Plot of Corrosion Rate Against Exposure Time for The Control and Solution Annealed Heat Affected Zone (HAZ) of The Samples Immersed in 1.0M NaCl Environment.

Figure 4.7b show that there was a sharp increase in corrosion rate with exposure time in the 20th day of immersion for both the control and solution annealed samples respectively, with the solution annealed samples displaying the least corrosion rate and the control samples displaying the highest corrosion rate throughout the period of exposure time.

Table 4.8: Corrosion Penetration Rate Results from Gravimetric Corrosion Measurement for the Control and Solution Annealed Welded Zone (WZ) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W ₀ (g)	W _f (g)	(W ₀ -W _f)g	(W ₀ -W _f)mg	CR (mg/cm ² /yr)
20	CWZ	12.002	11.956	0.046	46	138.554
	SAWZ	12.000	11.967	0.033	33	99.398
40	CWZ	12.000	11.951	0.049	49	73.795
	SAWZ	12.000	11.961	0.039	39	58.735
60	CWZ	12.001	11.925	0.076	76	76.845
	SAWZ	12.000	11.952	0.048	48	48.534
80	CWZ	12.000	11.922	0.078	78	59.046
	SAWZ	12.003	11.946	0.057	57	43.149
100	CWZ	12.000	11.911	0.089	89	53.842
	SAWZ	12.000	11.936	0.064	64	38.718

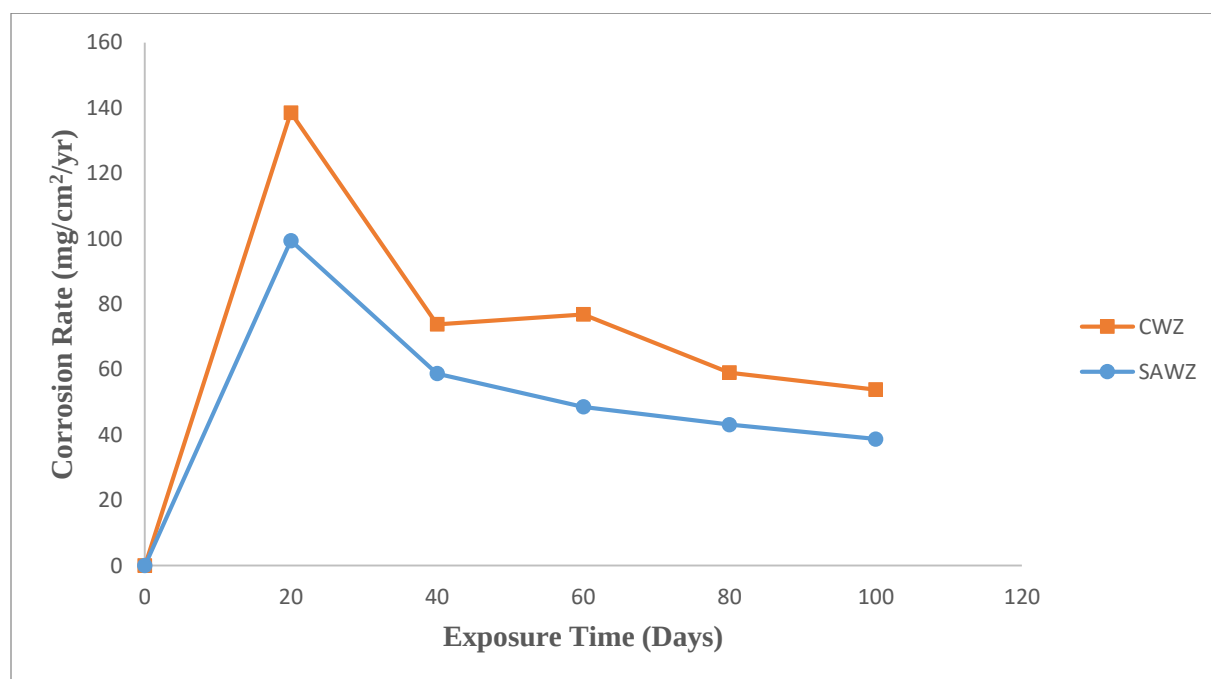


Figure 4.7c: Plot of Corrosion Rate Against Exposure Time for The Control and Solution Annealed Welded Zone (WZ) of The Samples Immersed in 1.0M NaCl Environment.

Figure 4.7c show that there was a sharp increase in corrosion rate with exposure time in the 20th day of immersion for both the control and solution annealed samples respectively, with the solution annealed samples displaying the least corrosion rate and the control samples displaying the highest corrosion rate throughout the period of exposure time.

4.5.1.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Corrosion Penetration Rate Obtained from Gravimetric Measurement

Figure 4.7a show the plot of corrosion rate against exposure time for the control and solution annealed parent metal (PM) samples immersed in 1.0M NaCl solution for the period of 100 days. The result revealed high corrosion rate of 99.398 (mg/cm²/yr) for the control samples with exposure time on the 20th day of immersion, followed by a decrease in the corrosion rate on the 40th day with a spike in the corrosion rate on the 60th day and afterwards followed by a progressive decrease in the corrosion rate for the remaining period of exposure time. The solution annealed samples displayed a sharp transition of corrosion rate of 63.253 (mg/cm²/yr) from active after the 20th day of immersion to passive state resulting in progressive decrease in the corrosion rate throughout the remaining period of exposure time. The sharp increase in corrosion rate observed for both the control and solution annealed samples can be attributed to the anodic dissolution at the interface of the metal/solution and this observation aligns with Loto et al., (1988), they reported that there is an initial increase in corrosion rate within the first period of immersion and that it continues till a passive film is formed due to initial anodic dissolution at the interface of the metal/solution. It was also observed that the corrosion rate in the control samples is greater than that of the solution annealed samples. The possible reason as to why the corrosion rate is greater for the control samples can be attributed to the presence of carbide at the grain boundaries. These carbides present at the grain boundaries are more susceptible to anodic dissolution. The decreased corrosion rate observed with the solution annealed samples can be attributed to the homogeneous dissolution of the carbides at the matrix of the steel, thus, resulting in the reduced presence of carbides at the grain boundaries of the samples and thereby making the solution annealed samples to be less susceptible to corrosion. The formation of iron oxide film which help to partially passivate the samples surfaces could have been explained as the reason for the decrease in the corrosion rate on the 40th day by the control samples and the progressive decrease in the corrosion

rate observed for both the control and solution annealed samples. This observation is in good alignment with David and Denise (2005) and Awheme et al., (2018). They reported that corrosion rate of carbon steel decreases with exposure period as protective films barriers are formed on its surfaces. However, chloride ion has higher tendency of destroying the iron oxide protective film formed on the interface of the metal/solution and as a result exposes fresh samples surface to the chloride environment (Uhlig, 2000; Silverman 2003 and Ikpeseni 2008, 2012). This ultimately increases the corrosion rate as observed in the spike in corrosion rate with the control samples on the 60th day of exposure time. The spike observed indicates the tendency of the control samples to be susceptible to pitting corrosion which is in good agreement with the ECN results, while the sharp transition of corrosion rate of 63.253 (mg/cm²/yr) from active after the 20th day of immersion to passive state resulting in progressive decrease in the corrosion rate throughout the remaining period of exposure time, indicates the tendency of the solution annealed samples to be more susceptible to uniform corrosion and less susceptible to pitting corrosion which also is in good agreement with the ECN results

The gravimetric corrosion rate plots in Figure 4.7b and 4.7c of the control and solution annealed heat affected zone (HAZ) and the welded zone (WZ), were observed to follow the same pattern of corrosion tendencies as the (PM). Higher corrosion rate of 111.446 (mg/cm²/yr) was observed for the control heat affected zone (CHAZ) samples as compared to the solution annealed heat affected zone (SAHAZ) samples that displayed a lower corrosion rate of 75.301 (mg/cm²/yr) with exposure time on the 20th day of immersion. The highest corrosion rate of 138.554 (mg/cm²/yr) was observed for the control welded zone (CWZ) samples as compared to the solution annealed welded zone (SAWZ) samples that displayed a lower corrosion rate of 99.398 (mg/cm²/yr) with exposure time on the 20th day of immersion. The increased corrosion rate of the CHAZ and CWZ samples could be credited to the increased presence of carbides at the grain boundaries, while the decreased

corrosion rate of the SAHAZ and SAWZ samples could be attributed to the reduced presence of carbides at the grain boundaries due to the homogenous dissolution of the carbides in the matrix of the steel and these observations aligns with Anburaj et al., (2012), and Vignal et al., (2015).

In summary, the results obtained from this investigation showed that the solution annealed samples were not prone to pitting corrosion and less susceptible to uniform corrosion compared to the control samples that were prone to pitting corrosion and more susceptible to uniform corrosion, and these observations are in good trend alignment with the results obtained from electrochemical measurements.

4.5.2: Determination of Corrosion Penetration Rate from Specific Metal Loss (S.M.L) and Weight Loss (WL)

The corrosion penetration rate results obtained from specific metal loss and weight loss of gravimetric corrosion analysis of the solution annealed and un-heat treated samples are presented in this section. Tables 4.9 -4.11 data were used to plot the graphs in Figures 4.8a – 4.8c.

Table 4.9: Specific Metal Loss from Gravimetric Corrosion Measurement for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W ₀ (g)	W _f (g)	(W ₀ -W _f)g	(W ₀ -W _f)mg	SML (mg/cm ²)
20	CPM	12	11.967	0.033	33	5.470
	SAPM	12	11.979	0.021	21	3.481
40	CPM	12	11.947	0.053	53	8.785
	SAPM	12.001	11.969	0.032	32	5.304
60	CPM	12	11.919	0.081	81	13.426
	SAPM	12	11.963	0.037	37	6.133
80	CPM	12.003	11.935	0.068	68	11.271
	SAPM	12	11.955	0.045	45	7.459
100	CPM	12.002	11.926	0.076	76	12.597
	SAPM	12	11.948	0.052	52	8.619

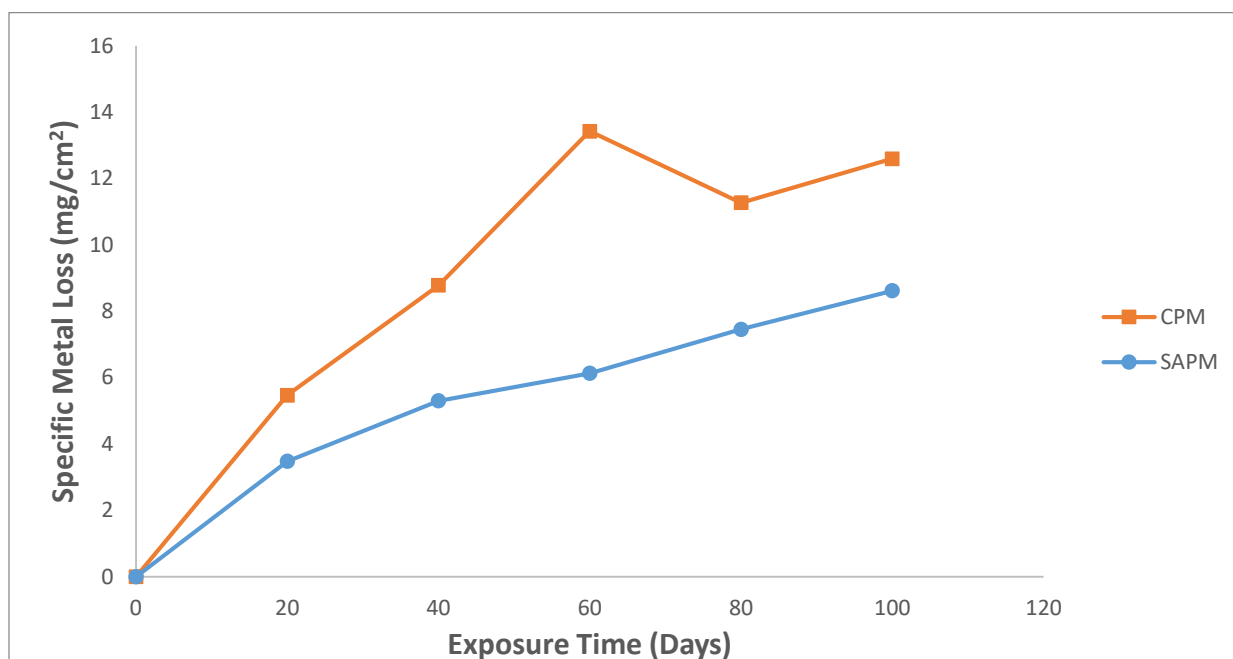


Figure 4.8a: Plot of Specific Metal Loss Against Exposure Time for The Control and Solution Annealed Parent Metal (PM) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.8a revealed that there were increments in the specific metal loss for the control and solution annealed steel investigated samples with the control samples displaying higher metal loss.

Table 4.10: Specific Metal Loss from Gravimetric Corrosion Measurement for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W ₀ (g)	W _f (g)	(W ₀ -W _f)g	(W ₀ -W _f)mg	SML (mg/cm ²)
20	CHAZ	12	11.963	0.037	37	6.133
	SAHAZ	12.001	11.976	0.025	25	4.144
40	CHAZ	12	11.955	0.045	45	7.459
	SAHAZ	12	11.963	0.037	37	6.133
60	CHAZ	12	11.93	0.07	70	11.603
	SAHAZ	12.003	11.95	0.053	53	8.785
80	CHAZ	12	11.929	0.071	71	11.769
	SAHAZ	12.001	11.941	0.06	60	9.945
100	CHAZ	12	11.92	0.08	80	13.260
	SAHAZ	12	11.932	0.068	68	11.271

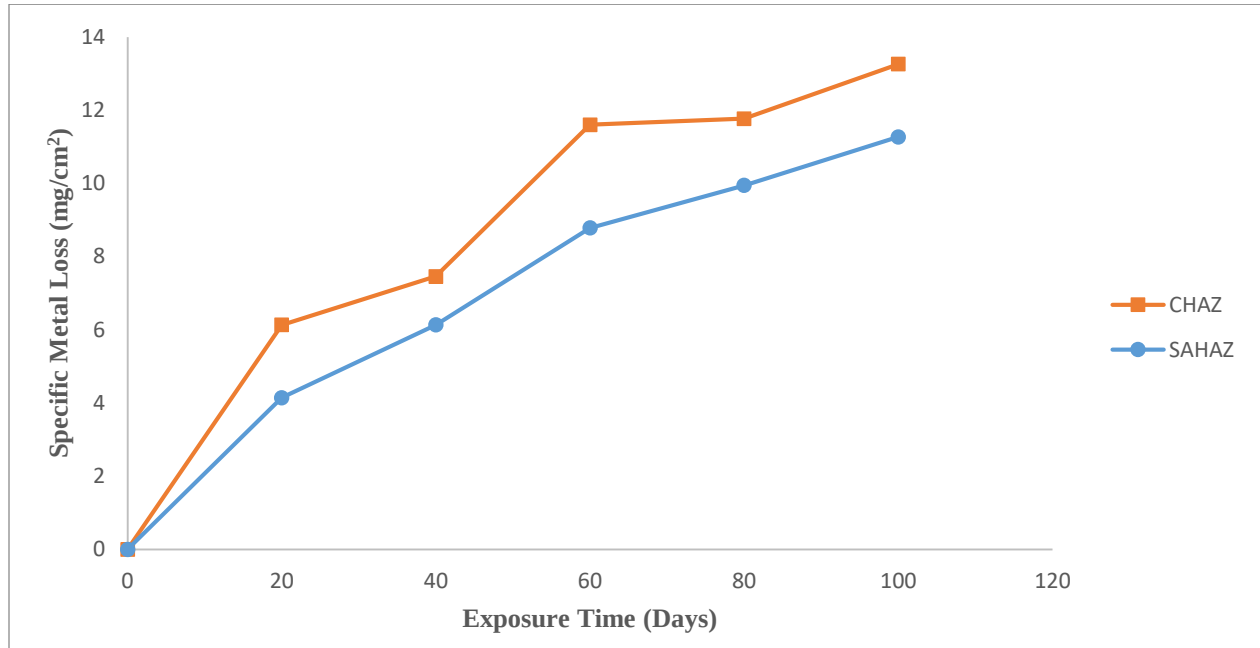


Figure 4.8b: Plot of Specific Metal Loss Against Exposure Time for The Control and Solution Annealed Heat Affected Zone (HAZ) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.8b revealed that there were increase in the specific metal loss for the control and solution annealed steel investigated samples with the control samples displaying higher metal loss.

Table 4.11: Specific Metal Loss from Gravimetric Corrosion Measurement for the Control and Solution Annealed Welded Zone (WZ) of the Samples Immersed in 1.0M NaCl Environment.

Time (Days)	Samples	W ₀ (g)	W _f (g)	(W ₀ -W _f)g	(W ₀ -W _f)mg	SML (mg/cm ²)
20	CWZ	12.002	11.956	0.046	46	7.625
	SAWZ	12	11.967	0.033	33	5.470
40	CWZ	12	11.951	0.049	49	8.122
	SAWZ	12	11.961	0.039	39	6.465
60	CWZ	12.001	11.925	0.076	76	12.597
	SAWZ	12	11.952	0.048	48	7.956
80	CWZ	12	11.922	0.078	78	12.929
	SAWZ	12.003	11.946	0.057	57	9.448
100	CWZ	12	11.911	0.089	89	14.752
	SAWZ	12	11.936	0.064	64	10.608

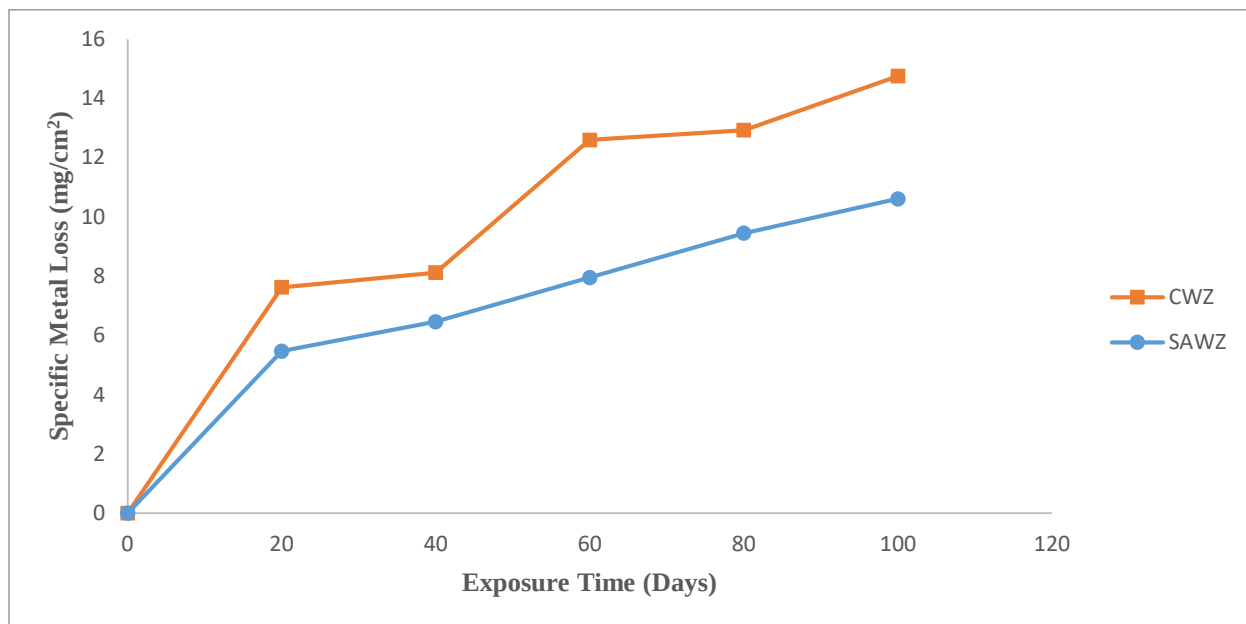


Figure 4.8c: Plot of Specific Metal Loss Against Exposure Time for The Control and Solution Annealed Heat Welded Zone (WZ) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.8c revealed that there were increase in the specific metal loss for the control and solution annealed steel investigated samples with the control samples displaying higher metal loss.

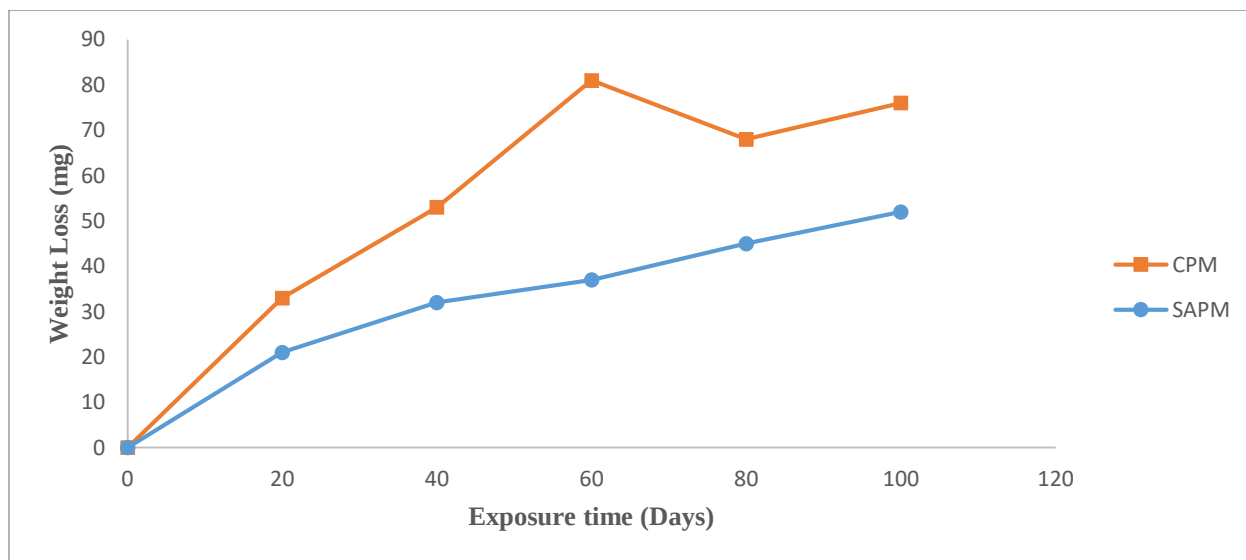


Figure 4.9a: Plot of Weight Loss Against Exposure Time for The Control and Solution Annealed Parent Metal (PM) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.9a show that the weight loss for the control and solution annealed steel investigated samples increases with exposure time with the control samples displaying higher weight loss.

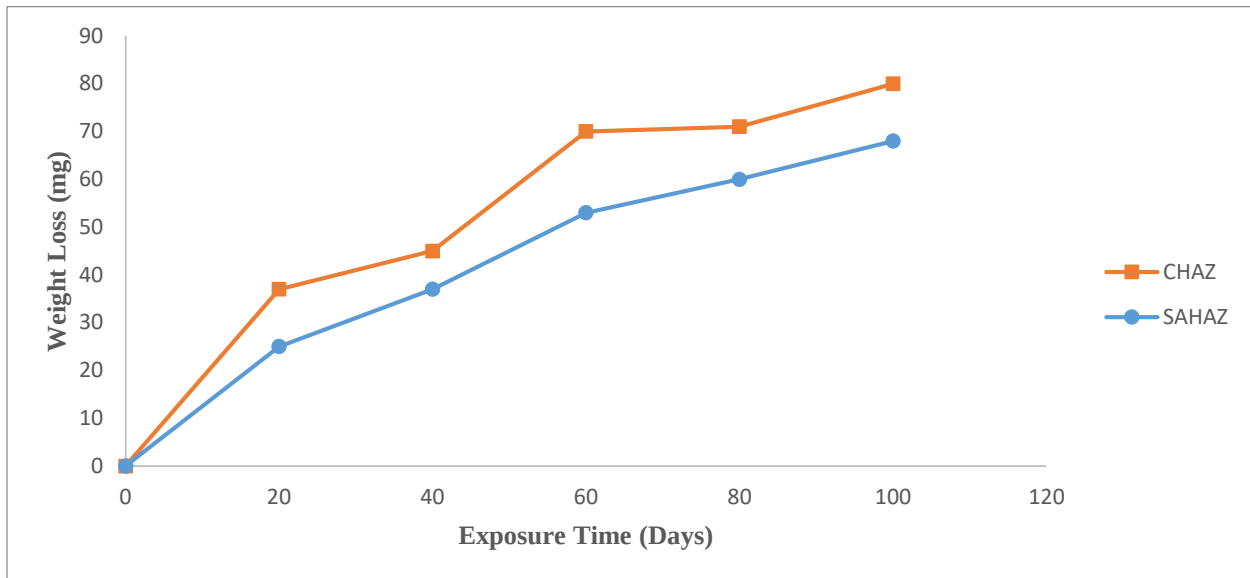


Figure 4.9b: Plot of Weight Loss Against Exposure Time for The Control and Solution Annealed Heat Affected Zone (HAZ) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.9b show that the weight loss for the control and solution annealed steel investigated samples increases with exposure time with the control samples displaying higher weight loss.

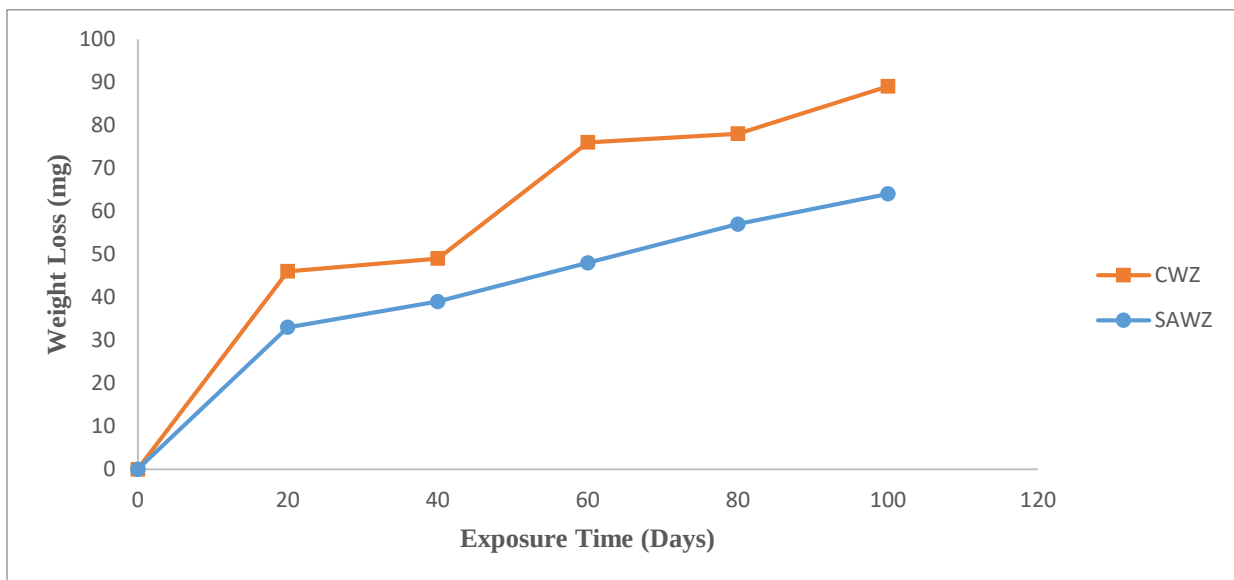


Figure 4.9c: Plot of Weight Loss Against Exposure Time for The Control and Solution Annealed Welded Zone (WZ) of The Samples Immersed in 1.0M NaCl Environment

Figure 4.9C show that the weight loss for the control and solution annealed steel investigated samples increases with exposure time with the control samples displaying higher weight loss.

4.5.2.1 Effect of Solution Annealing on the Corrosion Resistance of Welded 0.36%C Steel in 1.0M NaCl Environment from Specific Metal Loss (S.M.L) and Weight Loss (WL) Obtained from Gravimetric Measurement

Figure 4.8a to 4.9c revealed that the specific metal loss and weight loss were observed to increase with exposure time for the investigated control and solution annealed parent metal (PM), heat affected zone (HAZ) and welded zone (WZ) of the samples. The rate of increase was observed to be higher for the control samples than the solution annealed samples. This indicated rapid anodic dissolution of the metal at the interface of the metal/solution for the control samples than the solution annealed samples in the chloride environment. Though, it was observed that the specific metal loss and weight loss of the solution annealed samples increased with time, it was however observed to be more stable and at a much lower rate than the control samples. The lower specific metal loss and weight loss observed for the solution annealed samples can be attributed to the homogenous dissolution of the carbides at the matrix of the investigated steel, while the higher loss observed for the control samples can be credited to the presence of carbides at the grain boundaries of the steel samples as the carbides acts as anodic dissolution sites at the grain boundaries, hence, more metal loss. Again, these observations are in good trend alignment with the results obtained from the corrosion penetration rate of gravimetric measurement.

4.6 Effect of Solution Annealing on Microstructural Evolution and Corrosion Rate of 0.36%C Steel in 1.0M Chloride Environment.

Marcuci et al., (2014), in their research reported that the corrosion susceptibility of a material hinge on its microstructure and this finding was observed in the result obtained from the microstructural investigation as presented in Plate 4.3a – 4.3f. After solution annealing, the solution annealed samples revealed a microstructure of mixture of martensite lath and retained austenite, while the control samples revealed a mixture of carbide dispersion in the ferrite matrix. These observed microstructures possibly affected the rate at which they are susceptible to corrosion. The corrosion results obtained from electrochemical and gravimetric corrosion measurements showed that the

control samples were more susceptible to corrosion than the solution annealed samples. The reason as to why the solution annealed samples gave low corrosion susceptibility in the chloride environment can be attributed to its microstructure. The dissolved carbides in the martensite structure could have helped to reduce the corrosion rate due to balance dissolution and passivation of the solution annealed samples by stabilizing the passive film formed. This observation aligns with Kadowaki et al., (2020), they reported that active martensite dissolutions were suppressed by carbides by enhancing the stability of the impassive state of martensite. They also reported that martensite resistance to pitting corrosion is improved by carbides in the matrix of the steel. Also, Wilson et al., (2018) attributed the reduced corrosion rate to lower boundary corrosion as a result of bainite/martensite phase. They also stated that the BCT structure of martensite obtained due to martensite transformation was observed to offer the least Fe content and hence, decreased corrosion susceptibility as it becomes the cathode. This observation aligns with Jinlong et al., (2016). The decreased corrosion rate of the solution annealed samples can also be attributed to the retained austenite structure. Handoko et al., (2018), in their investigation reported that retained austenite had lower corrosion susceptibility damage. Also, Kimura et al., (2000) in their investigation reported that retained austenite were observed to have no harmful effect on corrosion resistance. They also reported that the dissolution of carbon in the austenite phase decreased carbide precipitation and thus, improved the corrosion resistance of the steel. Jiang, et al., (2017) reported that the reduction of undissolved carbides were found to improve corrosion resistance of steels. This observation is in good agreement with the effect of solution annealing on the solution annealed steel samples. The reason as to why the control samples were found to be more susceptible to corrosion can be attributed to the cementite and ferrite phase. Igwemezie and Ovri (2013) in their research found out that the ferrite acts as the anode while the cementite becomes the cathode. Also, Shin et al., (2007) and Du et al., (2009) had similar observations, they found

out that corrosion susceptibility increases as cathode/anode area increases and owing to the more stable electrochemical nature of cementite than ferrite, the ferrite were observed to have a higher corrosion rate due to the galvanic effect between the ferrite and cementite. One major reason as to why the control samples had increased corrosion rates could possibly be due to the presence of carbides at the grain boundaries, as the carbides were found to be active sites, thus, more susceptible to anodic dissolution. This observation is in good alignment with Kimura et al., (2000), they discovered that corrosion susceptibility increases with increased carbide precipitation.

The corrosion rate for both samples were observed to increase from the parent metal (PM), heat affected zone (HAZ) to the welded zone (WZ). The increased corrosion susceptibility from the PM>HAZ>WZ can be attributed to increased coarsening from PM>HAZ>WZ. This observation aligns with Kato et al., (1978), who reported that accelerated corrosion rates were due to massive grain growth.

4.7 Summary of Findings

From the investigations carried out in this research work, the findings are summarized as follows

- (i) Solution annealing was effective in causing the homogenous dissolution of precipitated intermetallic phase (Fe_3C).
- (ii) The hardness distribution in the different region of the sample were found to increase from the WZ, HAZ and PM for both control and solution annealed samples. Though, the solution annealed samples were found to have higher hardness across the different regions.
- (iii) The un-heat treated (control) samples were found to be more susceptible to corrosion when compared to the solution annealed samples. This can be due to the precipitate of intermetallic phase (Fe_3C) which should be more in the control samples according to literature.
- (iv) The corrosion rate of the different regions of the samples were found to increase from the PM, to the HAZ and to the WZ.
- (v) The protective capabilities of the passive film on the investigated steel in chloride environment were found to have improved with the solution annealed samples.
- (vi) The control samples were observed to be susceptible to pitting and uniform corrosion, while the solution annealed samples were observed to be only susceptible to uniform corrosion.
- (vii) The morphological microstructures were found to have effect on the corrosion susceptibility of the samples.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The effect of solution annealing on the corrosion resistance of welded 0.36%C steel in chloride environment has been investigated in this research. Solution annealing was carried out on the steel at three different stages. To better illustrate the effect of solution annealing on corrosion susceptibility of the welded steel, some samples were solution annealed while some were not. From the investigations carried out in this research, the following conclusions can be drawn.

- i. The optimum heat treatment conditions (temperature and holding time) for solution annealing treatment of 0.36%C steel are 990 °C and 2.0 hours.
- ii. The morphological microstructures were found to have a mixture of martensite lath and retained austenite with increased coarsening from the PM, to HAZ, and to the WZ. The morphological microstructures were found to have effect on the hardness property. For the investigated steels, it was observed that the hardness value increased from the WZ to the HAZ and with PM having the highest value. The control samples were found to have a lower hardness values of 148 -174 HV at the WZ, 174 - 187 HV at the HAZ and 187 – 252 HV at the PM. The solution annealed samples were found to have higher hardness values of 186-255.8 HV at the WZ, 255.8-325.6 HV at the HAZ and 325.6-535 HV at the PM.
- iii. The solution annealing heat treatment was found to influence the corrosion performance of the investigated steel. The solution annealed samples were found to be more noble in the chloride environment than the control samples. The nobility of the samples was found to decrease from the PM, to the HAZ, and with the WZ the least. The SAPM samples were found to have a lower anodic potential of -0.70V (SCE), higher R_p of 786.061 $\Omega \cdot \text{cm}^2$ and with a lower corrosion rate of 0.591 mm/yr, while the CPM samples were found to have a higher anodic potential of -0.72V (SCE), lower R_p of 269.867 $\Omega \cdot \text{cm}^2$, and with a higher corrosion rate of 1.673 mm/yr. The SAHAZ samples were found to have a lower anodic

potential of -0.71V (SCE), higher R_p of 180.452 $\Omega\cdot\text{cm}^2$, and with a lower corrosion rate of 1.017 mm/yr, while the CHAZ samples were found to have a higher anodic potential of -0.73V (SCE), lower R_p of 61.263 $\Omega\cdot\text{cm}^2$, and with a higher corrosion rate of 3.143 mm/yr. The SAWZ samples were found to have a lower anodic potential of -0.72V (SCE), higher R_p of 54.483 $\Omega\cdot\text{cm}^2$, and with a lower corrosion rate of 3.207 mm/yr, while the CWZ samples were found to have a higher anodic potential of -0.74V (SCE), lower R_p of 41.133 $\Omega\cdot\text{cm}^2$, and with a higher corrosion rate of 4.832 mm/yr.

The protective capabilities of the passive film on the investigated steel in chloride environment were found to have improved with the solution annealed samples than the control samples. The OCP results of the different regions of the investigated welded steel, showed that the parent metal (PM) was more cathodic than the heat affected zone (HAZ) and the weld zone (WZ). Film repair rate on the sample surfaces was found to have improved with the solution annealed samples than the control samples. The rate of repair was found to increase from the WZ, to the HAZ, with the PM the highest.

The solution annealed samples were found not prone to pitting corrosion and less susceptible to uniform corrosion compared to the control samples that were found to be prone to pitting corrosion and more susceptible to uniform corrosion. The susceptibility of the samples was found to decrease from the PM, to the HAZ with the WZ the least.

The statistical ECN signals for the solution annealed samples in the chloride environment were found to be more unidirectional (i.e. symmetrical distribution on the positive /negative direction) than the control samples.

The solution annealing heat treatment (SAHT) was found to be very effective toward corrosion protection of the investigated steel in chloride environment. Thus, the solution annealed samples were found to have better corrosion resistance than the control samples.

- iv. The corrosion susceptibility of the solution annealed and control samples in the chloride environment was found to hinge on its microstructure. The control and solution annealed samples were found to have experienced increased corrosion rate at the early stage of exposure and later experienced decreased corrosion rate with exposure time in the chloride environment. Though, the control samples were found to have higher corrosion rates.

5.2 Recommendation

- (i) The effect of these solution annealing parameters should be investigated under different environments to see their variations
- (ii) More work should be done to investigate the effect of these solution annealing parameters on the mechanical properties of these steels.

5.3 Contribution to Knowledge

- (i) This research work has demonstrated that solution annealing can be effectively used to improve the corrosion resistance of welded 0.36% C in chloride environment.
- (ii) The research further demonstrated that the optimum solution annealing temperature for welded 0.36% C to be 990 °C, and the optimum soaking/holding time to be 2 hrs.
- (iii) It has established that carbides within the matrix of the steel made the steel not to be prone to pitting corrosion and less susceptible to uniform corrosion.
- (iv) The incidence of pipeline failures due to corrosion at the HAZ and WZ will be drastically reduced if the outcome of the study is introduced into pipeline production processes.

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APPENDIX A1

A.1: Micrograph of Solution Annealing Heat Treatment Stage 1 at 920 °C

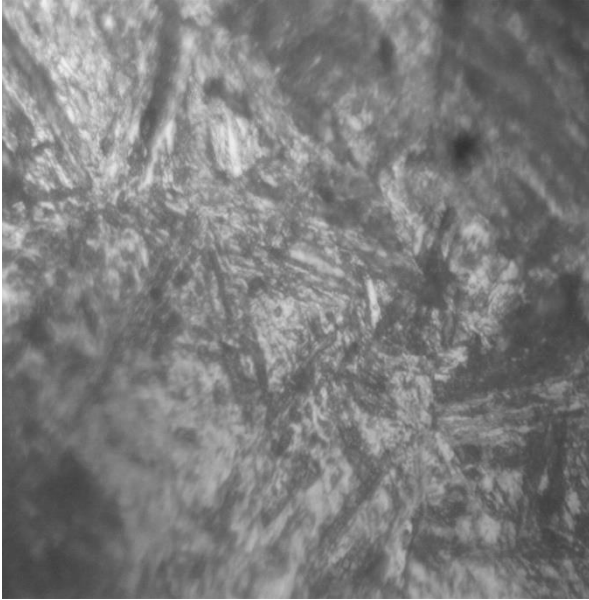


Plate A.1a: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 920 °C for 1hr at X1000.

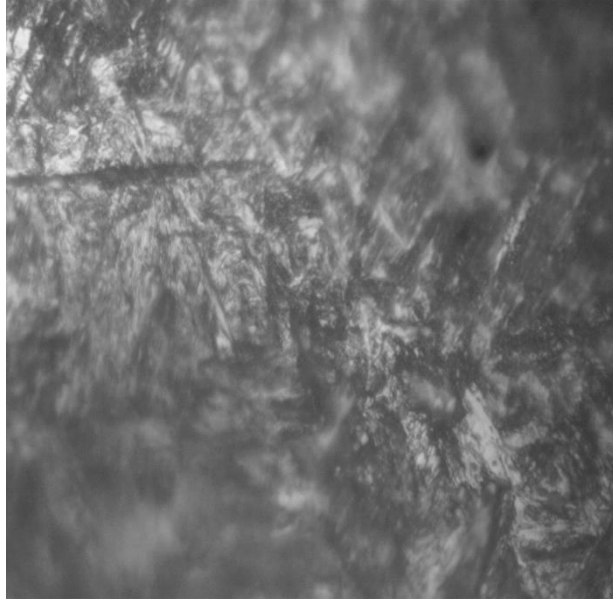


Plate A.1b: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 920 °C for 1hr at X1000

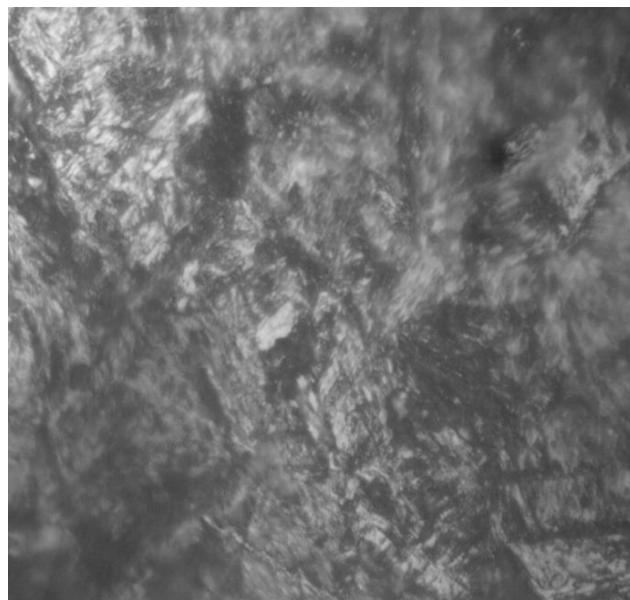


Plate A.1c: Optical Micrograph of the Welded Zone

of 0.36%C Steel annealed at 920 °C for 1hr at X1000.

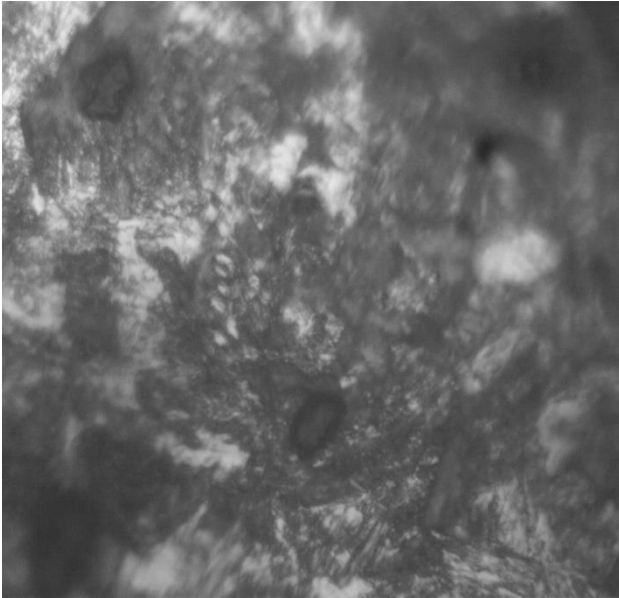


Plate A.1d: Optical Micrograph of the Parent Material of 0.36%C Steel annealed at 920 °C for 1hr 30min at X1000

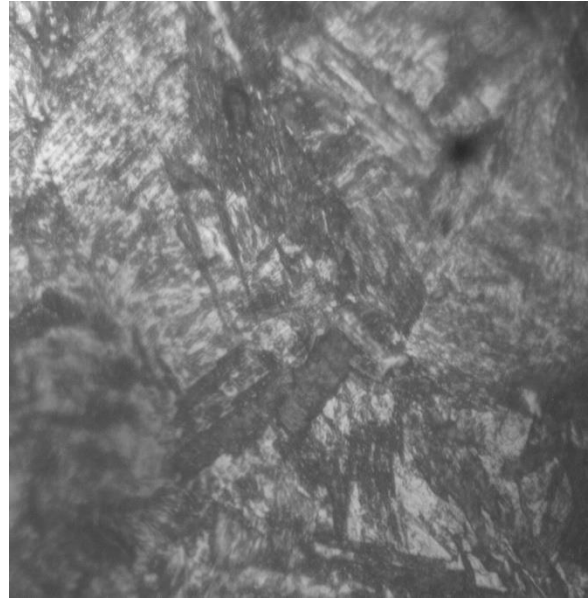


Plate A.1e: Optical Micrograph of the Heat Affected Zone (HAZ) of the 0.36%C Steel annealed at 920 °C for 1hr 30min at X1000

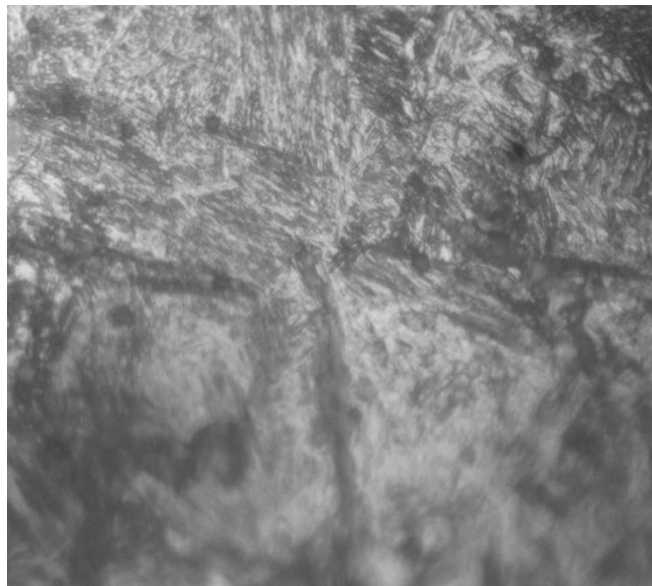


Plate A.1f: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 920 °C for 1hr 30min at X1000

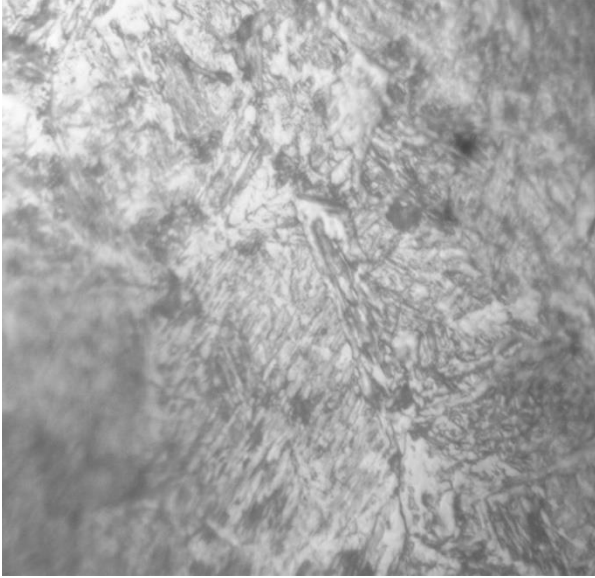


Plate A.1g: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 920 °C for 2hr at X1000.

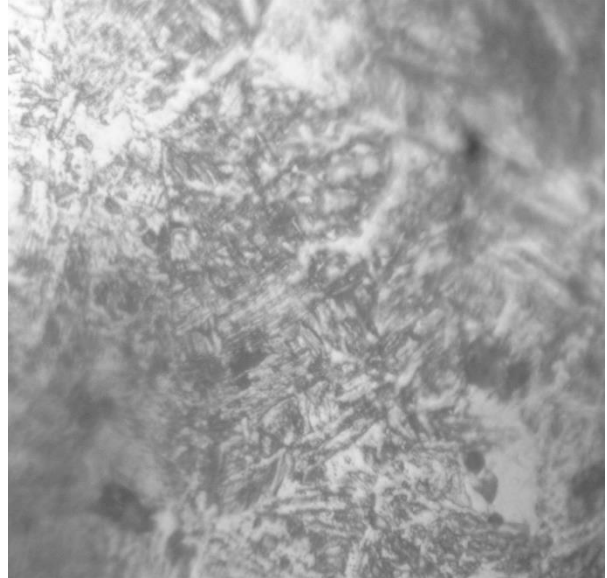


Plate A.1h: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 920 °C for 2hr at X1000

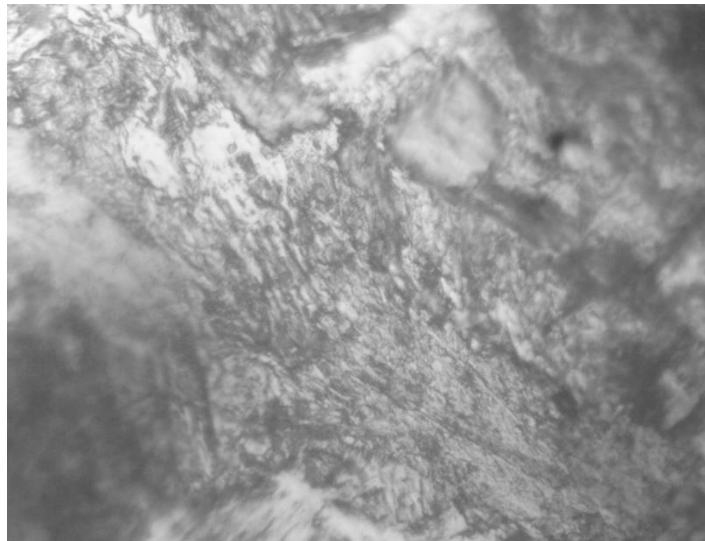


Plate A.1i: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 920 °C for 2hr at X1000

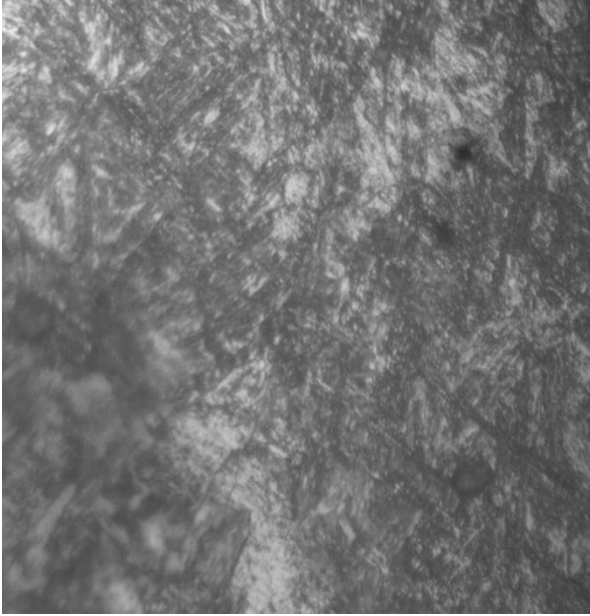


Plate A.1j: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 920 °C for 2hr 30min at X1000

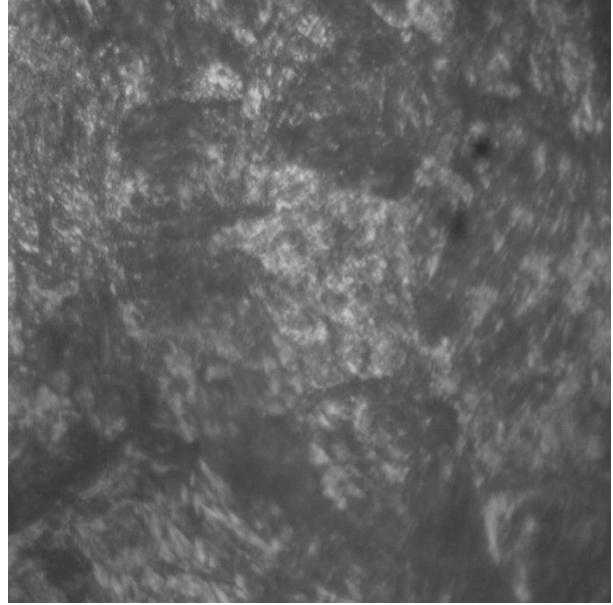


Plate A.1k: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 920 °C for 2hr 30min at X1000

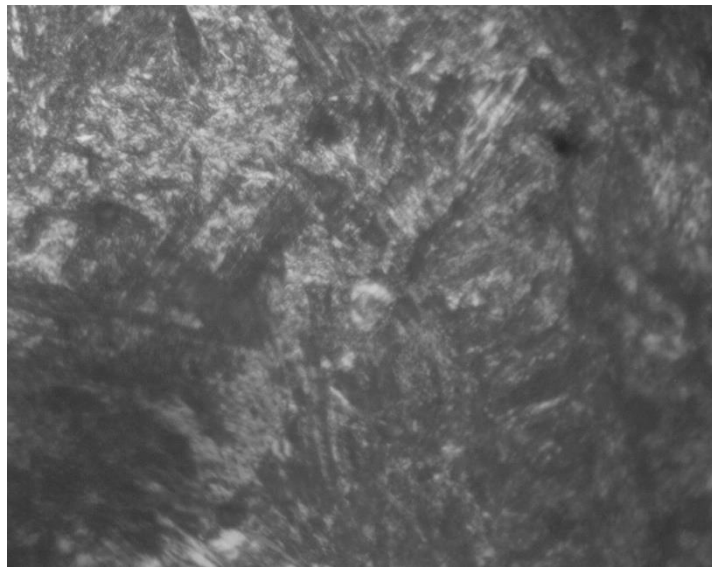


Plate A.1l: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 920 °C for 2hr 30min at X1000

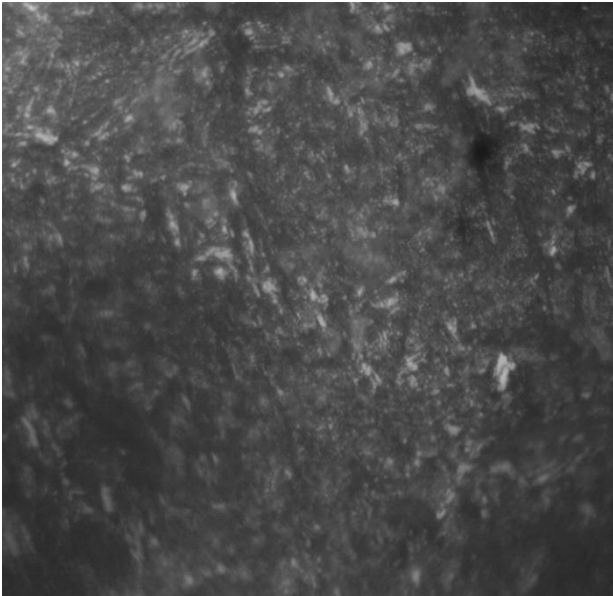


Plate A.1m: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 920 °C for 3hr at X1000.

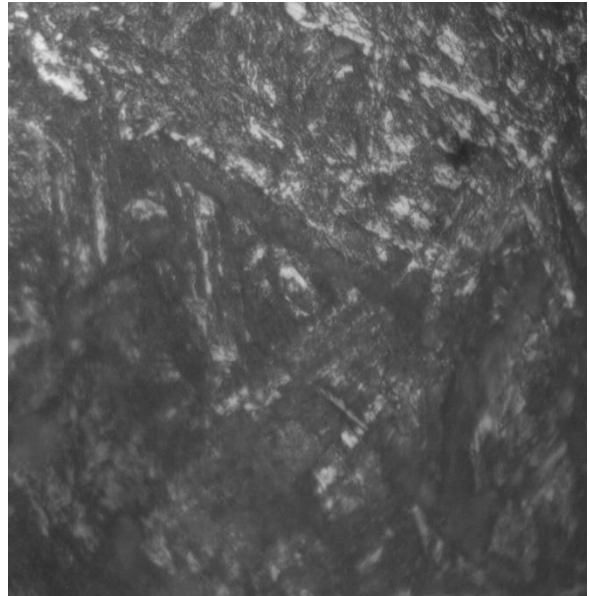


Plate A.1n: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 920 °C for 3hr at X1000.

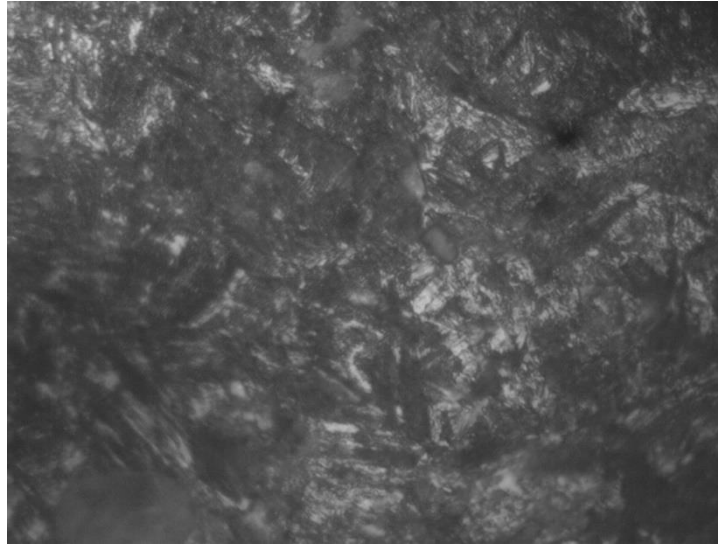


Plate A.1o: Optical Micrograph of the Welded Zone of
0.36%C Steel annealed at 920 °C for 3hr at X1000.

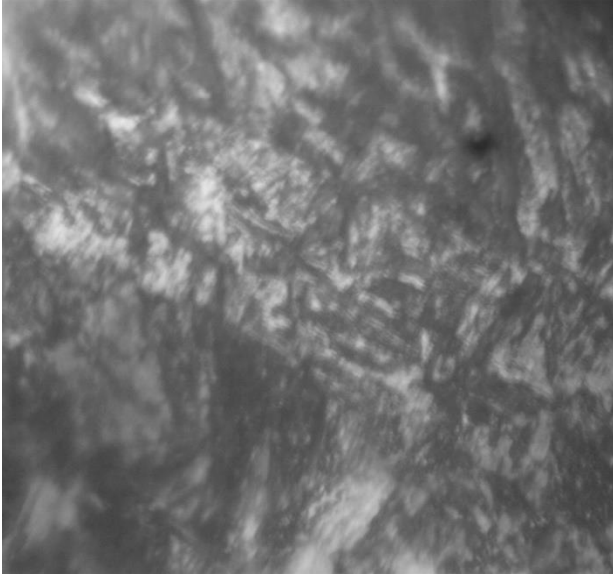


Plate A.1p: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 920 °C for 3hr 30min at X1000.



Plate A.1q: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 920 °C for 3hr 30min at X1000.

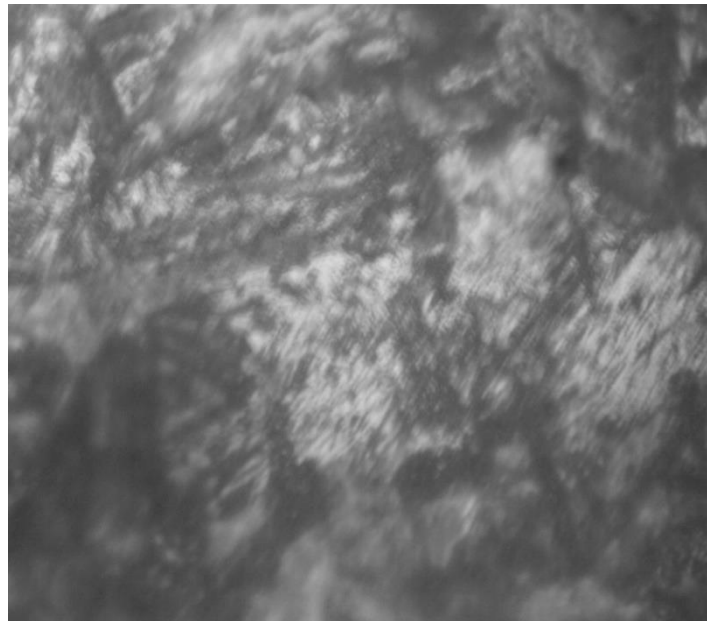


Plate A.1r: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 920 °C for 3hr 30min at X1000

APPENDIX A2

A.2: Micrograph of Solution Annealing Heat Treatment Stage 1 at 1000 °C

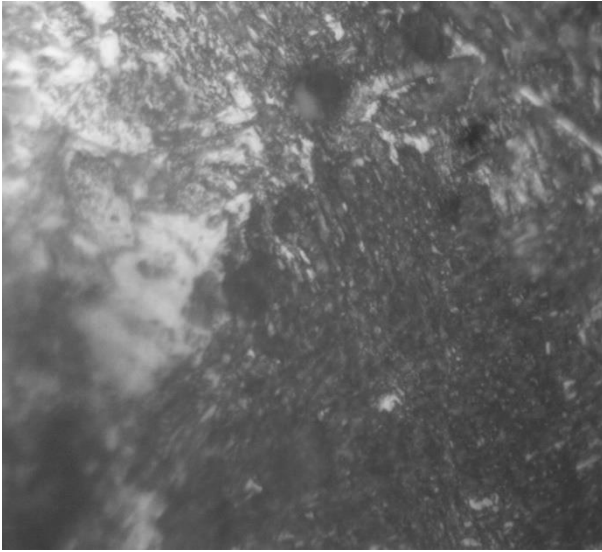


Plate A.2a: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1000 °C for 1hr at X1000.

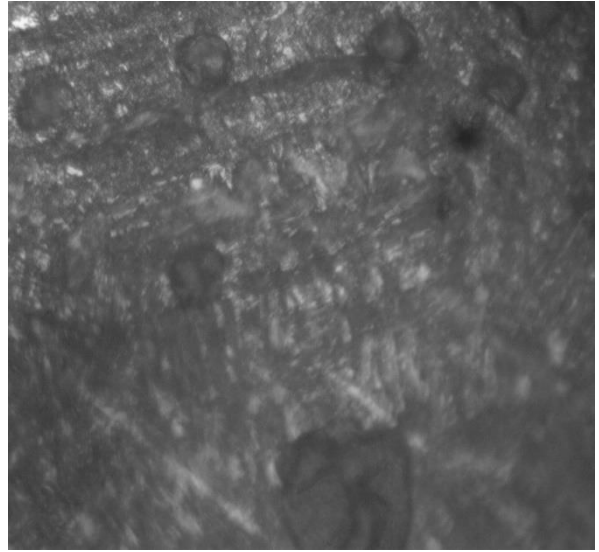


Plate A.2b: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1000 °C for 1hr at X1000

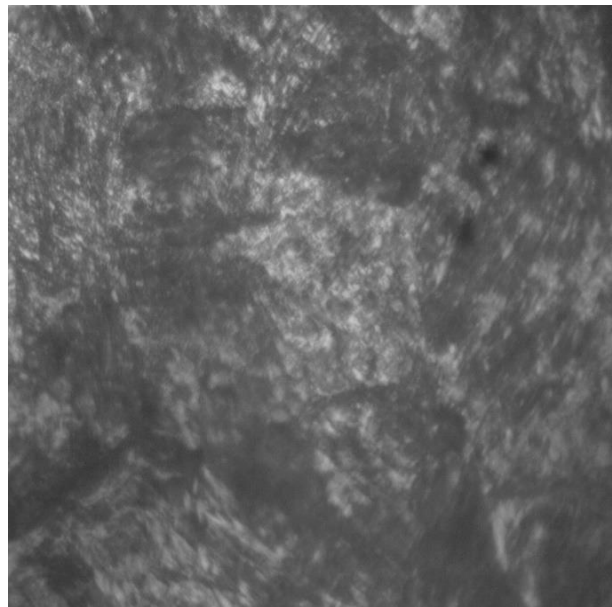


Plate A.2c: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 1hr at X1000.

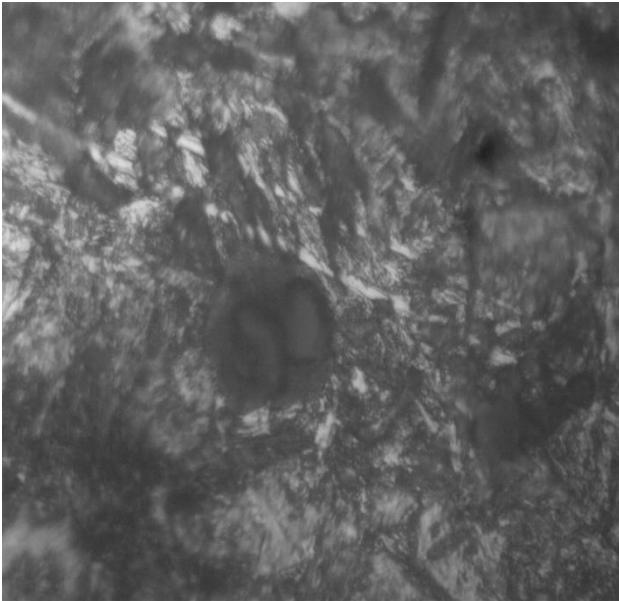


Plate A.2d: Optical Micrograph of the Parent Material of 0.36%C Steel annealed at 1000 °C for 1hr 30min at X1000

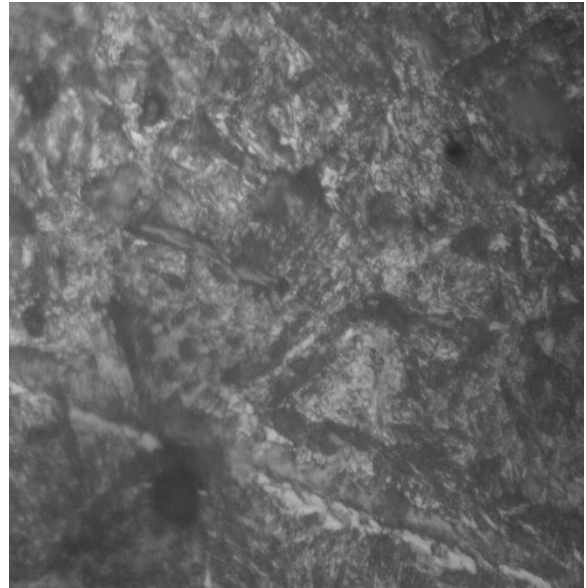


Plate A.2e: Optical Micrograph of the Heat Affected Zone (HAZ) of the 0.36%C Steel annealed at 1000 °C for 1hr 30min at X1000

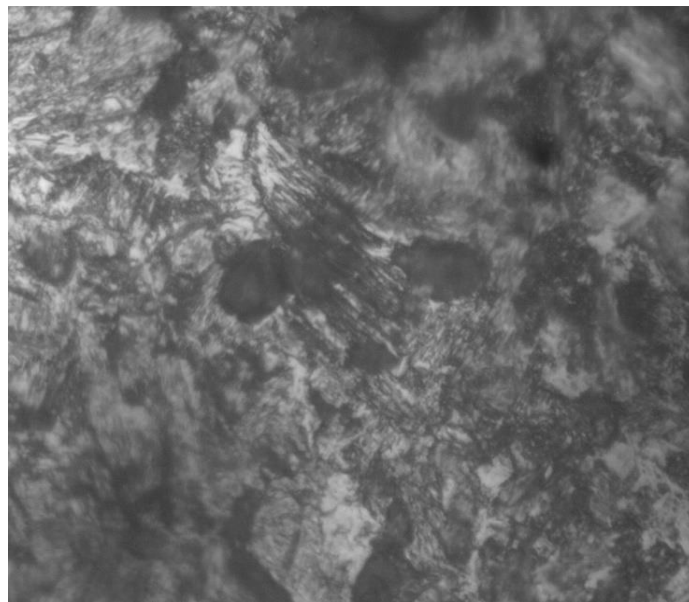


Plate A.2f: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 1hr 30min at X1000

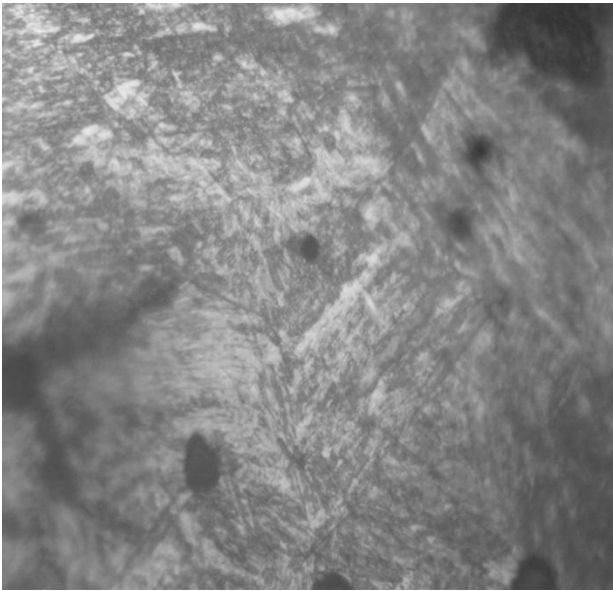


Plate A.2g: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1000 °C for 2hr at X1000

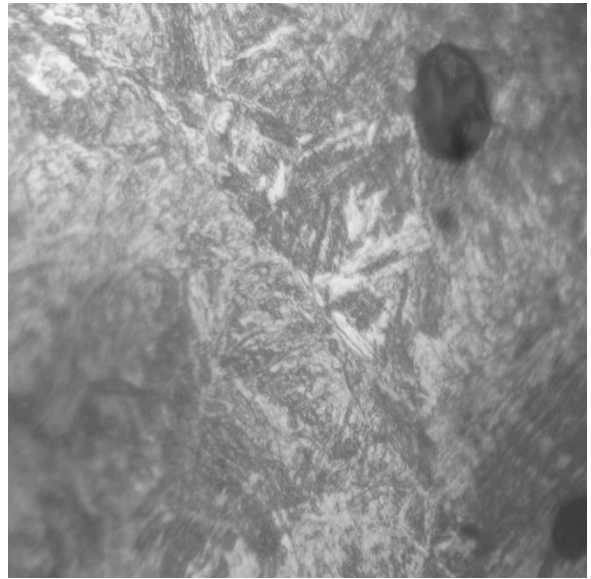


Plate A.2h: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1000 °C for 2hr at X1000

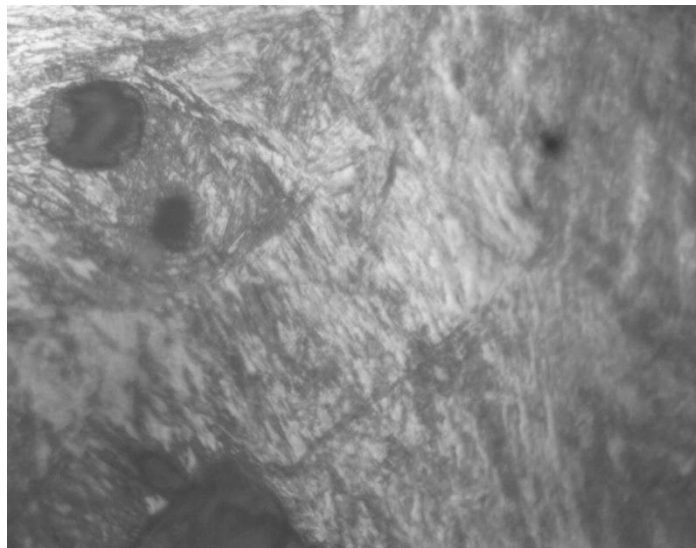


Plate A.2i: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 2hr at X1000

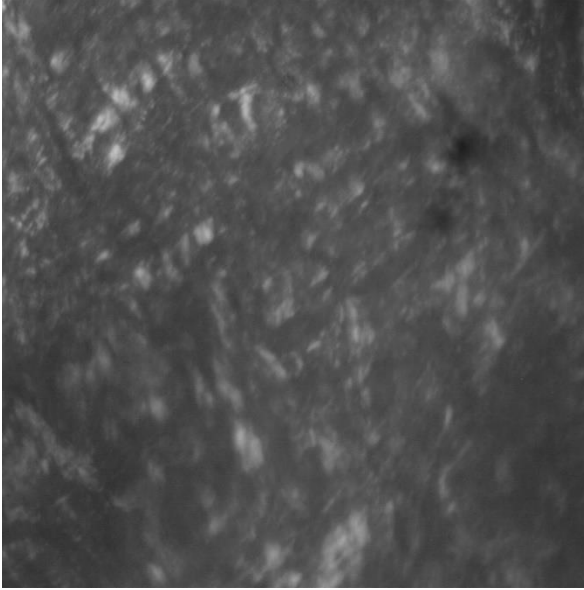


Plate A.2j: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1000 °C for 2hr 30min at X1000.

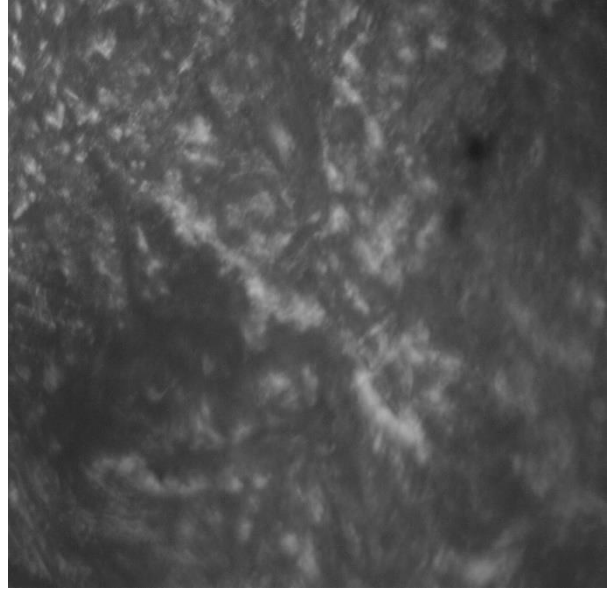


Plate A.2k: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1000 °C for 2hr 30min at X1000.

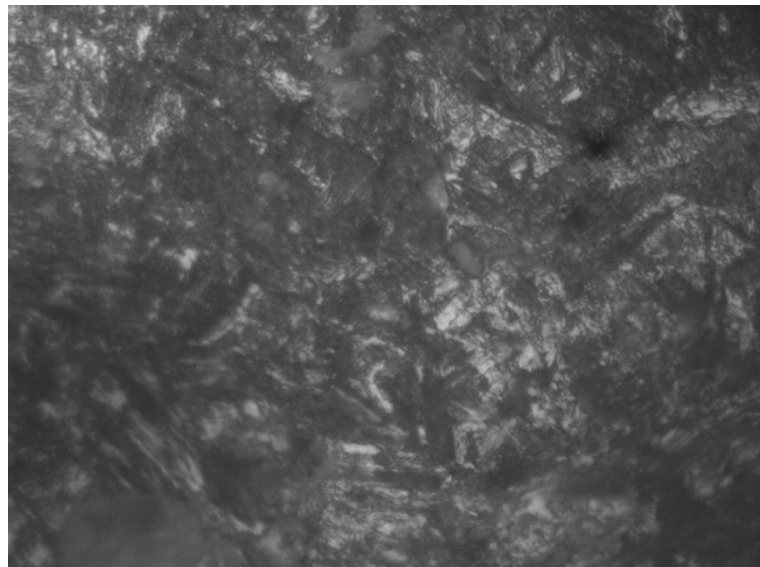


Plate A.2l: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 2hr 30min at X1000

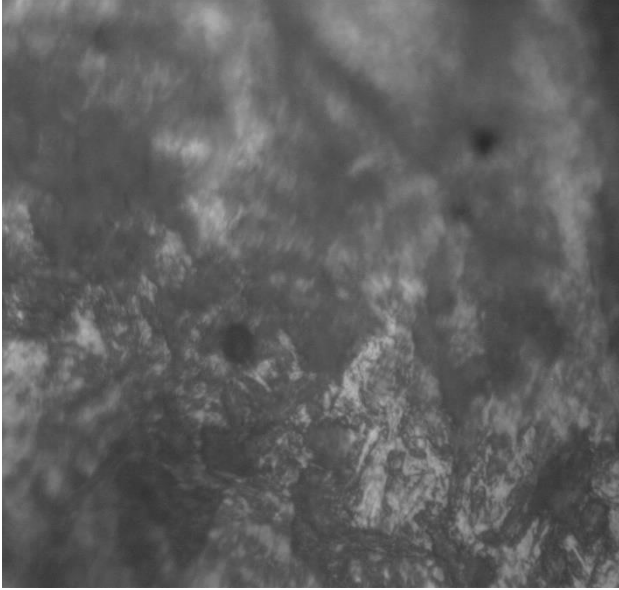


Plate A.2m: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1000 °C for 3hr at X1000.

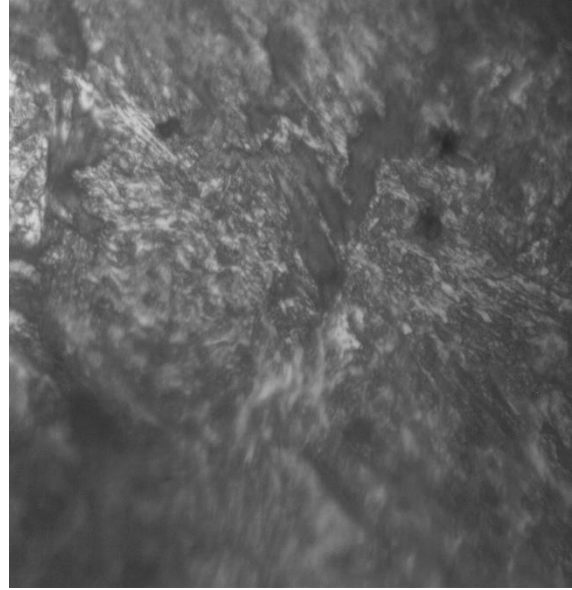


Plate A.2n: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1000 °C for 3hr at X1000.

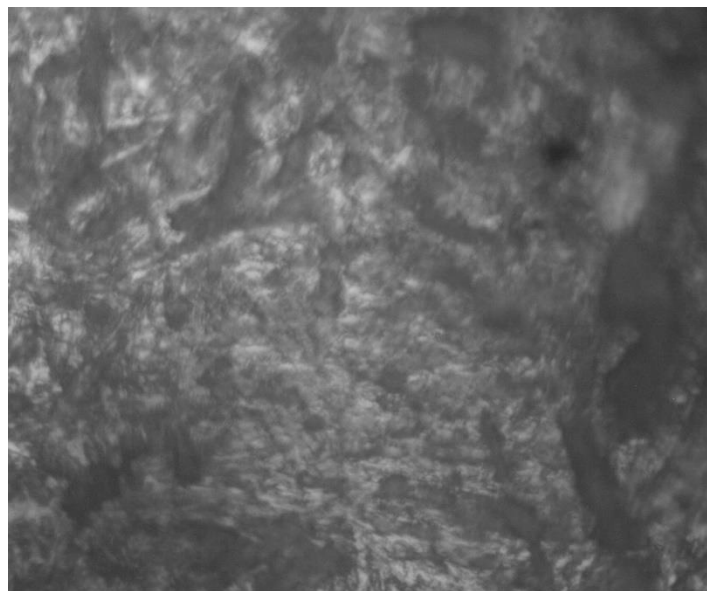


Plate A.2o: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 3hr at X1000.

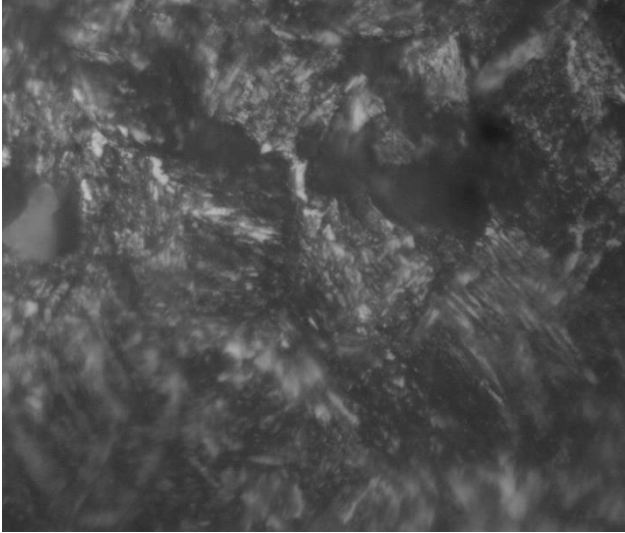


Plate A.2p: Optical Micrograph of the Parent Metal of 0.36%C Steel annealed at 1000 °C for 3hr 30min at X1000.

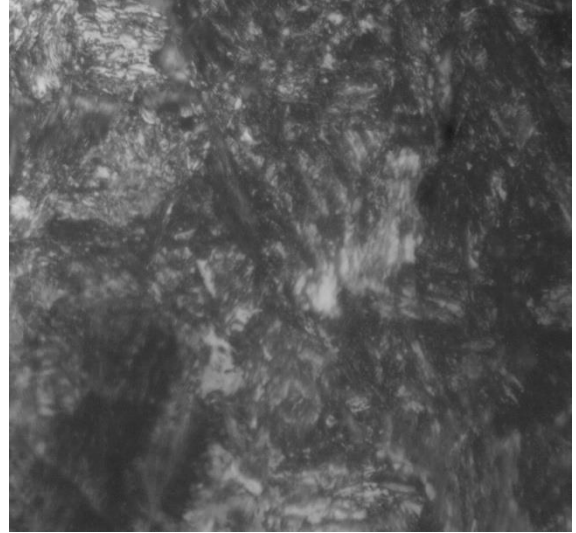


Plate A.2q: Optical Micrograph of the Heat Affected Zone (HAZ) of 0.36%C Steel annealed at 1000 °C for 3hr 30min at X1000.



Plate A.1r: Optical Micrograph of the Welded Zone of 0.36%C Steel annealed at 1000 °C for 3hr 30min at X1000

APPENDIX B

Table B.1: SEM-EDX Results for the Control and Solution Annealed Parent Metal (PM) and Welded Metal (WM) Samples

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
1	0	0	1	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	1	5
12	5	0	0	4
13	4	0	0	2
14	9	1	0	3
15	26	11	7	16
16	68	46	31	57
17	129	90	89	102
18	167	116	133	154
19	228	154	133	169
20	267	164	137	154
21	272	149	144	196
22	274	141	149	182
23	294	168	156	146
24	323	195	189	157
25	319	174	181	178
26	349	192	188	197
27	388	205	190	164
28	382	184	199	169
29	411	154	173	155
30	416	145	130	139
31	370	134	128	128

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
35	236	120	121	120
36	252	139	120	144
37	249	145	152	163
38	244	147	167	158
39	230	171	145	176
40	257	195	173	198
41	275	203	203	210
42	280	209	214	225
43	305	215	225	206
44	281	247	272	237
45	313	271	271	290
46	367	275	297	277
47	384	314	303	306
48	415	347	322	330
49	433	390	336	372
50	492	404	411	429
51	538	438	392	384
52	558	438	422	431
53	631	524	465	545
54	703	569	554	598
55	819	672	603	697
56	1009	825	739	849
57	1381	1081	959	1038
58	1769	1410	1339	1500
59	2320	1882	1688	1833
60	2899	2374	2150	2317
61	3328	2678	2402	2613
62	3547	2885	2680	2931
63	3610	2977	2782	2893
64	3635	3021	2656	2952
65	3630	2912	2641	2945

32	345	108	122	121
33	292	100	100	102
34	294	99	125	103

66	3788	3070	2962	3247
67	4443	3707	3461	3637
68	5369	4412	4015	4430

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
69	6293	5165	4774	5096
70	7242	5764	5236	5556
71	7135	6024	5471	5783
72	6730	5547	5300	5506
73	5769	4726	4238	4714
74	4482	3717	3444	3666
75	3178	2696	2419	2540
76	2166	1744	1625	1670
77	1390	1079	1005	1089
78	774	648	623	634
79	567	418	395	409
80	457	298	275	337
81	268	250	250	253
82	269	240	202	228
83	257	201	200	198
84	225	171	193	185
85	259	196	179	177
86	203	178	172	185
87	211	188	182	171
88	189	186	149	181
89	203	173	156	177
90	216	186	159	162
91	236	178	170	188
92	193	163	160	171
93	215	187	172	162
94	241	182	172	157
95	216	167	175	188
96	258	169	175	206
97	238	169	162	187
98	256	175	160	191
99	237	182	195	171

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
103	227	160	209	193
104	257	182	174	184
105	226	217	184	184
106	229	199	158	193
107	258	192	205	205
108	272	192	169	215
109	264	193	178	223
110	269	202	183	200
111	241	220	178	201
112	282	192	216	204
113	239	211	194	220
114	276	204	184	204
115	255	237	221	249
116	283	253	193	266
117	278	243	220	220
118	285	205	199	232
119	300	235	211	249
120	291	236	221	252
121	287	250	199	219
122	306	234	213	247
123	277	248	242	231
124	294	236	229	224
125	288	240	228	224
126	299	250	249	270
127	283	251	216	244
128	293	247	214	245
129	292	250	217	243
130	293	265	236	238
131	300	229	210	209
132	289	245	199	219
133	280	284	224	274

100	213	157	160	168
101	235	179	156	184
102	231	195	176	178

134	264	269	245	272
135	329	224	216	241
136	272	250	233	236

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
137	307	232	233	264
138	326	239	245	280
139	315	248	243	257
140	326	241	220	237
141	332	266	233	253
142	330	247	190	269
143	329	279	248	224
144	303	304	205	262
145	340	250	231	260
146	309	270	230	253
147	331	273	250	286
148	347	235	245	282
149	306	251	244	273
150	296	255	240	247
151	346	249	246	261
152	308	258	244	259
153	307	250	226	257
154	313	272	240	273
155	301	259	227	247
156	329	264	231	257
157	306	248	222	279
158	301	260	237	256
159	311	266	237	241
160	321	245	248	264
161	353	261	232	261
162	308	247	220	250
163	331	298	230	226
164	335	282	251	266
165	359	274	257	244
166	330	247	248	256

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
171	387	308	278	299
172	376	316	272	350
173	378	349	306	363
174	430	362	335	377
175	404	378	298	422
176	405	348	272	371
177	401	352	288	399
178	382	372	320	356
179	369	354	284	318
180	362	303	278	312
181	364	279	279	279
182	350	311	276	290
183	371	260	262	305
184	332	276	262	295
185	314	273	253	274
186	334	271	245	246
187	305	254	247	258
188	317	258	265	277
189	322	267	251	261
190	307	254	238	250
191	329	224	233	246
192	301	264	215	223
193	295	248	239	258
194	324	274	234	269
195	307	255	260	268
196	332	253	253	256
197	315	244	244	238
198	319	267	251	240
199	319	250	239	241
200	318	241	217	246

167	305	288	236	257
168	342	304	261	279
169	365	273	221	301
170	368	318	244	308

201	303	256	241	237
202	329	227	230	275
203	342	274	236	222
204	339	256	269	228

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
205	317	267	222	249
206	351	253	259	251
207	302	255	225	272
208	313	238	263	212
209	336	251	221	254
210	295	223	249	246
211	329	250	219	257
212	310	257	236	279
213	298	253	222	249
214	319	249	238	257
215	296	255	199	247
216	327	250	222	231
217	282	277	237	227
218	303	229	237	227
219	320	291	221	234
220	308	240	198	274
221	303	230	215	247
222	301	248	221	244
223	303	234	253	256
224	299	231	273	254
225	316	206	243	274
226	299	228	228	244
227	335	272	261	261
228	354	259	259	239
229	329	242	248	237
230	346	234	265	269
231	327	266	259	209
232	342	266	259	257
233	396	253	236	257

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
239	301	224	214	229
240	298	242	199	257
241	291	241	208	271
242	284	257	233	250
243	294	208	244	239
244	280	247	193	216
245	277	255	193	257
246	276	224	216	225
247	307	249	219	255
248	323	265	214	227
249	302	231	208	239
250	285	219	204	224
251	282	250	206	229
252	305	233	221	249
253	285	228	197	214
254	293	230	224	244
255	283	234	196	220
256	284	238	226	231
257	314	206	228	236
258	296	219	194	236
259	248	232	241	215
260	284	202	205	224
261	285	207	215	250
262	267	205	217	228
263	265	215	188	207
264	292	244	199	226
265	288	208	191	218
266	293	226	216	242
267	244	201	231	194

234	343	246	228	245
235	322	262	264	227
236	338	245	236	238
237	299	232	240	235
238	311	255	216	211

268	275	204	213	230
269	303	209	179	233
270	273	189	214	225
271	301	195	208	222
272	273	273	209	206

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
273	290	199	201	217
274	252	219	188	220
275	294	247	205	213
276	273	226	181	203
277	281	204	169	224
278	277	211	205	237
279	254	217	225	209
280	290	213	200	215
281	262	224	197	227
282	279	213	212	223
283	265	205	195	236
284	261	216	186	206
285	296	198	203	198
286	266	197	209	212
287	273	237	208	201
288	257	215	181	186
289	257	217	179	214
290	260	215	171	198
291	259	197	209	198
292	242	204	175	214
293	239	196	169	212
294	244	212	185	217
295	258	206	188	224
296	237	223	174	190
297	257	215	180	190
298	248	228	197	209
299	240	209	184	207
300	223	188	188	234

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
307	238	202	175	187
308	240	216	212	197
309	264	180	178	180
310	263	205	180	191
311	234	193	168	188
312	272	214	168	209
313	211	198	197	204
314	235	185	167	201
315	244	190	166	184
316	258	217	167	183
317	239	203	163	192
318	246	195	168	185
319	227	211	174	190
320	228	194	169	198
321	257	177	167	194
322	236	194	174	168
323	213	210	173	173
324	239	189	159	182
325	233	200	146	172
326	222	169	161	194
327	241	208	194	188
328	221	189	156	173
329	255	189	157	189
330	231	185	163	184
331	232	194	144	170
332	262	178	155	193
333	238	170	172	211
334	231	212	179	177

301	259	208	180	197
302	244	218	176	187
303	250	219	199	191
304	254	212	215	185
305	235	194	213	205
306	216	205	175	179

335	252	189	162	209
336	242	169	155	195
337	227	195	197	168
338	217	183	175	168
339	259	190	139	176
340	242	178	163	183

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
341	241	178	148	156
342	229	191	153	149
343	244	155	161	187
344	250	199	172	167
345	228	175	161	169
346	252	188	150	184
347	238	173	141	152
348	225	162	161	148
349	212	173	158	182
350	201	156	158	172
351	215	181	161	158
352	217	176	156	190
353	211	193	158	159
354	165	184	173	152
355	187	190	160	174
356	206	144	144	169
357	201	166	142	180
358	183	172	154	179
359	213	163	142	168
360	214	167	131	161
361	199	176	181	179
362	189	173	166	174
363	216	156	163	171
364	225	191	145	150
365	197	176	134	161
366	199	170	129	184
367	208	177	145	154

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
375	187	165	149	165
376	201	175	138	148
377	210	135	146	166
378	192	141	122	135
379	185	139	150	154
380	181	162	149	148
381	203	148	155	134
382	192	179	155	153
383	199	168	142	152
384	180	157	127	146
385	189	170	161	148
386	194	140	145	148
387	187	175	147	177
388	186	146	157	160
389	179	163	126	182
390	183	164	135	143
391	191	139	126	157
392	191	151	131	130
393	196	155	121	147
394	185	155	132	131
395	176	148	139	157
396	195	148	144	152
397	182	160	124	130
398	183	151	132	163
399	180	155	142	141
400	187	144	124	145
401	161	157	151	166

368	199	175	118	193
369	205	180	167	168
370	187	170	152	138
371	225	161	167	148
372	205	172	141	157
373	185	180	151	180
374	215	153	138	149

402	176	145	133	143
403	182	149	146	167
404	196	136	139	116
405	178	160	121	138
406	185	172	141	122
407	163	152	137	132
408	183	168	138	129

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
409	194	148	134	128
410	187	152	132	154
411	167	171	112	163
412	189	148	142	122
413	182	136	111	139
414	166	147	109	135
415	176	132	134	133
416	169	149	140	147
417	188	143	120	162
418	168	147	136	149
419	162	143	137	129
420	192	150	116	137
421	168	131	134	141
422	182	112	143	147
423	185	135	120	138
424	174	148	128	148
425	187	123	136	149
426	147	146	104	167
427	189	137	132	134
428	164	160	118	161
429	154	137	95	131
430	172	121	113	142
431	176	149	112	150
432	167	129	133	135
433	162	125	118	133
434	169	133	131	132

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
443	166	132	127	126
444	154	162	125	143
445	156	131	109	132
446	151	130	99	132
447	174	112	103	143
448	166	128	123	125
449	176	126	134	127
450	150	123	130	127
451	162	125	134	136
452	150	144	102	139
453	162	136	109	118
454	150	119	135	139
455	142	122	115	143
456	144	117	104	135
457	156	139	121	132
458	142	142	123	130
459	170	122	112	121
460	144	124	111	130
461	180	151	127	127
462	163	143	111	148
463	167	142	130	125
464	177	152	121	123
465	184	152	117	151
466	168	154	115	131
467	161	148	120	150
468	179	116	128	146

435	161	104	135	138
436	150	137	110	128
437	150	159	108	129
438	174	130	111	133
439	163	124	121	111
440	173	137	106	138
441	155	120	109	116
442	171	130	94	123

469	154	154	116	134
470	164	153	124	145
471	165	124	109	128
472	161	145	135	138
473	185	161	138	122
474	169	132	124	137
475	164	105	139	133
476	134	117	123	111

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
477	148	134	108	116
478	141	117	116	105
479	156	111	83	113
480	149	126	101	116
481	132	129	112	134
482	148	116	140	119
483	149	109	121	115
484	152	111	100	115
485	168	123	87	109
486	166	108	84	122
487	131	117	103	105
488	160	121	96	111
489	128	115	117	115
490	149	107	106	123
491	150	134	95	105
492	163	105	126	113
493	130	120	113	113
494	132	112	107	138
495	135	104	101	107
496	138	106	88	114
497	130	123	133	107
498	126	117	113	106
499	130	117	105	107
500	156	93	96	131
501	144	97	97	115

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
511	135	118	120	126
512	137	97	97	102
513	135	107	126	115
514	126	91	95	85
515	130	104	101	93
516	125	118	101	104
517	140	119	108	100
518	139	115	95	122
519	133	117	113	105
520	117	101	98	118
521	129	96	87	123
522	114	113	114	128
523	129	104	103	106
524	110	102	107	98
525	124	109	80	129
526	139	92	85	97
527	136	103	96	120
528	111	99	103	108
529	113	131	103	114
530	120	111	87	117
531	121	96	97	100
532	122	109	79	110
533	148	110	91	97
534	130	124	98	101
535	120	113	101	105

502	140	100	117	103
503	124	106	130	92
504	121	122	91	104
505	137	131	96	109
506	123	132	110	116
507	126	116	110	114
508	113	113	123	106
509	129	99	110	93
510	132	115	103	115

536	137	98	94	97
537	140	114	116	103
538	129	96	105	111
539	135	109	105	125
540	145	90	98	101
541	146	102	110	85
542	140	101	120	112
543	141	99	89	113
544	154	93	106	108

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
545	147	104	117	108
546	143	100	100	97
547	129	109	120	90
548	143	127	84	98
549	132	114	96	99
550	139	101	91	90
551	129	116	77	101
552	108	105	93	115
553	125	107	98	103
554	121	93	78	90
555	97	131	95	93
556	123	90	93	93
557	109	83	87	108
558	114	101	90	88
559	127	96	90	99
560	138	90	79	100
561	124	93	74	103
562	117	114	96	92
563	112	94	98	74
564	123	94	94	97
565	120	110	92	94
566	121	94	96	90
567	128	115	90	101
568	130	93	92	73

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
579	117	93	99	110
580	128	91	85	85
581	132	104	87	111
582	132	113	93	99
583	153	115	98	106
584	132	119	101	132
585	148	121	112	116
586	176	143	119	129
587	182	157	111	149
588	185	125	120	141
589	157	146	112	122
590	180	136	124	142
591	179	148	118	146
592	171	114	121	134
593	166	127	117	152
594	161	131	118	147
595	154	130	116	122
596	144	106	116	108
597	139	110	107	109
598	130	110	96	92
599	122	132	108	110
600	131	114	88	105
601	104	110	95	115
602	124	97	99	86

569	106	75	81	108
570	108	82	94	95
571	137	82	97	79
572	118	94	86	107
573	97	93	88	90
574	101	83	93	94
575	116	84	80	85
576	122	78	87	78
577	127	101	84	87
578	126	102	91	90

603	126	106	83	88
604	123	105	83	101
605	120	104	68	106
606	130	93	78	93
607	122	75	69	70
608	114	100	89	81
609	114	92	68	83
610	110	101	81	85
611	107	82	84	89
612	115	104	83	111

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
613	108	89	76	77
614	123	83	72	97
615	126	111	86	76
616	98	102	80	98
617	128	114	99	92
618	139	102	77	99
619	146	108	106	98
620	142	91	104	105
621	160	112	92	91
622	157	135	115	132
623	157	143	126	127
624	203	149	151	150
625	246	212	185	197
626	336	282	231	239
627	426	362	281	353
628	557	500	398	461
629	708	620	557	614
630	962	787	770	763
631	1279	1100	956	1014
632	1666	1420	1267	1371
633	2165	1719	1584	1718
634	2560	2193	1910	2075
635	3097	2656	2346	2502

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
647	3099	2632	2202	2485
648	2603	2176	1896	2050
649	2160	1778	1573	1681
650	1724	1453	1213	1369
651	1312	1086	946	1079
652	1010	809	719	832
653	747	604	562	606
654	571	490	421	498
655	413	369	319	331
656	345	252	214	284
657	244	195	190	188
658	192	164	160	164
659	142	144	104	125
660	135	80	105	121
661	141	102	91	110
662	120	95	78	79
663	122	94	85	85
664	112	84	78	91
665	117	85	69	88
666	111	78	67	74
667	82	85	87	86
668	95	78	69	92
669	104	65	70	88

636	3568	3025	2627	2844
637	4122	3277	3040	3264
638	4538	3794	3350	3637
639	4862	3845	3566	3836
640	5026	4309	3667	4059
641	5100	4291	3699	4049
642	5097	4192	3792	4047
643	4837	4034	3578	3843
644	4426	3654	3198	3579
645	4178	3360	3032	3282
646	3590	2845	2594	2913

670	122	96	88	78
671	90	67	74	74
672	101	101	77	87
673	123	93	55	91
674	104	97	64	72
675	119	68	80	68
676	98	85	72	81
677	126	78	70	104
678	112	83	79	90
679	110	98	94	73
680	124	80	73	78

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
681	123	85	81	95
682	126	96	90	99
683	131	92	76	84
684	120	109	84	86
685	137	86	85	76
686	114	86	90	93
687	133	101	79	96
688	151	108	94	105
689	128	101	97	123
690	129	108	84	115
691	143	124	111	132
692	162	143	138	130
693	169	136	138	133
694	193	175	146	144
695	253	187	152	197
696	246	212	198	190
697	304	213	247	225
698	326	254	275	276
699	424	351	296	330
700	473	390	361	361
701	509	476	386	452
702	596	507	422	447

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
715	336	270	249	285
716	304	223	220	209
717	236	178	171	167
718	203	158	143	158
719	179	145	126	118
720	147	131	107	106
721	135	103	84	88
722	106	85	76	83
723	98	66	76	76
724	86	91	69	65
725	89	68	59	62
726	74	57	60	62
727	66	72	57	52
728	81	71	50	48
729	68	59	50	57
730	74	54	44	45
731	66	67	49	60
732	79	56	42	58
733	62	62	59	61
734	64	59	55	55
735	75	70	56	55
736	87	57	60	68

703	618	521	461	485
704	725	561	483	523
705	690	600	502	565
706	687	572	546	556
707	723	609	477	581
708	711	553	480	538
709	695	576	527	527
710	625	507	494	487
711	549	470	452	483
712	517	425	364	417
713	464	402	364	357
714	418	311	302	360

737	73	61	49	49
738	64	80	38	49
739	88	78	42	65
740	69	63	48	48
741	80	68	49	55
742	89	72	59	59
743	78	60	50	63
744	82	49	68	57
745	78	53	56	58
746	72	52	70	60
747	81	63	44	48
748	70	49	64	54

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
749	75	63	50	50
750	67	53	64	51
751	69	68	63	50
752	68	56	64	63
753	77	63	50	55
754	69	58	56	61
755	84	51	49	64
756	73	62	52	50
757	70	60	48	54
758	79	64	48	61
759	65	54	55	52
760	74	74	48	62
761	53	48	43	59
762	81	61	54	72
763	61	72	49	68
764	61	61	63	58
765	58	57	59	62
766	70	67	54	61
767	79	65	62	58
768	75	62	53	62
769	67	46	65	53

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
783	65	47	39	56
784	61	61	42	51
785	58	52	49	51
786	77	50	70	61
787	63	66	42	46
788	61	46	40	62
789	66	53	58	57
790	66	67	50	44
791	65	58	40	45
792	59	64	42	49
793	60	56	49	41
794	67	59	56	49
795	78	47	47	49
796	79	55	51	54
797	81	46	47	48
798	70	58	47	69
799	74	51	50	49
800	65	59	38	41
801	68	43	54	71
802	75	55	61	63
803	69	45	73	67

770	76	59	52	57
771	77	61	55	46
772	71	66	55	46
773	62	48	46	56
774	68	59	54	65
775	60	54	57	61
776	67	45	47	56
777	57	46	40	41
778	54	47	37	42
779	67	51	49	50
780	51	59	38	41
781	65	64	42	61
782	72	52	55	41

804	73	48	43	52
805	63	53	57	45
806	69	51	49	48
807	60	66	51	54
808	85	65	55	56
809	64	60	55	51
810	78	60	50	48
811	50	54	50	52
812	64	60	56	30
813	54	63	51	55
814	67	59	57	54
815	54	66	48	50
816	63	50	32	50

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
817	68	50	43	46
818	52	59	35	44
819	55	40	44	56
820	66	43	47	47
821	64	59	48	47
822	52	42	51	46
823	60	66	32	47
824	48	55	61	56
825	59	62	45	59
826	65	55	40	44
827	70	59	43	56
828	56	60	42	43
829	56	41	40	40
830	60	47	48	64
831	82	45	52	52
832	68	60	47	47
833	70	61	50	44
834	53	41	59	52
835	65	46	51	54
836	59	48	49	44

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
851	62	54	48	45
852	58	47	55	43
853	71	50	50	56
854	64	51	46	44
855	67	50	48	49
856	58	37	48	39
857	58	47	39	48
858	58	50	54	45
859	57	43	50	51
860	56	45	39	42
861	37	54	39	39
862	62	58	37	31
863	69	42	42	38
864	57	42	38	48
865	56	49	35	48
866	50	41	34	46
867	46	51	47	43
868	57	57	44	41
869	53	45	54	44
870	54	42	44	49

837	56	52	46	41
838	66	58	52	49
839	63	49	43	53
840	41	59	43	41
841	61	36	54	39
842	54	51	49	46
843	63	43	45	56
844	58	46	31	48
845	70	45	52	45
846	41	52	29	57
847	62	53	27	45
848	56	51	42	35
849	72	52	44	37
850	69	39	43	49

871	48	46	41	47
872	68	57	47	41
873	55	46	34	59
874	54	53	39	46
875	48	37	45	39
876	53	58	44	30
877	55	48	27	45
878	59	46	35	46
879	54	54	33	45
880	65	41	46	38
881	49	39	36	46
882	53	45	30	51
883	53	43	49	62
884	52	60	32	38

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
885	57	38	34	43
886	52	53	40	40
887	58	37	49	33
888	52	46	37	48
889	61	40	33	39
890	61	46	26	55
891	55	39	41	53
892	69	62	42	39
893	58	55	38	46
894	54	55	43	40
895	53	43	42	41
896	56	45	41	41
897	45	45	36	45
898	46	47	35	49
899	52	34	38	43
900	46	50	39	33
901	52	56	33	55
902	61	40	36	37
903	43	54	32	30

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
919	55	48	47	32
920	46	41	38	31
921	53	47	35	26
922	44	49	36	44
923	45	46	41	38
924	50	42	37	48
925	59	44	29	34
926	50	44	31	43
927	52	44	36	41
928	47	36	29	38
929	39	44	38	37
930	36	35	34	34
931	52	41	31	50
932	50	36	21	40
933	50	49	44	40
934	48	40	32	29
935	38	39	32	35
936	45	44	31	38
937	46	31	40	28

904	61	38	40	42
905	54	35	38	42
906	55	28	37	44
907	54	59	38	34
908	42	38	46	40
909	52	45	35	46
910	54	44	52	49
911	60	36	38	43
912	48	44	34	35
913	45	37	35	43
914	57	43	39	40
915	45	35	41	41
916	56	37	40	52
917	45	41	47	39
918	47	41	39	45

938	41	36	29	42
939	41	52	34	38
940	49	35	32	33
941	49	45	38	29
942	61	41	38	28
943	43	47	34	28
944	61	55	31	38
945	49	43	34	37
946	37	31	39	45
947	55	41	35	38
948	53	36	27	49
949	45	38	26	39
950	53	28	30	34
951	52	28	27	37
952	52	39	32	35

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
953	49	33	29	36
954	46	45	41	38
955	49	32	28	45
956	57	33	36	29
957	43	44	35	45
958	45	49	31	41
959	46	32	41	35
960	52	34	28	46
961	51	40	41	37
962	56	33	35	45
963	51	35	39	30
964	40	34	33	37
965	43	34	29	36
966	48	52	34	34
967	49	37	37	37
968	42	35	30	33
969	53	42	30	26
970	47	31	28	50
971	40	33	40	32

Energy (Kev)	Control Parent Metal Frequency (au)	Control Welded Metal Frequency (au)	Heat Treated Parent Metal Frequency (au)	Heat Treated Welded Metal Frequency (au)
989	44	41	26	38
990	57	43	31	28
991	40	41	30	40
992	33	38	38	37
993	43	23	30	29
994	44	41	27	34
995	49	41	31	35
996	42	42	41	32
997	48	36	24	28
998	40	38	37	22
999	41	28	34	41
1000	34	48	32	37
1001	51	32	28	20
1002	41	41	32	24
1003	35	31	31	37
1004	26	35	36	35
1005	46	29	38	25
1006	34	30	37	43
1007	34	35	31	26

972	37	32	31	46
973	37	39	36	39
974	58	48	34	38
975	47	43	36	26
976	34	42	27	31
977	49	33	48	33
978	39	40	32	45
979	38	44	42	39
980	49	43	27	30
981	36	37	33	39
982	44	36	36	27
983	44	42	28	41
984	47	43	30	37
985	44	33	21	43
986	41	45	30	31
987	47	32	21	40
988	41	36	25	26

1008	54	37	37	36
1009	47	35	23	36
1010	41	37	30	29
1011	34	34	28	31
1012	60	30	17	33
1013	40	24	26	38
1014	46	25	29	30
1015	49	31	28	42
1016	32	39	21	29
1017	42	25	39	29
1018	41	32	28	37
1019	47	33	28	33
1020	44	36	24	32
1021	44	23	19	44
1022	43	35	33	33
1023	47	38	31	37
1024	31	23	33	29

Table B.2: Hardness Test Results for the Control (As-welded) Samples

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
1	3,6	67,354	1,2	75,164	167
2	3,8	67,554	1,2	75,164	165
3	4	67,754	1,2	75,164	159
4	4,2	67,954	1,2	75,164	158
5	4,4	68,154	1,2	75,164	165
6	4,6	68,354	1,2	75,164	161
7	4,8	68,554	1,2	75,164	158
8	5	68,754	1,2	75,164	171
9	5,2	68,954	1,2	75,164	164
10	5,4	69,154	1,2	75,164	165
11	5,6	69,354	1,2	75,164	160
12	5,8	69,554	1,2	75,164	163
13	6	69,754	1,2	75,164	163
14	6,2	69,954	1,2	75,164	160
15	6,4	70,154	1,2	75,164	157
16	6,6	70,354	1,2	75,164	164
17	6,8	70,554	1,2	75,164	163
18	7	70,754	1,2	75,164	163
19	7,2	70,954	1,2	75,164	164

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
35	10,4	74,154	1,2	75,164	215
36	10,6	74,354	1,2	75,164	207
37	10,8	74,554	1,2	75,164	214
38	11	74,754	1,2	75,164	209
39	11,2	74,954	1,2	75,164	201
40	11,4	75,154	1,2	75,164	198
41	11,6	75,354	1,2	75,164	190
42	11,8	75,554	1,2	75,164	195
43	12	75,754	1,2	75,164	208
44	12,2	75,954	1,2	75,164	201
45	12,4	76,154	1,2	75,164	198
46	12,6	76,354	1,2	75,164	210
47	12,8	76,554	1,2	75,164	207
48	13	76,754	1,2	75,164	205
49	13,2	76,954	1,2	75,164	219
50	13,4	77,154	1,2	75,164	203
51	13,6	77,354	1,2	75,164	199
52	13,8	77,554	1,2	75,164	215
53	14	77,754	1,2	75,164	211

20	7,4	71,154	1,2	75,164	169
21	7,6	71,354	1,2	75,164	164
22	7,8	71,554	1,2	75,164	169
23	8	71,754	1,2	75,164	180
24	8,2	71,954	1,2	75,164	206
25	8,4	72,154	1,2	75,164	205
26	8,6	72,354	1,2	75,164	209
27	8,8	72,554	1,2	75,164	206
28	9	72,754	1,2	75,164	194
29	9,2	72,954	1,2	75,164	204
30	9,4	73,154	1,2	75,164	200
31	9,6	73,354	1,2	75,164	207
32	9,8	73,554	1,2	75,164	197
33	10	73,754	1,2	75,164	195
34	10,2	73,954	1,2	75,164	201

54	14,2	77,954	1,2	75,164	208
55	14,4	78,154	1,2	75,164	203
56	14,6	78,354	1,2	75,164	208
57	14,8	78,554	1,2	75,164	206
58	15	78,754	1,2	75,164	215
59	15,2	78,954	1,2	75,164	214
60	15,4	79,154	1,2	75,164	214
61	15,6	79,354	1,2	75,164	205
62	15,8	79,554	1,2	75,164	201
63	16	79,754	1,2	75,164	199
64	16,2	79,954	1,2	75,164	200
65	16,4	80,154	1,2	75,164	200
66	16,6	80,354	1,2	75,164	196
67	16,8	80,554	1,2	75,164	207
68	17	80,754	1,2	75,164	202

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
69	17,2	80,954	1,2	75,164	207
70	17,4	81,154	1,2	75,164	202
71	17,6	81,354	1,2	75,164	200
72	17,8	81,554	1,2	75,164	207
73	18	81,754	1,2	75,164	204
74	18,2	81,954	1,2	75,164	211
75	18,4	82,154	1,2	75,164	214
76	3,6	67,354	1,4	74,964	164
77	3,8	67,554	1,4	74,964	162
78	4	67,754	1,4	74,964	161
79	4,2	67,954	1,4	74,964	156
80	4,4	68,154	1,4	74,964	159
81	4,6	68,354	1,4	74,964	159
82	4,8	68,554	1,4	74,964	157
83	5	68,754	1,4	74,964	158
84	5,2	68,954	1,4	74,964	158
85	5,4	69,154	1,4	74,964	159
86	5,6	69,354	1,4	74,964	160
87	5,8	69,554	1,4	74,964	169

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
106	9,6	73,354	1,4	74,964	208
107	9,8	73,554	1,4	74,964	203
108	10	73,754	1,4	74,964	203
109	10,2	73,954	1,4	74,964	200
110	10,4	74,154	1,4	74,964	208
111	10,6	74,354	1,4	74,964	211
112	10,8	74,554	1,4	74,964	206
113	11	74,754	1,4	74,964	206
114	11,2	74,954	1,4	74,964	205
115	11,4	75,154	1,4	74,964	204
116	11,6	75,354	1,4	74,964	196
117	11,8	75,554	1,4	74,964	201
118	12	75,754	1,4	74,964	193
119	12,2	75,954	1,4	74,964	205
120	12,4	76,154	1,4	74,964	205
121	12,6	76,354	1,4	74,964	205
122	12,8	76,554	1,4	74,964	212
123	13	76,754	1,4	74,964	207
124	13,2	76,954	1,4	74,964	214

88	6	69,754	1,4	74,964	161
89	6,2	69,954	1,4	74,964	164
90	6,4	70,154	1,4	74,964	167
91	6,6	70,354	1,4	74,964	158
92	6,8	70,554	1,4	74,964	167
93	7	70,754	1,4	74,964	159
94	7,2	70,954	1,4	74,964	164
95	7,4	71,154	1,4	74,964	165
96	7,6	71,354	1,4	74,964	166
97	7,8	71,554	1,4	74,964	166
98	8	71,754	1,4	74,964	197
99	8,2	71,954	1,4	74,964	209
100	8,4	72,154	1,4	74,964	208
101	8,6	72,354	1,4	74,964	211
102	8,8	72,554	1,4	74,964	201
103	9	72,754	1,4	74,964	204
104	9,2	72,954	1,4	74,964	205
105	9,4	73,154	1,4	74,964	207

125	13,4	77,154	1,4	74,964	216
126	13,6	77,354	1,4	74,964	196
127	13,8	77,554	1,4	74,964	200
128	14	77,754	1,4	74,964	202
129	14,2	77,954	1,4	74,964	216
130	14,4	78,154	1,4	74,964	206
131	14,6	78,354	1,4	74,964	213
132	14,8	78,554	1,4	74,964	225
133	15	78,754	1,4	74,964	214
134	15,2	78,954	1,4	74,964	213
135	15,4	79,154	1,4	74,964	222
136	15,6	79,354	1,4	74,964	210
137	15,8	79,554	1,4	74,964	203
138	16	79,754	1,4	74,964	203
139	16,2	79,954	1,4	74,964	195
140	16,4	80,154	1,4	74,964	206
141	16,6	80,354	1,4	74,964	207
142	16,8	80,554	1,4	74,964	189

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
143	17	80,754	1,4	74,964	206
144	17,2	80,954	1,4	74,964	219
145	17,4	81,154	1,4	74,964	214
146	17,6	81,354	1,4	74,964	212
147	17,8	81,554	1,4	74,964	216
148	18	81,754	1,4	74,964	212
149	18,2	81,954	1,4	74,964	228
150	18,4	82,154	1,4	74,964	230
151	3,6	67,354	1,6	74,764	157
152	3,8	67,554	1,6	74,764	159
153	4	67,754	1,6	74,764	159
154	4,2	67,954	1,6	74,764	159
155	4,4	68,154	1,6	74,764	157
156	4,6	68,354	1,6	74,764	161
157	4,8	68,554	1,6	74,764	164
158	5	68,754	1,6	74,764	163
159	5,2	68,954	1,6	74,764	167
160	5,4	69,154	1,6	74,764	161
161	5,6	69,354	1,6	74,764	148

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
180	9,4	73,154	1,6	74,764	203
181	9,6	73,354	1,6	74,764	206
182	9,8	73,554	1,6	74,764	201
183	10	73,754	1,6	74,764	197
184	10,2	73,954	1,6	74,764	197
185	10,4	74,154	1,6	74,764	197
186	10,6	74,354	1,6	74,764	212
187	10,8	74,554	1,6	74,764	209
188	11	74,754	1,6	74,764	196
189	11,2	74,954	1,6	74,764	204
190	11,4	75,154	1,6	74,764	196
191	11,6	75,354	1,6	74,764	189
192	11,8	75,554	1,6	74,764	198
193	12	75,754	1,6	74,764	206
194	12,2	75,954	1,6	74,764	207
195	12,4	76,154	1,6	74,764	191
196	12,6	76,354	1,6	74,764	215
197	12,8	76,554	1,6	74,764	205
198	13	76,754	1,6	74,764	210

162	5,8	69,554	1,6	74,764	164
163	6	69,754	1,6	74,764	158
164	6,2	69,954	1,6	74,764	161
165	6,4	70,154	1,6	74,764	161
166	6,6	70,354	1,6	74,764	162
167	6,8	70,554	1,6	74,764	162
168	7	70,754	1,6	74,764	162
169	7,2	70,954	1,6	74,764	169
170	7,4	71,154	1,6	74,764	171
171	7,6	71,354	1,6	74,764	164
172	7,8	71,554	1,6	74,764	181
173	8	71,754	1,6	74,764	211
174	8,2	71,954	1,6	74,764	205
175	8,4	72,154	1,6	74,764	208
176	8,6	72,354	1,6	74,764	207
177	8,8	72,554	1,6	74,764	202
178	9	72,754	1,6	74,764	208
179	9,2	72,954	1,6	74,764	203

199	13,2	76,954	1,6	74,764	207
200	13,4	77,154	1,6	74,764	212
201	13,6	77,354	1,6	74,764	223
202	13,8	77,554	1,6	74,764	202
203	14	77,754	1,6	74,764	207
204	14,2	77,954	1,6	74,764	214
205	14,4	78,154	1,6	74,764	212
206	14,6	78,354	1,6	74,764	209
207	14,8	78,554	1,6	74,764	217
208	15	78,754	1,6	74,764	222
209	15,2	78,954	1,6	74,764	222
210	15,4	79,154	1,6	74,764	213
211	15,6	79,354	1,6	74,764	213
212	15,8	79,554	1,6	74,764	212
213	16	79,754	1,6	74,764	206
214	16,2	79,954	1,6	74,764	208
215	16,4	80,154	1,6	74,764	215
216	16,6	80,354	1,6	74,764	207

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
217	16,8	80,554	1,6	74,764	203
218	17	80,754	1,6	74,764	205
219	17,2	80,954	1,6	74,764	221
220	17,4	81,154	1,6	74,764	214
221	17,6	81,354	1,6	74,764	201
222	17,8	81,554	1,6	74,764	218
223	18	81,754	1,6	74,764	229
224	18,2	81,954	1,6	74,764	217
225	18,4	82,154	1,6	74,764	236
226	3,6	67,354	1,8	74,564	153
227	3,8	67,554	1,8	74,564	162
228	4	67,754	1,8	74,564	155
229	4,2	67,954	1,8	74,564	155
230	4,4	68,154	1,8	74,564	164
231	4,6	68,354	1,8	74,564	166
232	4,8	68,554	1,8	74,564	158
233	5	68,754	1,8	74,564	161
234	5,2	68,954	1,8	74,564	164
235	5,4	69,154	1,8	74,564	165

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
254	9,2	72,954	1,8	74,564	208
255	9,4	73,154	1,8	74,564	206
256	9,6	73,354	1,8	74,564	206
257	9,8	73,554	1,8	74,564	207
258	10	73,754	1,8	74,564	199
259	10,2	73,954	1,8	74,564	199
260	10,4	74,154	1,8	74,564	200
261	10,6	74,354	1,8	74,564	206
262	10,8	74,554	1,8	74,564	208
263	11	74,754	1,8	74,564	203
264	11,2	74,954	1,8	74,564	205
265	11,4	75,154	1,8	74,564	205
266	11,6	75,354	1,8	74,564	194
267	11,8	75,554	1,8	74,564	201
268	12	75,754	1,8	74,564	215
269	12,2	75,954	1,8	74,564	204
270	12,4	76,154	1,8	74,564	211
271	12,6	76,354	1,8	74,564	200
272	12,8	76,554	1,8	74,564	218

236	5,6	69,354	1,8	74,564	158
237	5,8	69,554	1,8	74,564	169
238	6	69,754	1,8	74,564	170
239	6,2	69,954	1,8	74,564	161
240	6,4	70,154	1,8	74,564	166
241	6,6	70,354	1,8	74,564	164
242	6,8	70,554	1,8	74,564	157
243	7	70,754	1,8	74,564	164
244	7,2	70,954	1,8	74,564	167
245	7,4	71,154	1,8	74,564	50
246	7,6	71,354	1,8	74,564	167
247	7,8	71,554	1,8	74,564	202
248	8	71,754	1,8	74,564	209
249	8,2	71,954	1,8	74,564	208
250	8,4	72,154	1,8	74,564	209
251	8,6	72,354	1,8	74,564	211
252	8,8	72,554	1,8	74,564	205
253	9	72,754	1,8	74,564	206

273	13	76,754	1,8	74,564	227
274	13,2	76,954	1,8	74,564	215
275	13,4	77,154	1,8	74,564	215
276	13,6	77,354	1,8	74,564	202
277	13,8	77,554	1,8	74,564	214
278	14	77,754	1,8	74,564	207
279	14,2	77,954	1,8	74,564	208
280	14,4	78,154	1,8	74,564	213
281	14,6	78,354	1,8	74,564	218
282	14,8	78,554	1,8	74,564	216
283	15	78,754	1,8	74,564	223
284	15,2	78,954	1,8	74,564	212
285	15,4	79,154	1,8	74,564	224
286	15,6	79,354	1,8	74,564	224
287	15,8	79,554	1,8	74,564	219
288	16	79,754	1,8	74,564	220
289	16,2	79,954	1,8	74,564	215
290	16,4	80,154	1,8	74,564	214

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
291	16,6	80,354	1,8	74,564	211
292	16,8	80,554	1,8	74,564	200
293	17	80,754	1,8	74,564	212
294	17,2	80,954	1,8	74,564	206
295	17,4	81,154	1,8	74,564	223
296	17,6	81,354	1,8	74,564	220
297	17,8	81,554	1,8	74,564	248
298	18	81,754	1,8	74,564	235
299	18,2	81,954	1,8	74,564	231
300	18,4	82,154	1,8	74,564	225
301	3,6	67,354	2	74,364	160
302	3,8	67,554	2	74,364	152
303	4	67,754	2	74,364	152
304	4,2	67,954	2	74,364	154
305	4,4	68,154	2	74,364	157
306	4,6	68,354	2	74,364	162
307	4,8	68,554	2	74,364	163
308	5	68,754	2	74,364	158
309	5,2	68,954	2	74,364	169

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
328	9	72,754	2	74,364	207
329	9,2	72,954	2	74,364	206
330	9,4	73,154	2	74,364	203
331	9,6	73,354	2	74,364	206
332	9,8	73,554	2	74,364	205
333	10	73,754	2	74,364	201
334	10,2	73,954	2	74,364	201
335	10,4	74,154	2	74,364	206
336	10,6	74,354	2	74,364	200
337	10,8	74,554	2	74,364	204
338	11	74,754	2	74,364	205
339	11,2	74,954	2	74,364	203
340	11,4	75,154	2	74,364	207
341	11,6	75,354	2	74,364	197
342	11,8	75,554	2	74,364	201
343	12	75,754	2	74,364	195
344	12,2	75,954	2	74,364	200
345	12,4	76,154	2	74,364	201
346	12,6	76,354	2	74,364	207

310	5,4	69,154	2	74,364	153
311	5,6	69,354	2	74,364	165
312	5,8	69,554	2	74,364	165
313	6	69,754	2	74,364	162
314	6,2	69,954	2	74,364	162
315	6,4	70,154	2	74,364	162
316	6,6	70,354	2	74,364	165
317	6,8	70,554	2	74,364	167
318	7	70,754	2	74,364	165
319	7,2	70,954	2	74,364	167
320	7,4	71,154	2	74,364	165
321	7,6	71,354	2	74,364	168
322	7,8	71,554	2	74,364	201
323	8	71,754	2	74,364	208
324	8,2	71,954	2	74,364	207
325	8,4	72,154	2	74,364	212
326	8,6	72,354	2	74,364	204
327	8,8	72,554	2	74,364	211

347	12,8	76,554	2	74,364	207
348	13	76,754	2	74,364	215
349	13,2	76,954	2	74,364	208
350	13,4	77,154	2	74,364	211
351	13,6	77,354	2	74,364	216
352	13,8	77,554	2	74,364	209
353	14	77,754	2	74,364	200
354	14,2	77,954	2	74,364	207
355	14,4	78,154	2	74,364	224
356	14,6	78,354	2	74,364	216
357	14,8	78,554	2	74,364	214
358	15	78,754	2	74,364	214
359	15,2	78,954	2	74,364	234
360	15,4	79,154	2	74,364	218
361	15,6	79,354	2	74,364	228
362	15,8	79,554	2	74,364	215
363	16	79,754	2	74,364	212
364	16,2	79,954	2	74,364	210

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
365	16,4	80,154	2	74,364	202
366	16,6	80,354	2	74,364	209
367	16,8	80,554	2	74,364	202
368	17	80,754	2	74,364	211
369	17,2	80,954	2	74,364	211
370	17,4	81,154	2	74,364	216
371	17,6	81,354	2	74,364	234
372	17,8	81,554	2	74,364	241
373	18	81,754	2	74,364	235
374	18,2	81,954	2	74,364	236
375	18,4	82,154	2	74,364	240
376	3,6	67,354	2,2	74,164	153
377	3,8	67,554	2,2	74,164	156
378	4	67,754	2,2	74,164	157
379	4,2	67,954	2,2	74,164	159
380	4,4	68,154	2,2	74,164	155
381	4,6	68,354	2,2	74,164	155
382	4,8	68,554	2,2	74,164	169
383	5	68,754	2,2	74,164	165

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
402	8,8	72,554	2,2	74,164	205
403	9	72,754	2,2	74,164	208
404	9,2	72,954	2,2	74,164	209
405	9,4	73,154	2,2	74,164	207
406	9,6	73,354	2,2	74,164	206
407	9,8	73,554	2,2	74,164	202
408	10	73,754	2,2	74,164	202
409	10,2	73,954	2,2	74,164	202
410	10,4	74,154	2,2	74,164	201
411	10,6	74,354	2,2	74,164	202
412	10,8	74,554	2,2	74,164	210
413	11	74,754	2,2	74,164	214
414	11,2	74,954	2,2	74,164	204
415	11,4	75,154	2,2	74,164	193
416	11,6	75,354	2,2	74,164	207
417	11,8	75,554	2,2	74,164	195
418	12	75,754	2,2	74,164	214
419	12,2	75,954	2,2	74,164	197
420	12,4	76,154	2,2	74,164	203

384	5,2	68,954	2,2	74,164	169
385	5,4	69,154	2,2	74,164	161
386	5,6	69,354	2,2	74,164	163
387	5,8	69,554	2,2	74,164	161
388	6	69,754	2,2	74,164	159
389	6,2	69,954	2,2	74,164	167
390	6,4	70,154	2,2	74,164	159
391	6,6	70,354	2,2	74,164	165
392	6,8	70,554	2,2	74,164	167
393	7	70,754	2,2	74,164	163
394	7,2	70,954	2,2	74,164	165
395	7,4	71,154	2,2	74,164	167
396	7,6	71,354	2,2	74,164	172
397	7,8	71,554	2,2	74,164	204
398	8	71,754	2,2	74,164	210
399	8,2	71,954	2,2	74,164	203
400	8,4	72,154	2,2	74,164	208
401	8,6	72,354	2,2	74,164	211

421	12,6	76,354	2,2	74,164	196
422	12,8	76,554	2,2	74,164	206
423	13	76,754	2,2	74,164	218
424	13,2	76,954	2,2	74,164	212
425	13,4	77,154	2,2	74,164	220
426	13,6	77,354	2,2	74,164	216
427	13,8	77,554	2,2	74,164	222
428	14	77,754	2,2	74,164	211
429	14,2	77,954	2,2	74,164	222
430	14,4	78,154	2,2	74,164	214
431	14,6	78,354	2,2	74,164	206
432	14,8	78,554	2,2	74,164	201
433	15	78,754	2,2	74,164	226
434	15,2	78,954	2,2	74,164	222
435	15,4	79,154	2,2	74,164	214
436	15,6	79,354	2,2	74,164	219
437	15,8	79,554	2,2	74,164	217
438	16	79,754	2,2	74,164	222

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
439	16,2	79,954	2,2	74,164	221
440	16,4	80,154	2,2	74,164	215
441	16,6	80,354	2,2	74,164	214
442	16,8	80,554	2,2	74,164	212
443	17	80,754	2,2	74,164	209
444	17,2	80,954	2,2	74,164	214
445	17,4	81,154	2,2	74,164	224
446	17,6	81,354	2,2	74,164	232
447	17,8	81,554	2,2	74,164	244
448	18	81,754	2,2	74,164	235
449	18,2	81,954	2,2	74,164	238
450	18,4	82,154	2,2	74,164	236
451	3,6	67,354	2,4	73,964	158
452	3,8	67,554	2,4	73,964	154
453	4	67,754	2,4	73,964	164
454	4,2	67,954	2,4	73,964	159
455	4,4	68,154	2,4	73,964	164
456	4,6	68,354	2,4	73,964	158
457	4,8	68,554	2,4	73,964	161

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
476	8,6	72,354	2,4	73,964	206
477	8,8	72,554	2,4	73,964	209
478	9	72,754	2,4	73,964	210
479	9,2	72,954	2,4	73,964	210
480	9,4	73,154	2,4	73,964	204
481	9,6	73,354	2,4	73,964	203
482	9,8	73,554	2,4	73,964	207
483	10	73,754	2,4	73,964	207
484	10,2	73,954	2,4	73,964	201
485	10,4	74,154	2,4	73,964	203
486	10,6	74,354	2,4	73,964	207
487	10,8	74,554	2,4	73,964	201
488	11	74,754	2,4	73,964	211
489	11,2	74,954	2,4	73,964	198
490	11,4	75,154	2,4	73,964	201
491	11,6	75,354	2,4	73,964	198
492	11,8	75,554	2,4	73,964	205
493	12	75,754	2,4	73,964	198
494	12,2	75,954	2,4	73,964	191

458	5	68,754	2,4	73,964	166
459	5,2	68,954	2,4	73,964	165
460	5,4	69,154	2,4	73,964	157
461	5,6	69,354	2,4	73,964	159
462	5,8	69,554	2,4	73,964	162
463	6	69,754	2,4	73,964	167
464	6,2	69,954	2,4	73,964	157
465	6,4	70,154	2,4	73,964	168
466	6,6	70,354	2,4	73,964	165
467	6,8	70,554	2,4	73,964	171
468	7	70,754	2,4	73,964	161
469	7,2	70,954	2,4	73,964	163
470	7,4	71,154	2,4	73,964	164
471	7,6	71,354	2,4	73,964	182
472	7,8	71,554	2,4	73,964	206
473	8	71,754	2,4	73,964	205
474	8,2	71,954	2,4	73,964	212
475	8,4	72,154	2,4	73,964	210

495	12,4	76,154	2,4	73,964	200
496	12,6	76,354	2,4	73,964	196
497	12,8	76,554	2,4	73,964	206
498	13	76,754	2,4	73,964	214
499	13,2	76,954	2,4	73,964	214
500	13,4	77,154	2,4	73,964	214
501	13,6	77,354	2,4	73,964	221
502	13,8	77,554	2,4	73,964	223
503	14	77,754	2,4	73,964	217
504	14,2	77,954	2,4	73,964	200
505	14,4	78,154	2,4	73,964	203
506	14,6	78,354	2,4	73,964	206
507	14,8	78,554	2,4	73,964	210
508	15	78,754	2,4	73,964	209
509	15,2	78,954	2,4	73,964	222
510	15,4	79,154	2,4	73,964	226
511	15,6	79,354	2,4	73,964	226
512	15,8	79,554	2,4	73,964	219

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
513	16	79,754	2,4	73,964	221
514	16,2	79,954	2,4	73,964	214
515	16,4	80,154	2,4	73,964	208
516	16,6	80,354	2,4	73,964	204
517	16,8	80,554	2,4	73,964	212
518	17	80,754	2,4	73,964	209
519	17,2	80,954	2,4	73,964	227
520	17,4	81,154	2,4	73,964	231
521	17,6	81,354	2,4	73,964	235
522	17,8	81,554	2,4	73,964	248
523	18	81,754	2,4	73,964	246
524	18,2	81,954	2,4	73,964	240
525	18,4	82,154	2,4	73,964	226
526	3,6	67,354	2,6	73,764	159
527	3,8	67,554	2,6	73,764	166
528	4	67,754	2,6	73,764	158
529	4,2	67,954	2,6	73,764	162
530	4,4	68,154	2,6	73,764	155
531	4,6	68,354	2,6	73,764	155

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
550	8,4	72,154	2,6	73,764	212
551	8,6	72,354	2,6	73,764	211
552	8,8	72,554	2,6	73,764	207
553	9	72,754	2,6	73,764	206
554	9,2	72,954	2,6	73,764	208
555	9,4	73,154	2,6	73,764	203
556	9,6	73,354	2,6	73,764	208
557	9,8	73,554	2,6	73,764	207
558	10	73,754	2,6	73,764	204
559	10,2	73,954	2,6	73,764	207
560	10,4	74,154	2,6	73,764	202
561	10,6	74,354	2,6	73,764	200
562	10,8	74,554	2,6	73,764	193
563	11	74,754	2,6	73,764	201
564	11,2	74,954	2,6	73,764	189
565	11,4	75,154	2,6	73,764	201
566	11,6	75,354	2,6	73,764	196
567	11,8	75,554	2,6	73,764	199
568	12	75,754	2,6	73,764	203

532	4,8	68,554	2,6	73,764	160
533	5	68,754	2,6	73,764	161
534	5,2	68,954	2,6	73,764	165
535	5,4	69,154	2,6	73,764	172
536	5,6	69,354	2,6	73,764	163
537	5,8	69,554	2,6	73,764	169
538	6	69,754	2,6	73,764	159
539	6,2	69,954	2,6	73,764	168
540	6,4	70,154	2,6	73,764	167
541	6,6	70,354	2,6	73,764	162
542	6,8	70,554	2,6	73,764	164
543	7	70,754	2,6	73,764	162
544	7,2	70,954	2,6	73,764	162
545	7,4	71,154	2,6	73,764	169
546	7,6	71,354	2,6	73,764	181
547	7,8	71,554	2,6	73,764	199
548	8	71,754	2,6	73,764	210
549	8,2	71,954	2,6	73,764	212

569	12,2	75,954	2,6	73,764	196
570	12,4	76,154	2,6	73,764	199
571	12,6	76,354	2,6	73,764	201
572	12,8	76,554	2,6	73,764	204
573	13	76,754	2,6	73,764	205
574	13,2	76,954	2,6	73,764	209
575	13,4	77,154	2,6	73,764	209
576	13,6	77,354	2,6	73,764	232
577	13,8	77,554	2,6	73,764	214
578	14	77,754	2,6	73,764	213
579	14,2	77,954	2,6	73,764	193
580	14,4	78,154	2,6	73,764	205
581	14,6	78,354	2,6	73,764	207
582	14,8	78,554	2,6	73,764	201
583	15	78,754	2,6	73,764	218
584	15,2	78,954	2,6	73,764	217
585	15,4	79,154	2,6	73,764	216
586	15,6	79,354	2,6	73,764	214

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
587	15,8	79,554	2,6	73,764	215
588	16	79,754	2,6	73,764	222
589	16,2	79,954	2,6	73,764	215
590	16,4	80,154	2,6	73,764	231
591	16,6	80,354	2,6	73,764	206
592	16,8	80,554	2,6	73,764	206
593	17	80,754	2,6	73,764	223
594	17,2	80,954	2,6	73,764	228
595	17,4	81,154	2,6	73,764	237
596	17,6	81,354	2,6	73,764	238
597	17,8	81,554	2,6	73,764	240
598	18	81,754	2,6	73,764	251
599	18,2	81,954	2,6	73,764	237
600	18,4	82,154	2,6	73,764	232
601	3,6	67,354	2,8	73,564	157
602	3,8	67,554	2,8	73,564	169
603	4	67,754	2,8	73,564	164
604	4,2	67,954	2,8	73,564	165
605	4,4	68,154	2,8	73,564	153

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
624	8,2	71,954	2,8	73,564	208
625	8,4	72,154	2,8	73,564	206
626	8,6	72,354	2,8	73,564	210
627	8,8	72,554	2,8	73,564	207
628	9	72,754	2,8	73,564	205
629	9,2	72,954	2,8	73,564	209
630	9,4	73,154	2,8	73,564	206
631	9,6	73,354	2,8	73,564	210
632	9,8	73,554	2,8	73,564	209
633	10	73,754	2,8	73,564	207
634	10,2	73,954	2,8	73,564	204
635	10,4	74,154	2,8	73,564	204
636	10,6	74,354	2,8	73,564	198
637	10,8	74,554	2,8	73,564	204
638	11	74,754	2,8	73,564	196
639	11,2	74,954	2,8	73,564	198
640	11,4	75,154	2,8	73,564	205
641	11,6	75,354	2,8	73,564	197
642	11,8	75,554	2,8	73,564	201

606	4,6	68,354	2,8	73,564	161
607	4,8	68,554	2,8	73,564	163
608	5	68,754	2,8	73,564	171
609	5,2	68,954	2,8	73,564	165
610	5,4	69,154	2,8	73,564	158
611	5,6	69,354	2,8	73,564	169
612	5,8	69,554	2,8	73,564	177
613	6	69,754	2,8	73,564	165
614	6,2	69,954	2,8	73,564	165
615	6,4	70,154	2,8	73,564	161
616	6,6	70,354	2,8	73,564	170
617	6,8	70,554	2,8	73,564	165
618	7	70,754	2,8	73,564	164
619	7,2	70,954	2,8	73,564	162
620	7,4	71,154	2,8	73,564	175
621	7,6	71,354	2,8	73,564	190
622	7,8	71,554	2,8	73,564	207
623	8	71,754	2,8	73,564	212

643	12	75,754	2,8	73,564	205
644	12,2	75,954	2,8	73,564	206
645	12,4	76,154	2,8	73,564	206
646	12,6	76,354	2,8	73,564	201
647	12,8	76,554	2,8	73,564	200
648	13	76,754	2,8	73,564	213
649	13,2	76,954	2,8	73,564	220
650	13,4	77,154	2,8	73,564	209
651	13,6	77,354	2,8	73,564	222
652	13,8	77,554	2,8	73,564	215
653	14	77,754	2,8	73,564	205
654	14,2	77,954	2,8	73,564	217
655	14,4	78,154	2,8	73,564	207
656	14,6	78,354	2,8	73,564	222
657	14,8	78,554	2,8	73,564	205
658	15	78,754	2,8	73,564	204
659	15,2	78,954	2,8	73,564	196
660	15,4	79,154	2,8	73,564	227

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
661	15,6	79,354	2,8	73,564	236
662	15,8	79,554	2,8	73,564	217
663	16	79,754	2,8	73,564	207
664	16,2	79,954	2,8	73,564	212
665	16,4	80,154	2,8	73,564	217
666	16,6	80,354	2,8	73,564	216
667	16,8	80,554	2,8	73,564	224
668	17	80,754	2,8	73,564	217
669	17,2	80,954	2,8	73,564	228
670	17,4	81,154	2,8	73,564	241
671	17,6	81,354	2,8	73,564	233
672	17,8	81,554	2,8	73,564	248
673	18	81,754	2,8	73,564	244
674	18,2	81,954	2,8	73,564	240
675	18,4	82,154	2,8	73,564	229
676	3,6	67,354	3	73,364	158
677	3,8	67,554	3	73,364	160
678	4	67,754	3	73,364	168
679	4,2	67,954	3	73,364	165

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
714	11,2	74,954	3	73,364	201
715	11,4	75,154	3	73,364	205
716	11,6	75,354	3	73,364	204
717	11,8	75,554	3	73,364	201
718	12	75,754	3	73,364	199
719	12,2	75,954	3	73,364	198
720	12,4	76,154	3	73,364	202
721	12,6	76,354	3	73,364	208
722	12,8	76,554	3	73,364	212
723	13	76,754	3	73,364	195
724	13,2	76,954	3	73,364	209
725	13,4	77,154	3	73,364	202
726	13,6	77,354	3	73,364	207
727	13,8	77,554	3	73,364	204
728	14	77,754	3	73,364	207
729	14,2	77,954	3	73,364	209
730	14,4	78,154	3	73,364	204
731	14,6	78,354	3	73,364	201
732	14,8	78,554	3	73,364	201

680	4,4	68,154	3	73,364	159
681	4,6	68,354	3	73,364	172
682	4,8	68,554	3	73,364	161
683	5	68,754	3	73,364	164
684	5,2	68,954	3	73,364	155
685	5,4	69,154	3	73,364	164
686	5,6	69,354	3	73,364	169
687	5,8	69,554	3	73,364	172
688	6	69,754	3	73,364	172
689	6,2	69,954	3	73,364	162
690	6,4	70,154	3	73,364	165
691	6,6	70,354	3	73,364	174
692	6,8	70,554	3	73,364	164
693	7	70,754	3	73,364	164
694	7,2	70,954	3	73,364	159
695	7,4	71,154	3	73,364	181
696	7,6	71,354	3	73,364	189
697	7,8	71,554	3	73,364	206

733	15	78,754	3	73,364	204
734	15,2	78,954	3	73,364	213
735	15,4	79,154	3	73,364	199
736	15,6	79,354	3	73,364	218
737	15,8	79,554	3	73,364	214
738	16	79,754	3	73,364	216
739	16,2	79,954	3	73,364	213
740	16,4	80,154	3	73,364	200
741	16,6	80,354	3	73,364	215
742	16,8	80,554	3	73,364	206
743	17	80,754	3	73,364	224
744	17,2	80,954	3	73,364	218
745	17,4	81,154	3	73,364	226
746	17,6	81,354	3	73,364	237
747	17,8	81,554	3	73,364	251
748	18	81,754	3	73,364	247
749	18,2	81,954	3	73,364	241
750	18,4	82,154	3	73,364	229

Table B.3: Hardness Test Results for the Solution Annealed (Heat-treated) Samples

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
1	6,2	92,462	1,4	71,502	213
2	6,4	92,662	1,4	71,502	209
3	6,6	92,862	1,4	71,502	227
4	6,8	93,062	1,4	71,502	205
5	7	93,262	1,4	71,502	224
6	7,2	93,462	1,4	71,502	187
7	7,4	93,662	1,4	71,502	269
8	7,6	93,862	1,4	71,502	197
9	7,8	94,062	1,4	71,502	206
10	8	94,262	1,4	71,502	205
11	8,2	94,462	1,4	71,502	203
12	8,4	94,662	1,4	71,502	193
13	8,6	94,862	1,4	71,502	208
14	8,8	95,062	1,4	71,502	203
15	9	95,262	1,4	71,502	211
16	9,2	95,462	1,4	71,502	287
17	9,4	95,662	1,4	71,502	228
18	9,6	95,862	1,4	71,502	326
19	9,8	96,062	1,4	71,502	309

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
38	13,6	99,862	1,4	71,502	430
39	13,8	100,062	1,4	71,502	398
40	14	100,262	1,4	71,502	413
41	14,2	100,462	1,4	71,502	444
42	14,4	100,662	1,4	71,502	403
43	14,6	100,862	1,4	71,502	420
44	14,8	101,062	1,4	71,502	428
45	15	101,262	1,4	71,502	441
46	15,2	101,462	1,4	71,502	446
47	15,4	101,662	1,4	71,502	423
48	15,6	101,862	1,4	71,502	444
49	15,8	102,062	1,4	71,502	436
50	16	102,262	1,4	71,502	436
51	16,2	102,462	1,4	71,502	441
52	16,4	102,662	1,4	71,502	431
53	16,6	102,862	1,4	71,502	436
54	16,8	103,062	1,4	71,502	452
55	17	103,262	1,4	71,502	441
56	17,2	103,462	1,4	71,502	466

20	10	96,262	1,4	71,502	352
21	10,2	96,462	1,4	71,502	330
22	10,4	96,662	1,4	71,502	420
23	10,6	96,862	1,4	71,502	408
24	10,8	97,062	1,4	71,502	368
25	11	97,262	1,4	71,502	411
26	11,2	97,462	1,4	71,502	392
27	11,4	97,662	1,4	71,502	418
28	11,6	97,862	1,4	71,502	412
29	11,8	98,062	1,4	71,502	404
30	12	98,262	1,4	71,502	417
31	12,2	98,462	1,4	71,502	390
32	12,4	98,662	1,4	71,502	383
33	12,6	98,862	1,4	71,502	394
34	12,8	99,062	1,4	71,502	404
35	13	99,262	1,4	71,502	408
36	13,2	99,462	1,4	71,502	410
37	13,4	99,662	1,4	71,502	420

57	17,4	103,662	1,4	71,502	446
58	17,6	103,862	1,4	71,502	460
59	17,8	104,062	1,4	71,502	418
60	18	104,262	1,4	71,502	422
61	18,2	104,462	1,4	71,502	444
62	18,4	104,662	1,4	71,502	460
63	18,6	104,862	1,4	71,502	458
64	18,8	105,062	1,4	71,502	449
65	19	105,262	1,4	71,502	418
66	19,2	105,462	1,4	71,502	425
67	19,4	105,662	1,4	71,502	478
68	19,6	105,862	1,4	71,502	466
69	19,8	106,062	1,4	71,502	431
70	20	106,262	1,4	71,502	466
71	20,2	106,462	1,4	71,502	482
72	20,4	106,662	1,4	71,502	455
73	20,6	106,862	1,4	71,502	458
74	20,8	107,062	1,4	71,502	458

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
75	21	107,262	1,4	71,502	449
76	6,2	92,462	1,6	71,302	227
77	6,4	92,662	1,6	71,302	223
78	6,6	92,862	1,6	71,302	216
79	6,8	93,062	1,6	71,302	210
80	7	93,262	1,6	71,302	215
81	7,2	93,462	1,6	71,302	200
82	7,4	93,662	1,6	71,302	196
83	7,6	93,862	1,6	71,302	196
84	7,8	94,062	1,6	71,302	195
85	8	94,262	1,6	71,302	186
86	8,2	94,462	1,6	71,302	190
87	8,4	94,662	1,6	71,302	199
88	8,6	94,862	1,6	71,302	202
89	8,8	95,062	1,6	71,302	248
90	9	95,262	1,6	71,302	214
91	9,2	95,462	1,6	71,302	296
92	9,4	95,662	1,6	71,302	255
93	9,6	95,862	1,6	71,302	298

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
112	13,4	99,662	1,6	71,302	420
113	13,6	99,862	1,6	71,302	376
114	13,8	100,062	1,6	71,302	428
115	14	100,262	1,6	71,302	413
116	14,2	100,462	1,6	71,302	399
117	14,4	100,662	1,6	71,302	452
118	14,6	100,862	1,6	71,302	418
119	14,8	101,062	1,6	71,302	394
120	15	101,262	1,6	71,302	444
121	15,2	101,462	1,6	71,302	449
122	15,4	101,662	1,6	71,302	423
123	15,6	101,862	1,6	71,302	452
124	15,8	102,062	1,6	71,302	394
125	16	102,262	1,6	71,302	461
126	16,2	102,462	1,6	71,302	443
127	16,4	102,662	1,6	71,302	461
128	16,6	102,862	1,6	71,302	452
129	16,8	103,062	1,6	71,302	413
130	17	103,262	1,6	71,302	441

94	9,8	96,062	1,6	71,302	310
95	10	96,262	1,6	71,302	341
96	10,2	96,462	1,6	71,302	341
97	10,4	96,662	1,6	71,302	370
98	10,6	96,862	1,6	71,302	378
99	10,8	97,062	1,6	71,302	392
100	11	97,262	1,6	71,302	418
101	11,2	97,462	1,6	71,302	431
102	11,4	97,662	1,6	71,302	418
103	11,6	97,862	1,6	71,302	396
104	11,8	98,062	1,6	71,302	417
105	12	98,262	1,6	71,302	425
106	12,2	98,462	1,6	71,302	403
107	12,4	98,662	1,6	71,302	444
108	12,6	98,862	1,6	71,302	423
109	12,8	99,062	1,6	71,302	413
110	13	99,262	1,6	71,302	423
111	13,2	99,462	1,6	71,302	433

131	17,2	103,462	1,6	71,302	433
132	17,4	103,662	1,6	71,302	472
133	17,6	103,862	1,6	71,302	455
134	17,8	104,062	1,6	71,302	452
135	18	104,262	1,6	71,302	447
136	18,2	104,462	1,6	71,302	439
137	18,4	104,662	1,6	71,302	461
138	18,6	104,862	1,6	71,302	475
139	18,8	105,062	1,6	71,302	469
140	19	105,262	1,6	71,302	413
141	19,2	105,462	1,6	71,302	478
142	19,4	105,662	1,6	71,302	426
143	19,6	105,862	1,6	71,302	479
144	19,8	106,062	1,6	71,302	497
145	20	106,262	1,6	71,302	476
146	20,2	106,462	1,6	71,302	484
147	20,4	106,662	1,6	71,302	436
148	20,6	106,862	1,6	71,302	466

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
149	20,8	107,062	1,6	71,302	458
150	21	107,262	1,6	71,302	466
151	6,2	92,462	1,8	71,102	204
152	6,4	92,662	1,8	71,102	241
153	6,6	92,862	1,8	71,102	219
154	6,8	93,062	1,8	71,102	208
155	7	93,262	1,8	71,102	218
156	7,2	93,462	1,8	71,102	201
157	7,4	93,662	1,8	71,102	214
158	7,6	93,862	1,8	71,102	219
159	7,8	94,062	1,8	71,102	215
160	8	94,262	1,8	71,102	192
161	8,2	94,462	1,8	71,102	203
162	8,4	94,662	1,8	71,102	199
163	8,6	94,862	1,8	71,102	193
164	8,8	95,062	1,8	71,102	247
165	9	95,262	1,8	71,102	216
166	9,2	95,462	1,8	71,102	231
167	9,4	95,662	1,8	71,102	256

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
186	13,2	99,462	1,8	71,102	436
187	13,4	99,662	1,8	71,102	449
188	13,6	99,862	1,8	71,102	444
189	13,8	100,062	1,8	71,102	423
190	14	100,262	1,8	71,102	413
191	14,2	100,462	1,8	71,102	452
192	14,4	100,662	1,8	71,102	399
193	14,6	100,862	1,8	71,102	406
194	14,8	101,062	1,8	71,102	461
195	15	101,262	1,8	71,102	454
196	15,2	101,462	1,8	71,102	431
197	15,4	101,662	1,8	71,102	390
198	15,6	101,862	1,8	71,102	421
199	15,8	102,062	1,8	71,102	401
200	16	102,262	1,8	71,102	427
201	16,2	102,462	1,8	71,102	423
202	16,4	102,662	1,8	71,102	455
203	16,6	102,862	1,8	71,102	473
204	16,8	103,062	1,8	71,102	397

168	9,6	95,862	1,8	71,102	304
169	9,8	96,062	1,8	71,102	279
170	10	96,262	1,8	71,102	327
171	10,2	96,462	1,8	71,102	415
172	10,4	96,662	1,8	71,102	413
173	10,6	96,862	1,8	71,102	418
174	10,8	97,062	1,8	71,102	408
175	11	97,262	1,8	71,102	428
176	11,2	97,462	1,8	71,102	431
177	11,4	97,662	1,8	71,102	404
178	11,6	97,862	1,8	71,102	426
179	11,8	98,062	1,8	71,102	423
180	12	98,262	1,8	71,102	441
181	12,2	98,462	1,8	71,102	423
182	12,4	98,662	1,8	71,102	428
183	12,6	98,862	1,8	71,102	431
184	12,8	99,062	1,8	71,102	444
185	13	99,262	1,8	71,102	441

205	17	103,262	1,8	71,102	444
206	17,2	103,462	1,8	71,102	444
207	17,4	103,662	1,8	71,102	473
208	17,6	103,862	1,8	71,102	422
209	17,8	104,062	1,8	71,102	479
210	18	104,262	1,8	71,102	472
211	18,2	104,462	1,8	71,102	425
212	18,4	104,662	1,8	71,102	433
213	18,6	104,862	1,8	71,102	464
214	18,8	105,062	1,8	71,102	482
215	19	105,262	1,8	71,102	472
216	19,2	105,462	1,8	71,102	452
217	19,4	105,662	1,8	71,102	494
218	19,6	105,862	1,8	71,102	443
219	19,8	106,062	1,8	71,102	435
220	20	106,262	1,8	71,102	441
221	20,2	106,462	1,8	71,102	476
222	20,4	106,662	1,8	71,102	491

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
223	20,6	106,862	1,8	71,102	514
224	20,8	107,062	1,8	71,102	488
225	21	107,262	1,8	71,102	455
226	6,2	92,462	2	70,902	253
227	6,4	92,662	2	70,902	246
228	6,6	92,862	2	70,902	215
229	6,8	93,062	2	70,902	221
230	7	93,262	2	70,902	212
231	7,2	93,462	2	70,902	193
232	7,4	93,662	2	70,902	255
233	7,6	93,862	2	70,902	236
234	7,8	94,062	2	70,902	190
235	8	94,262	2	70,902	196
236	8,2	94,462	2	70,902	229
237	8,4	94,662	2	70,902	202
238	8,6	94,862	2	70,902	197
239	8,8	95,062	2	70,902	232
240	9	95,262	2	70,902	237
241	9,2	95,462	2	70,902	228

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
260	13	99,262	2	70,902	418
261	13,2	99,462	2	70,902	461
262	13,4	99,662	2	70,902	376
263	13,6	99,862	2	70,902	452
264	13,8	100,062	2	70,902	447
265	14	100,262	2	70,902	452
266	14,2	100,462	2	70,902	428
267	14,4	100,662	2	70,902	447
268	14,6	100,862	2	70,902	441
269	14,8	101,062	2	70,902	408
270	15	101,262	2	70,902	455
271	15,2	101,462	2	70,902	467
272	15,4	101,662	2	70,902	475
273	15,6	101,862	2	70,902	444
274	15,8	102,062	2	70,902	461
275	16	102,262	2	70,902	470
276	16,2	102,462	2	70,902	455
277	16,4	102,662	2	70,902	478
278	16,6	102,862	2	70,902	455

242	9,4	95,662	2	70,902	232
243	9,6	95,862	2	70,902	228
244	9,8	96,062	2	70,902	368
245	10	96,262	2	70,902	302
246	10,2	96,462	2	70,902	339
247	10,4	96,662	2	70,902	377
248	10,6	96,862	2	70,902	406
249	10,8	97,062	2	70,902	413
250	11	97,262	2	70,902	428
251	11,2	97,462	2	70,902	428
252	11,4	97,662	2	70,902	425
253	11,6	97,862	2	70,902	426
254	11,8	98,062	2	70,902	447
255	12	98,262	2	70,902	441
256	12,2	98,462	2	70,902	450
257	12,4	98,662	2	70,902	403
258	12,6	98,862	2	70,902	455
259	12,8	99,062	2	70,902	433

279	16,8	103,062	2	70,902	479
280	17	103,262	2	70,902	464
281	17,2	103,462	2	70,902	464
282	17,4	103,662	2	70,902	482
283	17,6	103,862	2	70,902	461
284	17,8	104,062	2	70,902	469
285	18	104,262	2	70,902	458
286	18,2	104,462	2	70,902	444
287	18,4	104,662	2	70,902	479
288	18,6	104,862	2	70,902	435
289	18,8	105,062	2	70,902	449
290	19	105,262	2	70,902	476
291	19,2	105,462	2	70,902	479
292	19,4	105,662	2	70,902	449
293	19,6	105,862	2	70,902	478
294	19,8	106,062	2	70,902	488
295	20	106,262	2	70,902	491
296	20,2	106,462	2	70,902	458

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
297	20,4	106,662	2	70,902	507
298	20,6	106,862	2	70,902	511
299	20,8	107,062	2	70,902	507
300	21	107,262	2	70,902	517
301	6,2	92,462	2,2	70,702	214
302	6,4	92,662	2,2	70,702	232
303	6,6	92,862	2,2	70,702	231
304	6,8	93,062	2,2	70,702	209
305	7	93,262	2,2	70,702	214
306	7,2	93,462	2,2	70,702	205
307	7,4	93,662	2,2	70,702	275
308	7,6	93,862	2,2	70,702	197
309	7,8	94,062	2,2	70,702	242
310	8	94,262	2,2	70,702	235
311	8,2	94,462	2,2	70,702	197
312	8,4	94,662	2,2	70,702	225
313	8,6	94,862	2,2	70,702	198
314	8,8	95,062	2,2	70,702	231
315	9	95,262	2,2	70,702	238

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
334	12,8	99,062	2,2	70,702	450
335	13	99,262	2,2	70,702	455
336	13,2	99,462	2,2	70,702	455
337	13,4	99,662	2,2	70,702	467
338	13,6	99,862	2,2	70,702	461
339	13,8	100,062	2,2	70,702	458
340	14	100,262	2,2	70,702	463
341	14,2	100,462	2,2	70,702	415
342	14,4	100,662	2,2	70,702	447
343	14,6	100,862	2,2	70,702	458
344	14,8	101,062	2,2	70,702	447
345	15	101,262	2,2	70,702	455
346	15,2	101,462	2,2	70,702	450
347	15,4	101,662	2,2	70,702	413
348	15,6	101,862	2,2	70,702	466
349	15,8	102,062	2,2	70,702	473
350	16	102,262	2,2	70,702	470
351	16,2	102,462	2,2	70,702	469
352	16,4	102,662	2,2	70,702	467

316	9,2	95,462	2,2	70,702	265
317	9,4	95,662	2,2	70,702	266
318	9,6	95,862	2,2	70,702	292
319	9,8	96,062	2,2	70,702	348
320	10	96,262	2,2	70,702	360
321	10,2	96,462	2,2	70,702	411
322	10,4	96,662	2,2	70,702	418
323	10,6	96,862	2,2	70,702	420
324	10,8	97,062	2,2	70,702	423
325	11	97,262	2,2	70,702	426
326	11,2	97,462	2,2	70,702	403
327	11,4	97,662	2,2	70,702	399
328	11,6	97,862	2,2	70,702	455
329	11,8	98,062	2,2	70,702	418
330	12	98,262	2,2	70,702	428
331	12,2	98,462	2,2	70,702	433
332	12,4	98,662	2,2	70,702	449
333	12,6	98,862	2,2	70,702	450

353	16,6	102,862	2,2	70,702	452
354	16,8	103,062	2,2	70,702	485
355	17	103,262	2,2	70,702	472
356	17,2	103,462	2,2	70,702	491
357	17,4	103,662	2,2	70,702	464
358	17,6	103,862	2,2	70,702	464
359	17,8	104,062	2,2	70,702	473
360	18	104,262	2,2	70,702	472
361	18,2	104,462	2,2	70,702	433
362	18,4	104,662	2,2	70,702	450
363	18,6	104,862	2,2	70,702	497
364	18,8	105,062	2,2	70,702	491
365	19	105,262	2,2	70,702	497
366	19,2	105,462	2,2	70,702	504
367	19,4	105,662	2,2	70,702	504
368	19,6	105,862	2,2	70,702	510
369	19,8	106,062	2,2	70,702	469
370	20	106,262	2,2	70,702	517

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
371	20,2	106,462	2,2	70,702	479
372	20,4	106,662	2,2	70,702	494
373	20,6	106,862	2,2	70,702	488
374	20,8	107,062	2,2	70,702	485
375	21	107,262	2,2	70,702	504
376	6,2	92,462	2,4	70,502	216
377	6,4	92,662	2,4	70,502	233
378	6,6	92,862	2,4	70,502	223
379	6,8	93,062	2,4	70,502	250
380	7	93,262	2,4	70,502	247
381	7,2	93,462	2,4	70,502	215
382	7,4	93,662	2,4	70,502	234
383	7,6	93,862	2,4	70,502	205
384	7,8	94,062	2,4	70,502	206
385	8	94,262	2,4	70,502	196
386	8,2	94,462	2,4	70,502	197
387	8,4	94,662	2,4	70,502	201
388	8,6	94,862	2,4	70,502	224
389	8,8	95,062	2,4	70,502	253

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
408	12,6	98,862	2,4	70,502	449
409	12,8	99,062	2,4	70,502	411
410	13	99,262	2,4	70,502	418
411	13,2	99,462	2,4	70,502	415
412	13,4	99,662	2,4	70,502	458
413	13,6	99,862	2,4	70,502	479
414	13,8	100,062	2,4	70,502	458
415	14	100,262	2,4	70,502	464
416	14,2	100,462	2,4	70,502	467
417	14,4	100,662	2,4	70,502	433
418	14,6	100,862	2,4	70,502	447
419	14,8	101,062	2,4	70,502	447
420	15	101,262	2,4	70,502	466
421	15,2	101,462	2,4	70,502	452
422	15,4	101,662	2,4	70,502	481
423	15,6	101,862	2,4	70,502	431
424	15,8	102,062	2,4	70,502	461
425	16	102,262	2,4	70,502	491
426	16,2	102,462	2,4	70,502	452

390	9	95,262	2,4	70,502	225
391	9,2	95,462	2,4	70,502	315
392	9,4	95,662	2,4	70,502	266
393	9,6	95,862	2,4	70,502	279
394	9,8	96,062	2,4	70,502	290
395	10	96,262	2,4	70,502	347
396	10,2	96,462	2,4	70,502	346
397	10,4	96,662	2,4	70,502	428
398	10,6	96,862	2,4	70,502	425
399	10,8	97,062	2,4	70,502	420
400	11	97,262	2,4	70,502	433
401	11,2	97,462	2,4	70,502	428
402	11,4	97,662	2,4	70,502	433
403	11,6	97,862	2,4	70,502	452
404	11,8	98,062	2,4	70,502	401
405	12	98,262	2,4	70,502	403
406	12,2	98,462	2,4	70,502	455
407	12,4	98,662	2,4	70,502	455

427	16,4	102,662	2,4	70,502	464
428	16,6	102,862	2,4	70,502	485
429	16,8	103,062	2,4	70,502	485
430	17	103,262	2,4	70,502	458
431	17,2	103,462	2,4	70,502	464
432	17,4	103,662	2,4	70,502	491
433	17,6	103,862	2,4	70,502	482
434	17,8	104,062	2,4	70,502	444
435	18	104,262	2,4	70,502	447
436	18,2	104,462	2,4	70,502	461
437	18,4	104,662	2,4	70,502	511
438	18,6	104,862	2,4	70,502	482
439	18,8	105,062	2,4	70,502	494
440	19	105,262	2,4	70,502	504
441	19,2	105,462	2,4	70,502	494
442	19,4	105,662	2,4	70,502	491
443	19,6	105,862	2,4	70,502	470
444	19,8	106,062	2,4	70,502	501

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
445	20	106,262	2,4	70,502	455
446	20,2	106,462	2,4	70,502	475
447	20,4	106,662	2,4	70,502	514
448	20,6	106,862	2,4	70,502	531
449	20,8	107,062	2,4	70,502	517
450	21	107,262	2,4	70,502	521
451	6,2	92,462	2,6	70,302	265
452	6,4	92,662	2,6	70,302	209
453	6,6	92,862	2,6	70,302	223
454	6,8	93,062	2,6	70,302	215
455	7	93,262	2,6	70,302	206
456	7,2	93,462	2,6	70,302	225
457	7,4	93,662	2,6	70,302	204
458	7,6	93,862	2,6	70,302	210
459	7,8	94,062	2,6	70,302	201
460	8	94,262	2,6	70,302	206
461	8,2	94,462	2,6	70,302	201
462	8,4	94,662	2,6	70,302	261
463	8,6	94,862	2,6	70,302	230

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
482	12,4	98,662	2,6	70,302	418
483	12,6	98,862	2,6	70,302	455
484	12,8	99,062	2,6	70,302	447
485	13	99,262	2,6	70,302	461
486	13,2	99,462	2,6	70,302	431
487	13,4	99,662	2,6	70,302	464
488	13,6	99,862	2,6	70,302	455
489	13,8	100,062	2,6	70,302	467
490	14	100,262	2,6	70,302	438
491	14,2	100,462	2,6	70,302	464
492	14,4	100,662	2,6	70,302	491
493	14,6	100,862	2,6	70,302	447
494	14,8	101,062	2,6	70,302	479
495	15	101,262	2,6	70,302	428
496	15,2	101,462	2,6	70,302	444
497	15,4	101,662	2,6	70,302	476
498	15,6	101,862	2,6	70,302	478
499	15,8	102,062	2,6	70,302	461
500	16	102,262	2,6	70,302	485

464	8,8	95,062	2,6	70,302	215
465	9	95,262	2,6	70,302	207
466	9,2	95,462	2,6	70,302	246
467	9,4	95,662	2,6	70,302	255
468	9,6	95,862	2,6	70,302	293
469	9,8	96,062	2,6	70,302	320
470	10	96,262	2,6	70,302	390
471	10,2	96,462	2,6	70,302	375
472	10,4	96,662	2,6	70,302	345
473	10,6	96,862	2,6	70,302	418
474	10,8	97,062	2,6	70,302	428
475	11	97,262	2,6	70,302	436
476	11,2	97,462	2,6	70,302	421
477	11,4	97,662	2,6	70,302	464
478	11,6	97,862	2,6	70,302	449
479	11,8	98,062	2,6	70,302	449
480	12	98,262	2,6	70,302	450
481	12,2	98,462	2,6	70,302	420

501	16,2	102,462	2,6	70,302	482
502	16,4	102,662	2,6	70,302	433
503	16,6	102,862	2,6	70,302	461
504	16,8	103,062	2,6	70,302	452
505	17	103,262	2,6	70,302	501
506	17,2	103,462	2,6	70,302	497
507	17,4	103,662	2,6	70,302	485
508	17,6	103,862	2,6	70,302	470
509	17,8	104,062	2,6	70,302	470
510	18	104,262	2,6	70,302	479
511	18,2	104,462	2,6	70,302	463
512	18,4	104,662	2,6	70,302	511
513	18,6	104,862	2,6	70,302	494
514	18,8	105,062	2,6	70,302	511
515	19	105,262	2,6	70,302	488
516	19,2	105,462	2,6	70,302	501
517	19,4	105,662	2,6	70,302	511
518	19,6	105,862	2,6	70,302	517

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
519	19,8	106,062	2,6	70,302	517
520	20	106,262	2,6	70,302	531
521	20,2	106,462	2,6	70,302	517
522	20,4	106,662	2,6	70,302	497
523	20,6	106,862	2,6	70,302	476
524	20,8	107,062	2,6	70,302	517
525	21	107,262	2,6	70,302	535
526	6,2	92,462	2,8	70,102	216
527	6,4	92,662	2,8	70,102	212
528	6,6	92,862	2,8	70,102	238
529	6,8	93,062	2,8	70,102	216
530	7	93,262	2,8	70,102	217
531	7,2	93,462	2,8	70,102	237
532	7,4	93,662	2,8	70,102	241
533	7,6	93,862	2,8	70,102	207
534	7,8	94,062	2,8	70,102	202
535	8	94,262	2,8	70,102	227
536	8,2	94,462	2,8	70,102	270
537	8,4	94,662	2,8	70,102	282

Test point	X Distance To Start point	X Abs	Y Distance To Start point	Y Abs	Hardness Value (HV 0.2)
564	13,8	100,062	2,8	70,102	485
565	14	100,262	2,8	70,102	473
566	14,2	100,462	2,8	70,102	458
567	14,4	100,662	2,8	70,102	478
568	14,6	100,862	2,8	70,102	444
569	14,8	101,062	2,8	70,102	466
570	15	101,262	2,8	70,102	479
571	15,2	101,462	2,8	70,102	479
572	15,4	101,662	2,8	70,102	464
573	15,6	101,862	2,8	70,102	472
574	15,8	102,062	2,8	70,102	467
575	16	102,262	2,8	70,102	485
576	16,2	102,462	2,8	70,102	485
577	16,4	102,662	2,8	70,102	467
578	16,6	102,862	2,8	70,102	488
579	16,8	103,062	2,8	70,102	485
580	17	103,262	2,8	70,102	518
581	17,2	103,462	2,8	70,102	441
582	17,4	103,662	2,8	70,102	488

538	8,6	94,862	2,8	70,102	229	583	17,6	103,862	2,8	70,102	488
539	8,8	95,062	2,8	70,102	228	584	17,8	104,062	2,8	70,102	426
540	9	95,262	2,8	70,102	299	585	18	104,262	2,8	70,102	491
541	9,2	95,462	2,8	70,102	292	586	18,2	104,462	2,8	70,102	507
542	9,4	95,662	2,8	70,102	241	587	18,4	104,662	2,8	70,102	481
543	9,6	95,862	2,8	70,102	293	588	18,6	104,862	2,8	70,102	491
544	9,8	96,062	2,8	70,102	374	589	18,8	105,062	2,8	70,102	488
545	10	96,262	2,8	70,102	336	590	19	105,262	2,8	70,102	494
546	10,2	96,462	2,8	70,102	387	591	19,2	105,462	2,8	70,102	507
547	10,4	96,662	2,8	70,102	392	592	19,4	105,662	2,8	70,102	464
548	10,6	96,862	2,8	70,102	426	593	19,6	105,862	2,8	70,102	507
549	10,8	97,062	2,8	70,102	426	594	19,8	106,062	2,8	70,102	497
550	11	97,262	2,8	70,102	418	595	20	106,262	2,8	70,102	521
551	11,2	97,462	2,8	70,102	404	596	20,2	106,462	2,8	70,102	481
552	11,4	97,662	2,8	70,102	455	597	20,4	106,662	2,8	70,102	497
553	11,6	97,862	2,8	70,102	449	598	20,6	106,862	2,8	70,102	511
554	11,8	98,062	2,8	70,102	423	599	20,8	107,062	2,8	70,102	528
555	12	98,262	2,8	70,102	387	600	21	107,262	2,8	70,102	514

Table B.4: Tafel Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Parent Metal Samples

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)	Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.037356794	-0.71646572	-0.70695782	0.021162734	-0.68487496	-0.67598048
0.034749825	-0.71493219	-0.705424289	0.020856027	-0.68395484	-0.675060361
0.034001461	-0.71401207	-0.70450417	0.020579992	-0.68303473	-0.674140242
0.033289902	-0.71309195	-0.703890757	0.02031009	-0.68211461	-0.673220123
0.032609014	-0.71217183	-0.702970638	0.02002792	-0.68088778	-0.672300004
0.031983333	-0.71125171	-0.702050519	0.019727348	-0.67996766	-0.671379885
0.031431262	-0.71033159	-0.7011304	0.019469715	-0.67904754	-0.670459766
0.030885325	-0.70941147	-0.700210281	0.019205947	-0.67812742	-0.669539647
0.030314851	-0.70849135	-0.699290162	0.018923777	-0.67720731	-0.668619528
0.029775048	-0.70757123	-0.698370043	0.018641608	-0.67598048	-0.667699409
0.029339525	-0.70634441	-0.697449924	0.018371706	-0.67506036	-0.666472583
0.028891733	-0.70542429	-0.696529805	0.018101804	-0.67414024	-0.665552464
0.028394869	-0.70450417	-0.695609686	0.017825769	-0.67322012	-0.664632345
0.028002285	-0.70358405	-0.694689567	0.017623342	-0.6719933	-0.663712226
0.027603567	-0.70266393	-0.693769448	0.017408648	-0.67107318	-0.662792107
0.02716191	-0.70174381	-0.692849329	0.017157149	-0.67015306	-0.661871988
0.026830667	-0.70082369	-0.69192921	0.016899516	-0.66923294	-0.660951869

0.026487156	-0.69959687	-0.691009091
0.026094572	-0.69959687	-0.690088972
0.025701987	-0.69867675	-0.689168853
0.02533394	-0.69744992	-0.688248734
0.024959758	-0.69683651	-0.687328615
0.024573308	-0.69560969	-0.686408496
0.024199126	-0.69468957	-0.685488377
0.02389242	-0.69376945	-0.684568257
0.023616384	-0.69284933	-0.683648138
0.023266739	-0.6916225	-0.682728019
0.022917094	-0.69070238	-0.6818079
0.022579717	-0.68978227	-0.680887781
0.022285279	-0.68886215	-0.679967662
0.02196017	-0.68794203	-0.679047543
0.021720939	-0.68702191	-0.677820718
0.021432635	-0.68610179	-0.676900599

0.016648016	-0.66831282	-0.66003175
0.016427188	-0.667086	-0.659111631
0.016212493	-0.66616588	-0.657884806
0.016003933	-0.66524576	-0.656964687
0.015758568	-0.66432564	-0.656044568
0.015519337	-0.66340552	-0.655124449
0.015323045	-0.66217869	-0.65420433
0.015157424	-0.66125858	-0.653284211
0.014918193	-0.66033846	-0.652364092
0.014728035	-0.65941834	-0.651137266
0.014507206	-0.65849822	-0.650217147
0.014292512	-0.65727139	-0.649297028
0.014090085	-0.65635127	-0.648376909
0.014476538	-0.65543116	-0.648376909
0.014271658	-0.65451104	-0.64745679
0.014068005	-0.65328421	-0.646229965

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.013870487	-0.65236409	-0.645309846
0.013671127	-0.65144397	-0.644389727
0.013467474	-0.65052385	-0.643469608
0.013288358	-0.64960373	-0.642549489
0.013063849	-0.64837691	-0.641322664
0.012871237	-0.64745679	-0.640402545
0.012664517	-0.64653667	-0.639482425
0.01250871	-0.64561655	-0.638562306
0.012308124	-0.64438973	-0.637642187
0.012115513	-0.64346961	-0.636722068
0.011927195	-0.64254949	-0.635495243
0.011737037	-0.64162937	-0.634575124
0.011561601	-0.64070925	-0.633655005
0.011405181	-0.63978913	-0.632734886
0.011215636	-0.63856231	-0.631814767
0.01103468	-0.63764219	-0.630894648
0.010860471	-0.63672207	-0.629974529

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.00804736	-0.61770628	-0.610958736
0.007924677	-0.61678616	-0.610345323
0.007793407	-0.61586604	-0.609118498
0.007657843	-0.61494592	-0.608198379
0.00752964	-0.6140258	-0.60727826
0.007404503	-0.61279897	-0.606358141
0.007279367	-0.61187885	-0.605131315
0.007155458	-0.61095874	-0.604211196
0.007039523	-0.61003862	-0.603291077
0.006915614	-0.60881179	-0.602370958
0.006801519	-0.60789167	-0.601144133
0.006686811	-0.60697155	-0.600224014
0.006573943	-0.60605143	-0.599303895
0.006461075	-0.60482461	-0.598383776
0.006344526	-0.60390449	-0.597156951
0.006239019	-0.60298437	-0.596543538
0.006147008	-0.60206425	-0.595316713

0.010690555	-0.63549524	-0.628747704
0.010523707	-0.63457512	-0.627827585
0.010355632	-0.63365501	-0.626907466
0.010185103	-0.63273489	-0.625987347
0.010056287	-0.63181477	-0.625067228
0.009903547	-0.63058794	-0.623840402
0.00974958	-0.62966782	-0.622920283
0.009589479	-0.6287477	-0.622000164
0.009444714	-0.62782758	-0.620773339
0.009291974	-0.62690747	-0.620159926
0.009188921	-0.62568064	-0.618933101
0.00902882	-0.62476052	-0.618012982
0.008881601	-0.6238404	-0.617092863
0.008740516	-0.62261358	-0.616172744
0.008600045	-0.62169346	-0.614945918
0.008470001	-0.62077334	-0.614025799
0.008325849	-0.61985322	-0.61310568
0.008187218	-0.61862639	-0.612185561

0.006034753	-0.60083743	-0.594396593
0.005926792	-0.59991731	-0.593476474
0.005821285	-0.59899719	-0.592556355
0.005718845	-0.59807707	-0.591636236
0.005617632	-0.59715695	-0.590409411
0.005521327	-0.59593013	-0.589489292
0.005428701	-0.59501001	-0.588569173
0.005329942	-0.59408989	-0.587649054
0.00523609	-0.59286306	-0.586422229
0.005141011	-0.59194294	-0.58550211
0.005052679	-0.59102282	-0.584581991
0.004961894	-0.5901027	-0.583661872
0.004871109	-0.58918259	-0.582741753
0.004791365	-0.58795576	-0.581821634
0.00469874	-0.58703564	-0.580594808
0.004612249	-0.58611552	-0.579674689
0.004532505	-0.5851954	-0.57875457
0.004442947	-0.58396858	-0.577527745

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.004363817	-0.58304846	-0.576607626
0.004280393	-0.58212834	-0.575687507
0.004200649	-0.58120822	-0.574460681
0.004129493	-0.5802881	-0.573847269
0.00405159	-0.57906128	-0.572620443
0.00397246	-0.57814116	-0.571700324
0.003903144	-0.57722104	-0.570780205
0.003829534	-0.57599421	-0.56955338
0.003761446	-0.57507409	-0.568633261
0.003687836	-0.57415398	-0.567713142
0.003614227	-0.57323386	-0.566793023
0.003544297	-0.57231374	-0.565872904
0.003482956	-0.57108691	-0.564646079
0.003409347	-0.57016679	-0.563725959
0.003353526	-0.56924667	-0.56280584
0.003286051	-0.56801985	-0.561579015
0.003219802	-0.56709973	-0.560658896
0.003146806	-0.56617961	-0.559738777

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.002115659	-0.54747052	-0.54102969
0.002075174	-0.5462437	-0.540109571
0.002031622	-0.54532358	-0.538882746
0.00198807	-0.54440346	-0.537962627
0.001944517	-0.54348334	-0.537042508
0.001900965	-0.54225652	-0.536122389
0.00186232	-0.5413364	-0.534895564
0.001822448	-0.54041628	-0.533975444
0.001780736	-0.53949616	-0.533055325
0.001739637	-0.53826933	-0.532135206
0.001700992	-0.53734921	-0.530908381
0.001661734	-0.5364291	-0.529988262
0.001624316	-0.53550898	-0.529068143
0.001586284	-0.53428215	-0.528148024
0.001550706	-0.53336203	-0.526921199
0.001515128	-0.53244191	-0.52600108
0.001480777	-0.53152179	-0.525080961
0.001446426	-0.53060167	-0.523854135

0.003088532	-0.56525949	-0.558818658
0.003027191	-0.56403267	-0.557898539
0.002965849	-0.56311255	-0.556671714
0.002905735	-0.56219243	-0.555751595
0.002847461	-0.56127231	-0.554831476
0.00279164	-0.56035219	-0.553911357
0.002732139	-0.55912536	-0.552991238
0.002676932	-0.55820525	-0.551764412
0.002621111	-0.55728513	-0.551151
0.002565904	-0.5560583	-0.549924174
0.002514991	-0.55513818	-0.549004055
0.002465918	-0.55421806	-0.54777723
0.002410097	-0.55329794	-0.546857111
0.002357344	-0.55237782	-0.545936992
0.002310111	-0.551151	-0.545016873
0.002261038	-0.55023088	-0.544096754
0.002211352	-0.54931076	-0.542869928
0.002162279	-0.54839064	-0.541949809

0.001412075	-0.52937485	-0.522934016
0.001380056	-0.52845473	-0.522013897
0.001348158	-0.52753461	-0.521093778
0.001315279	-0.52661449	-0.520173659
0.001286081	-0.52538767	-0.51925354
0.001256085	-0.52446755	-0.518026715
0.001225414	-0.52354743	-0.517106596
0.001196645	-0.52262731	-0.516186477
0.001169226	-0.52140048	-0.514959651
0.001142297	-0.52048037	-0.514039532
0.001111258	-0.51956025	-0.513119413
0.001083409	-0.51864013	-0.512199294
0.001059302	-0.5174133	-0.511279175
0.00103311	-0.51649318	-0.510359056
0.001006794	-0.51557306	-0.509132231
0.00098054	-0.51434624	-0.508212112
0.000955881	-0.51342612	-0.507291993
0.000933307	-0.512506	-0.506065168

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.0009092	-0.51158588	-0.505145049
0.000884296	-0.51035906	-0.50422493
0.000860311	-0.50943894	-0.50330481
0.000835713	-0.50851882	-0.502077985
0.000813446	-0.5075987	-0.501157866
0.000790382	-0.50667858	-0.500237747
0.000769649	-0.50545175	-0.499317628
0.000749836	-0.50453164	-0.498090803
0.000728734	-0.50361152	-0.497170684
0.000708001	-0.5026914	-0.496250565
0.000687697	-0.50146457	-0.495330446
0.000670399	-0.50054445	-0.49410362
0.000651321	-0.49962433	-0.493183501
0.000630588	-0.49839751	-0.492263382
0.000609977	-0.49747739	-0.491343263
0.000592004	-0.49655727	-0.490116438
0.000573663	-0.49563715	-0.489196319
0.000555874	-0.49441033	-0.4882762

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.000240887	-0.47570124	-0.469260407
0.000226042	-0.47447441	-0.468340288
0.000210216	-0.4735543	-0.467420169
0.000195556	-0.47263418	-0.466193343
0.000180343	-0.47140735	-0.465273224
0.000164456	-0.47048723	-0.464353105
0.000149121	-0.46956711	-0.46312628
0.00013262	-0.46864699	-0.462206161
0.000117058	-0.46772688	-0.461286042
0.000100962	-0.46650005	-0.460365923
8.77E-05	-0.46557993	-0.459139098
7.32E-05	-0.46465981	-0.458218978
5.73E-05	-0.46373969	-0.457298859
4.15E-05	-0.46251287	-0.45637874
2.45E-05	-0.46312628	-0.455151915
1.63E-06	-0.46281957	-0.454231796
2.86E-07	-0.45975251	-0.453618383
1.77E-06	-0.4591391	-0.453311677

0.000536491	-0.49349021	-0.487356081
0.000518824	-0.49257009	-0.486129255
0.000501342	-0.49164997	-0.485209136
0.000484412	-0.49072985	-0.484289017
0.000467359	-0.48950303	-0.483368898
0.00045049	-0.48858291	-0.482142073
0.000433744	-0.48766279	-0.481221954
0.000415403	-0.48674267	-0.480301835
0.000398473	-0.48551584	-0.479381716
0.000381297	-0.48459572	-0.478154891
0.000366269	-0.4833689	-0.477234772
0.000351792	-0.48244878	-0.476314653
0.000337684	-0.48152866	-0.475087827
0.000322103	-0.48060854	-0.474167708
0.000305173	-0.47968842	-0.473247589
0.000288856	-0.4784616	-0.47232747
0.000272662	-0.47754148	-0.471407351
0.000256897	-0.47662136	-0.470180526

5.11E-06	-0.45821898	-0.451164733
2.01E-06	-0.45668545	-0.453618383
1.47E-05	-0.45545862	-0.449631201
1.79E-05	-0.4545385	-0.449017788
2.01E-05	-0.45361838	-0.448097669
0.000126197	-0.45239156	-0.446257431
0.00014225	-0.45147144	-0.445337312
0.000157678	-0.45055132	-0.444417193
0.00017305	-0.4496312	-0.443190368
0.000198439	-0.44871108	-0.442270249
0.000201997	-0.44748426	-0.441043423
0.000222485	-0.44656414	-0.440123304
0.000242789	-0.44564402	-0.439203185
0.000263952	-0.4447239	-0.438283066
0.000284808	-0.44349707	-0.437362947
0.000306645	-0.44257696	-0.436136122
0.000327869	-0.44165684	-0.435522709
0.000350627	-0.44073672	-0.434295884

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.000371728	-0.43950989	-0.433375765
0.000393934	-0.43858977	-0.43214894
0.000416201	-0.43766965	-0.431228821
0.000438652	-0.43674953	-0.430308702
0.000462513	-0.43552271	-0.429388583
0.000486007	-0.43460259	-0.428161757
0.000511709	-0.43368247	-0.427241638
0.000536245	-0.43276235	-0.426321519
0.000560598	-0.43153553	-0.4254014
0.000586361	-0.43061541	-0.424174575
0.000612615	-0.42969529	-0.423254456
0.000640648	-0.42877517	-0.422334337
0.000667577	-0.42785505	-0.421414218
0.00069469	-0.42693493	-0.420494099
0.000722662	-0.42570811	-0.419267273
0.000751247	-0.42478799	-0.418347154
0.000781979	-0.42386787	-0.417427035
0.000812097	-0.42264104	-0.416506916

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.001506542	-0.40393196	-0.397491123
0.001550155	-0.40301184	-0.396264298
0.001595425	-0.40178501	-0.395344179
0.001638793	-0.40086489	-0.39442406
0.001682039	-0.39994477	-0.393503941
0.001728229	-0.39902465	-0.392583822
0.001775646	-0.39779783	-0.391356996
0.001823799	-0.39687771	-0.390743584
0.001871523	-0.39595759	-0.389516758
0.001919369	-0.39503747	-0.388596639
0.001969056	-0.39411735	-0.38767652
0.002020582	-0.39319723	-0.386449695
0.002072109	-0.39197041	-0.385529576
0.002122409	-0.39105029	-0.384609457
0.002172709	-0.39013017	-0.383382631
0.002226689	-0.38921005	-0.382462512
0.002280669	-0.38798323	-0.381542393
0.00233465	-0.38706311	-0.380622274

0.000843381	-0.42172092	-0.415280091
0.000874175	-0.4208008	-0.414359972
0.000905459	-0.41988069	-0.413439853
0.000937601	-0.41865386	-0.412213027
0.000970664	-0.41773374	-0.411292908
0.001005874	-0.41681362	-0.410372789
0.001040287	-0.4158935	-0.40945267
0.001075987	-0.41466668	-0.408225845
0.001110952	-0.41374656	-0.407305726
0.001146284	-0.41282644	-0.406385607
0.001184071	-0.41190632	-0.405465488
0.001222409	-0.4106795	-0.404238663
0.001262158	-0.41006608	-0.403318544
0.001300374	-0.40883926	-0.402398425
0.001339141	-0.40791914	-0.401478306
0.001381221	-0.40699902	-0.400558187
0.001423486	-0.40577219	-0.399331361
0.001464952	-0.40485208	-0.398411242

0.00238679	-0.38614299	-0.379702155
0.002440157	-0.38522287	-0.378782036
0.002497204	-0.38430275	-0.377555211
0.002552411	-0.38307593	-0.376635092
0.002607005	-0.38215581	-0.375714973
0.002662212	-0.38123569	-0.374794854
0.002717419	-0.38031557	-0.373568029
0.002775693	-0.37939545	-0.37264791
0.002831514	-0.37816862	-0.371727791
0.002886108	-0.3772485	-0.370807672
0.002940701	-0.37632839	-0.369580846
0.002996522	-0.37540827	-0.368660727
0.003054183	-0.37448815	-0.367740608
0.003108776	-0.37356803	-0.366820489
0.003162757	-0.3723412	-0.365593664
0.00321735	-0.37142108	-0.364673545
0.003273784	-0.37050097	-0.363753426
0.003329605	-0.36958085	-0.362833307

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.003382972	-0.36866073	-0.361606481
0.003435725	-0.3674339	-0.360686362
0.003490319	-0.36651378	-0.359766243
0.003542459	-0.36559366	-0.358846124
0.003597666	-0.36467354	-0.357619299
0.003649193	-0.36375343	-0.35669918
0.003701946	-0.3625266	-0.355779061
0.00375102	-0.36160648	-0.354858942
0.003800093	-0.36068636	-0.353632117
0.003849166	-0.35976624	-0.352711997
0.003900079	-0.35884612	-0.351791878
0.003948538	-0.3576193	-0.350871759
0.003993318	-0.35669918	-0.34995164
0.004039323	-0.35577906	-0.348724815
0.004084716	-0.35485894	-0.347804696
0.004127041	-0.35393882	-0.346884577
0.004171821	-0.352712	-0.345964458
0.004213533	-0.35209858	-0.344737633

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.004899941	-0.3333895	-0.326028546
0.004925705	-0.33246938	-0.324801721
0.004955149	-0.33124255	-0.323881602
0.004979072	-0.33032243	-0.322961482
0.005007902	-0.32940232	-0.322041363
0.005036732	-0.3284822	-0.320814538
0.00507047	-0.32756208	-0.319894419
0.005098687	-0.32664196	-0.3189743
0.005126291	-0.32541513	-0.318054181
0.005152054	-0.32449501	-0.316827356
0.005186405	-0.3235749	-0.315907237
0.00524652	-0.32265478	-0.314987118
0.005275963	-0.32142795	-0.314066999
0.005298046	-0.32050783	-0.312840173
0.00532565	-0.31958771	-0.311920054
0.005355707	-0.31866759	-0.310999935
0.005393739	-0.31774747	-0.310079816
0.005434224	-0.31652065	-0.308852991

0.004255858	-0.35087176	-0.343817514
0.004296343	-0.34995164	-0.342897395
0.004333762	-0.34903152	-0.341670569
0.004374247	-0.3481114	-0.34075045
0.004412892	-0.34688458	-0.339830331
0.004454604	-0.34596446	-0.338910212
0.004494476	-0.34504434	-0.337990093
0.0045276	-0.34412422	-0.336763268
0.004561951	-0.3432041	-0.335843149
0.004595075	-0.34228398	-0.33492303
0.004636174	-0.34105716	-0.334002911
0.004712237	-0.34013704	-0.333082792
0.004733707	-0.33921692	-0.331855966
0.004756403	-0.3382968	-0.330935847
0.00478278	-0.33737668	-0.330015728
0.004812837	-0.33614986	-0.329095609
0.004839214	-0.33522974	-0.327868784
0.004872338	-0.33430962	-0.326948665

0.005473482	-0.31560053	-0.307932872
0.005517648	-0.31468041	-0.307012753
0.005560587	-0.31376029	-0.306092634
0.005648305	-0.31284017	-0.304865808
0.005698605	-0.31161335	-0.303945689
0.005739703	-0.31099994	-0.30302557
0.005794911	-0.30977311	-0.302105451
0.005856865	-0.30885299	-0.301185332
0.005924954	-0.30885299	-0.299958507
0.005988749	-0.30793287	-0.299038388
0.006061745	-0.30701275	-0.298118269
0.006138422	-0.30609263	-0.29719815
0.006224299	-0.30486581	-0.295971325
0.006340234	-0.30394569	-0.295051206
0.006425499	-0.30302557	-0.294131087
0.006523031	-0.30210545	-0.293210967
0.006634059	-0.30118533	-0.291984142
0.006749381	-0.30026521	-0.291064023

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.006872063	-0.29903839	-0.290143904
0.007006401	-0.29811827	-0.289223785
0.007149326	-0.29719815	-0.288303666
0.007305133	-0.29627803	-0.287076841
0.00746646	-0.29535791	-0.286156722
0.007637602	-0.29413109	-0.285236603
0.007814265	-0.29321097	-0.284316484
0.007999516	-0.29229085	-0.283396365
0.008201329	-0.29137073	-0.282169539
0.008413569	-0.29045061	-0.28124942
0.008641145	-0.28953049	-0.280329301
0.008873629	-0.28830367	-0.279409182
0.009120221	-0.28738355	-0.278489063
0.009379694	-0.28646343	-0.277568944
0.009647142	-0.28554331	-0.276648825
0.009930539	-0.28462319	-0.275422
0.010222523	-0.28339636	-0.274501881
0.010524936	-0.28247625	-0.273581762

Current Density (A/cm ²)	Control Parent Metal Potential (V)	Solution Annealed Parent Metal Potential (V)
0.017789582	-0.26407387	-0.255486088
0.018234306	-0.26284704	-0.254565969
0.017721496	-0.26192692	-0.254565969
0.018138617	-0.2610068	-0.25364585
0.018568006	-0.26008668	-0.252725731
0.019015797	-0.25885986	-0.251805612
0.019457454	-0.25793974	-0.250885493
0.019905245	-0.25701962	-0.249965374
0.020359171	-0.2560995	-0.249045255
0.02081923	-0.25517938	-0.248125136
0.021291558	-0.25395256	-0.247205016
0.021757752	-0.25303244	-0.246284897
0.022230079	-0.25211232	-0.245671485
0.022708541	-0.2511922	-0.244444659
0.023193137	-0.24996537	-0.243831247
0.023683867	-0.24904525	-0.242911128
0.024174598	-0.24812514	-0.241684302
0.024671462	-0.24689831	-0.24107089

0.010837163	-0.28155613	-0.272661643	0.02517446	-0.2462849	-0.240150771
0.011157978	-0.28063601	-0.271741524	0.025683593	-0.24505807	-0.239230652
0.011490447	-0.27971589	-0.270821405	0.026192725	-0.24413795	-0.238310533
0.011830278	-0.27879577	-0.269901286	0.026707992	-0.24321783	-0.237390414
0.012180537	-0.27756894	-0.268981167	0.027229393	-0.24199101	-0.236470295
0.012541223	-0.27664883	-0.268061048	0.027750793	-0.24107089	-0.235550176
0.012909884	-0.27572871	-0.266834222	0.028290597	-0.24015077	-0.234936763
0.013293881	-0.27480859	-0.265914103	0.028811997	-0.23892395	-0.234016644
0.01367665	-0.27388847	-0.264993984	0.029357935	-0.23831053	-0.233096525
0.014056966	-0.27266164	-0.264073865	0.029897738	-0.23708371	-0.232176406
0.014450777	-0.27174152	-0.263153746	0.030425273	-0.23616359	-0.231256287
0.014842134	-0.2708214	-0.262233627	0.030958942	-0.23524347	-0.230336168
0.015243306	-0.26990129	-0.261313508	0.031529416	-0.23401664	-0.229416049
0.015654293	-0.26898117	-0.260393389	0.032069219	-0.23309652	-0.22849593
0.016067119	-0.26775434	-0.25947327	0.032615156	-0.23217641	-0.227575811
0.01648608	-0.26683422	-0.258246445	0.033161093	-0.23125629	-0.226655692
0.016911175	-0.2659141	-0.257326326	0.033713165	-0.23002946	-0.225735573
0.017345471	-0.26499398	-0.256406207	0.034283639	-0.22910934	-0.224815454

Table B.5: Tafel Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Heat Affected Zones of the Samples Immersed in 1M NaCl Environment

Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)
0.037356794	-0.72689	-0.71524	0.020856027	-0.69408	-0.68395	0.0134675	-0.66187	-0.65175
0.034749825	-0.72536	-0.71371	0.020579992	-0.69285	-0.68303	0.0132884	-0.66095	-0.65083
0.034001461	-0.72444	-0.71279	0.02031009	-0.69224	-0.68211	0.0130638	-0.66003	-0.64991
0.033289902	-0.72352	-0.71217	0.02002792	-0.69132	-0.68119	0.0128712	-0.65911	-0.64899
0.032609014	-0.7226	-0.71125	0.019727348	-0.69009	-0.68027	0.0126645	-0.65819	-0.64807
0.031983333	-0.72168	-0.71033	0.019469715	-0.68917	-0.67905	0.0125087	-0.65727	-0.64715
0.031431262	-0.72076	-0.70941	0.019205947	-0.68825	-0.67813	0.0123081	-0.65604	-0.64623
0.030885325	-0.71984	-0.7088	0.018923777	-0.68733	-0.67721	0.0121155	-0.65512	-0.64531
0.030314851	-0.71892	-0.70788	0.018641608	-0.68641	-0.67629	0.0119272	-0.6542	-0.64439
0.029775048	-0.718	-0.70696	0.018371706	-0.68549	-0.67537	0.011737	-0.65328	-0.64316
0.029339525	-0.71677	-0.70604	0.018101804	-0.68426	-0.67445	0.0115616	-0.65236	-0.64224
0.028891733	-0.71585	-0.70512	0.017825769	-0.68334	-0.67353	0.0114052	-0.65114	-0.64224
0.028394869	-0.71493	-0.7042	0.017623342	-0.68273	-0.67261	0.0112156	-0.65022	-0.64102
0.028002285	-0.71401	-0.70328	0.017408648	-0.6815	-0.67169	0.0110347	-0.6493	-0.6401
0.027603567	-0.71309	-0.70236	0.017157149	-0.68058	-0.67077	0.0108605	-0.64838	-0.63918

0.02716191	-0.71217	-0.70144	0.016899516	-0.67966	-0.66985	0.0106906	-0.64715	-0.63826
0.026830667	-0.71125	-0.70052	0.016648016	-0.67874	-0.66893	0.0105237	-0.64623	-0.63734
0.026487156	-0.71033	-0.6996	0.016427188	-0.67751	-0.66801	0.0103556	-0.64531	-0.63642
0.026094572	-0.70941	-0.69868	0.016212493	-0.67659	-0.66709	0.0101851	-0.64439	-0.63519
0.025701987	-0.70849	-0.69776	0.016003933	-0.67567	-0.66617	0.0100563	-0.64347	-0.63427
0.02533394	-0.70757	-0.69684	0.015758568	-0.67475	-0.66494	0.0099035	-0.64224	-0.63335
0.024959758	-0.70634	-0.69592	0.015519337	-0.67383	-0.66402	0.0097496	-0.64163	-0.63243
0.024573308	-0.70542	-0.695	0.015323045	-0.67291	-0.6631	0.0095895	-0.6404	-0.63151
0.024199126	-0.7045	-0.69408	0.015157424	-0.67199	-0.66218	0.0094447	-0.63948	-0.63028
0.02389242	-0.70358	-0.69316	0.014918193	-0.67077	-0.66126	0.009292	-0.63856	-0.62936
0.023616384	-0.70266	-0.69224	0.014728035	-0.67077	-0.66034	0.0091889	-0.63734	-0.62844
0.023266739	-0.70174	-0.69132	0.014507206	-0.66985	-0.65942	0.0090288	-0.63642	-0.62752
0.022917094	-0.70082	-0.6904	0.014292512	-0.66893	-0.6585	0.0088816	-0.6355	-0.6266
0.022579717	-0.6999	-0.68948	0.014090085	-0.66801	-0.65758	0.0087405	-0.63458	-0.62568
0.022285279	-0.69898	-0.68856	0.014476538	-0.66678	-0.65666	0.0086	-0.63366	-0.62476
0.02196017	-0.69806	-0.68764	0.014271658	-0.66586	-0.65574	0.00847	-0.63273	-0.62353
0.021720939	-0.69684	-0.68672	0.014068005	-0.66494	-0.65451	0.0083258	-0.63151	-0.62261
0.021432635	-0.69592	-0.6858	0.013870487	-0.66402	-0.65359	0.0081872	-0.63059	-0.62169
0.021162734	-0.695	-0.68487	0.013671127	-0.6631	-0.65267	0.0080474	-0.62967	-0.62077

Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)
0.007924677	-0.62875	-0.61955	0.004200649	-0.59317	-0.58428	0.0020316	-0.55729	-0.5487
0.007793407	-0.62752	-0.61863	0.004129493	-0.59194	-0.58336	0.0019881	-0.55637	-0.54778
0.007657843	-0.6266	-0.61771	0.00405159	-0.59102	-0.58244	0.0019445	-0.55544	-0.54686
0.00752964	-0.62568	-0.61679	0.00397246	-0.5901	-0.58121	0.001901	-0.55452	-0.54563
0.007404503	-0.62476	-0.61587	0.003903144	-0.58918	-0.58029	0.0018623	-0.5536	-0.54471
0.007279367	-0.62384	-0.61464	0.003829534	-0.58826	-0.57937	0.0018224	-0.55238	-0.54379
0.007155458	-0.62261	-0.61372	0.003761446	-0.58704	-0.57845	0.0017807	-0.55146	-0.54287
0.007039523	-0.62169	-0.6128	0.003687836	-0.58612	-0.57753	0.0017396	-0.55054	-0.54164
0.006915614	-0.62077	-0.61188	0.003614227	-0.5852	-0.5763	0.001701	-0.54931	-0.54072
0.006801519	-0.61985	-0.61096	0.003544297	-0.58428	-0.57538	0.0016617	-0.54839	-0.5398
0.006686811	-0.61863	-0.60973	0.003482956	-0.58336	-0.57446	0.0016243	-0.54747	-0.53888
0.006573943	-0.61771	-0.60881	0.003409347	-0.58213	-0.57354	0.0015863	-0.54655	-0.53796
0.006461075	-0.61679	-0.60789	0.003353526	-0.58121	-0.57231	0.0015507	-0.54563	-0.53674
0.006344526	-0.61587	-0.60697	0.003286051	-0.58029	-0.57139	0.0015151	-0.5444	-0.53582
0.006239019	-0.61464	-0.60605	0.003219802	-0.57937	-0.57047	0.0014808	-0.54348	-0.5349
0.006147008	-0.61372	-0.60482	0.003146806	-0.57814	-0.56925	0.0014464	-0.54256	-0.53367
0.006034753	-0.6128	-0.6039	0.003088532	-0.57722	-0.56863	0.0014121	-0.54134	-0.53275

0.005926792	-0.61188	-0.60298	0.003027191	-0.5763	-0.56741	0.0013801	-0.54042	-0.53183
0.005821285	-0.61065	-0.60206	0.002965849	-0.57538	-0.56649	0.0013482	-0.5395	-0.53091
0.005718845	-0.61004	-0.60114	0.002905735	-0.57415	-0.56557	0.0013153	-0.53858	-0.52968
0.005617632	-0.60912	-0.59992	0.002847461	-0.57323	-0.56465	0.0012861	-0.53766	-0.52876
0.005521327	-0.60789	-0.599	0.00279164	-0.57231	-0.56342	0.0012561	-0.53643	-0.52784
0.005428701	-0.60697	-0.59808	0.002732139	-0.57139	-0.5625	0.0012254	-0.53551	-0.52692
0.005329942	-0.60605	-0.59716	0.002676932	-0.57017	-0.56158	0.0011966	-0.53459	-0.526
0.00523609	-0.60513	-0.59624	0.002621111	-0.56925	-0.56066	0.0011692	-0.53367	-0.52477
0.005141011	-0.6039	-0.59501	0.002565904	-0.56833	-0.55943	0.0011423	-0.53275	-0.52385
0.005052679	-0.60298	-0.59409	0.002514991	-0.56741	-0.55851	0.0011113	-0.53152	-0.52293
0.004961894	-0.60206	-0.59317	0.002465918	-0.56618	-0.55759	0.0010834	-0.5306	-0.52201
0.004871109	-0.60114	-0.59225	0.002410097	-0.56526	-0.55667	0.0010593	-0.52968	-0.52079
0.004791365	-0.59992	-0.59133	0.002357344	-0.56434	-0.55544	0.0010331	-0.52845	-0.51987
0.00469874	-0.599	-0.5901	0.002310111	-0.56342	-0.55452	0.0010068	-0.52753	-0.51895
0.004612249	-0.59808	-0.58918	0.002261038	-0.5625	-0.5536	0.0009805	-0.52661	-0.51803
0.004532505	-0.59716	-0.58826	0.002211352	-0.56127	-0.55268	0.0009559	-0.52569	-0.5168
0.004442947	-0.59593	-0.58734	0.002162279	-0.56035	-0.55176	0.0009333	-0.52447	-0.51588
0.004363817	-0.59501	-0.58612	0.002115659	-0.55943	-0.55084	0.0009092	-0.52355	-0.51496
0.004280393	-0.59409	-0.5852	0.002075174	-0.55821	-0.54962	0.0008843	-0.52263	-0.51404

Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)
0.000860311	-0.52171	-0.51281	0.000210216	-0.48582	-0.47693	0.0004162	-0.44963	-0.44104
0.000835713	-0.52048	-0.51189	0.000195556	-0.4849	-0.47601	0.0004387	-0.44871	-0.44012
0.000813446	-0.51956	-0.51097	0.000180343	-0.48368	-0.47509	0.0004625	-0.44779	-0.4392
0.000790382	-0.51864	-0.51005	0.000164456	-0.48276	-0.47417	0.000486	-0.44687	-0.43828
0.000769649	-0.51772	-0.50883	0.000149121	-0.48184	-0.47294	0.0005117	-0.44564	-0.43706
0.000749836	-0.5168	-0.50791	0.00013262	-0.48061	-0.47202	0.0005362	-0.44472	-0.43614
0.000728734	-0.51557	-0.50699	0.000117058	-0.47969	-0.4711	0.0005606	-0.4438	-0.43522
0.000708001	-0.51465	-0.50607	0.000100962	-0.47877	-0.47018	0.0005864	-0.44288	-0.43399
0.000687697	-0.51373	-0.50484	8.77E-05	-0.47785	-0.46895	0.0006126	-0.44166	-0.43307
0.000670399	-0.51251	-0.50392	7.32E-05	-0.47662	-0.46803	0.0006406	-0.44074	-0.43215
0.000651321	-0.51159	-0.503	5.73E-05	-0.4757	-0.46711	0.0006676	-0.43982	-0.43123
0.000630588	-0.51067	-0.50208	4.15E-05	-0.47478	-0.46619	0.0006947	-0.4389	-0.43
0.000609977	-0.50975	-0.50085	2.45E-05	-0.47386	-0.46497	0.0007227	-0.43767	-0.42908
0.000592004	-0.50852	-0.49993	1.63E-06	-0.47263	-0.46405	0.0007512	-0.43675	-0.42816
0.000573663	-0.5076	-0.49901	2.86E-07	-0.47171	-0.46313	0.000782	-0.43583	-0.42724
0.000555874	-0.50668	-0.49809	1.77E-06	-0.47079	-0.46221	0.0008121	-0.4346	-0.42632
0.000536491	-0.50576	-0.49686	5.11E-06	-0.46957	-0.46098	0.0008434	-0.43368	-0.4254

0.000518824	-0.50484	-0.49594	2.01E-06	-0.46865	-0.46006	0.0008742	-0.43276	-0.42417
0.000501342	-0.50361	-0.49502	1.47E-05	-0.46773	-0.45914	0.0009055	-0.43184	-0.42325
0.000484412	-0.50269	-0.4941	1.79E-05	-0.46681	-0.45853	0.0009376	-0.43092	-0.42233
0.000467359	-0.50177	-0.49288	2.01E-05	-0.46589	-0.45761	0.0009707	-0.4297	-0.42111
0.00045049	-0.50085	-0.49196	0.000126197	-0.46466	-0.45699	0.0010059	-0.42878	-0.42019
0.000433744	-0.49962	-0.49104	0.00014225	-0.46374	-0.45515	0.0010403	-0.42786	-0.41927
0.000415403	-0.4987	-0.48981	0.000157678	-0.46282	-0.45423	0.001076	-0.42693	-0.41804
0.000398473	-0.49778	-0.48889	0.00017305	-0.4619	-0.453	0.001111	-0.42601	-0.41712
0.000381297	-0.49656	-0.48797	0.000198439	-0.46067	-0.45208	0.0011463	-0.42479	-0.4162
0.000366269	-0.49564	-0.48705	0.000201997	-0.45975	-0.45116	0.0011841	-0.42387	-0.41528
0.000351792	-0.49472	-0.48582	0.000222485	-0.45883	-0.45024	0.0012224	-0.42295	-0.41436
0.000337684	-0.4938	-0.4849	0.000242789	-0.45791	-0.44902	0.0012622	-0.42203	-0.41313
0.000322103	-0.49288	-0.48398	0.000263952	-0.45669	-0.4481	0.0013004	-0.4208	-0.41221
0.000305173	-0.49165	-0.48306	0.000284808	-0.45577	-0.44718	0.0013391	-0.41988	-0.41129
0.000288856	-0.49073	-0.48184	0.000306645	-0.45485	-0.44595	0.0013812	-0.41896	-0.41037
0.000272662	-0.48981	-0.48092	0.000327869	-0.45393	-0.44503	0.0014235	-0.41804	-0.40915
0.000256897	-0.48858	-0.48	0.000350627	-0.4527	-0.44411	0.001465	-0.41681	-0.40823
0.000240887	-0.48766	-0.47908	0.000371728	-0.45178	-0.44319	0.0015065	-0.41589	-0.40731
0.000226042	-0.48674	-0.47815	0.000393934	-0.45086	-0.44196	0.0015502	-0.41497	-0.40639

Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)	Current Density (A/cm ²)	CHAZ Potential (V)	SAHAZ Potential (V)
0.001595425	-0.41405	-0.40516	0.003490319	-0.37848	-0.36989	0.0049551	-0.3432	-0.334
0.001638793	-0.41283	-0.40424	0.003542459	-0.37756	-0.36897	0.0049791	-0.34198	-0.33308
0.001682039	-0.41191	-0.40332	0.003597666	-0.37664	-0.36774	0.0050079	-0.34106	-0.33216
0.001728229	-0.41099	-0.4024	0.003649193	-0.37571	-0.36682	0.0050367	-0.34014	-0.33124
0.001775646	-0.41007	-0.40148	0.003701946	-0.37479	-0.3659	0.0050705	-0.33922	-0.33002
0.001823799	-0.40884	-0.40025	0.00375102	-0.37357	-0.36467	0.0050987	-0.33799	-0.3291
0.001871523	-0.40792	-0.39933	0.003800093	-0.37265	-0.36375	0.0051263	-0.33707	-0.32818
0.001919369	-0.407	-0.39841	0.003849166	-0.37173	-0.36283	0.0051521	-0.33615	-0.32726
0.001969056	-0.40608	-0.39749	0.003900079	-0.37081	-0.36191	0.0051864	-0.33523	-0.32603
0.002020582	-0.40485	-0.39657	0.003948538	-0.36989	-0.36069	0.0052465	-0.334	-0.32511
0.002072109	-0.40393	-0.39534	0.003993318	-0.36866	-0.35977	0.005276	-0.33308	-0.32419
0.002122409	-0.40301	-0.39442	0.004039323	-0.36774	-0.35885	0.005298	-0.33216	-0.32327
0.002172709	-0.40209	-0.3935	0.004084716	-0.36682	-0.35793	0.0053257	-0.33124	-0.32204
0.002226689	-0.40117	-0.39258	0.004127041	-0.3659	-0.35701	0.0053557	-0.33002	-0.32112
0.002280669	-0.39994	-0.39136	0.004171821	-0.36498	-0.35609	0.0053937	-0.3291	-0.3202
0.00233465	-0.39902	-0.39044	0.004213533	-0.36375	-0.35486	0.0054342	-0.32818	-0.31928
0.00238679	-0.3981	-0.38952	0.004255858	-0.36283	-0.35394	0.0054735	-0.32726	-0.31805

0.002440157	-0.39718	-0.3886	0.004296343	-0.36191	-0.35302	0.0055176	-0.32603	-0.31713
0.002497204	-0.39596	-0.38737	0.004333762	-0.36099	-0.3521	0.0055606	-0.32511	-0.31621
0.002552411	-0.39534	-0.38645	0.004374247	-0.36007	-0.35087	0.0056483	-0.32419	-0.31529
0.002607005	-0.39442	-0.38553	0.004412892	-0.35885	-0.34995	0.0056986	-0.32296	-0.31437
0.002662212	-0.3932	-0.38461	0.004454604	-0.35793	-0.34903	0.0057397	-0.32235	-0.31315
0.002717419	-0.39228	-0.38369	0.004494476	-0.35701	-0.3478	0.0057949	-0.32112	-0.31223
0.002775693	-0.39136	-0.38246	0.0045276	-0.35609	-0.34719	0.0058569	-0.3202	-0.31131
0.002831514	-0.39044	-0.38154	0.004561951	-0.35486	-0.34596	0.005925	-0.31928	-0.31039
0.002886108	-0.38952	-0.38062	0.004595075	-0.35394	-0.34504	0.0059887	-0.31836	-0.30916
0.002940701	-0.38829	-0.3797	0.004636174	-0.35302	-0.34412	0.0060617	-0.31713	-0.30824
0.002996522	-0.38737	-0.37878	0.004712237	-0.3521	-0.3429	0.0061384	-0.31621	-0.30732
0.003054183	-0.38645	-0.37756	0.004733707	-0.35087	-0.34198	0.0062243	-0.31529	-0.3064
0.003108776	-0.38553	-0.37664	0.004756403	-0.34995	-0.34106	0.0063402	-0.31437	-0.30517
0.003162757	-0.38461	-0.37571	0.00478278	-0.34903	-0.34014	0.0064255	-0.31315	-0.30425
0.00321735	-0.38338	-0.37479	0.004812837	-0.34811	-0.33891	0.006523	-0.31223	-0.30333
0.003273784	-0.38246	-0.37357	0.004839214	-0.34719	-0.33799	0.0066341	-0.31131	-0.30241
0.003329605	-0.38154	-0.37265	0.004872338	-0.34596	-0.33707	0.0067494	-0.31039	-0.30149
0.003382972	-0.38062	-0.37173	0.004899941	-0.34504	-0.33615	0.0068721	-0.30916	-0.30027
0.003435725	-0.3797	-0.37081	0.004925705	-0.34412	-0.33523	0.0070064	-0.30824	-0.29935

Table B.6: Tafel Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Welded Zones of the Samples

Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)
0.037356794	-0.72812	-0.7143188	0.02031009	-0.69438	-0.6784341	0.0126645	-0.6588	-
0.034749825	-0.72659	-0.7133987	0.02002792	-0.69346	-0.677514	0.0125087	-0.65819	-
0.034001461	-0.72597	-0.7124785	0.019727348	-0.69254	-0.6762872	0.0123081	-0.65696	-
0.033289902	-0.72505	-0.7115584	0.019469715	-0.69162	-0.6753671	0.0121155	-0.65604	-
0.032609014	-0.72413	-0.7103316	0.019205947	-0.6904	-0.6744469	0.0119272	-0.65512	-
0.031983333	-0.72321	-0.7094115	0.018923777	-0.68948	-0.6735268	0.011737	-0.6542	-
0.031431262	-0.72229	-0.7084914	0.018641608	-0.68856	-0.6723	0.0115616	-0.65328	-
0.030885325	-0.72137	-0.7072645	0.018371706	-0.68764	-0.6713799	0.0114052	-0.65206	-
0.030314851	-0.72045	-0.7063444	0.018101804	-0.68641	-0.6704598	0.0112156	-0.65114	-
0.029775048	-0.71953	-0.7054243	0.017825769	-0.6858	-0.6695396	0.0110347	-0.65022	-
0.029339525	-0.71861	-0.7045042	0.017623342	-0.68457	-0.6683128	0.0108605	-0.64899	-
0.028891733	-0.71739	-0.7032773	0.017408648	-0.68365	-0.6673927	0.0106906	-0.64807	-
0.028394869	-0.71677	-0.7023572	0.017157149	-0.68273	-0.6664726	0.0105237	-0.64715	-
0.028002285	-0.71585	-0.7014371	0.016899516	-0.6815	-0.6655525	0.0103556	-0.64623	-

0.027603567	-0.71463	-0.7002103	0.016648016	-0.68089	-0.6643256	0.0101851	-0.64531	-0.628441
0.02716191	-0.71371	-0.6992902	0.016427188	-0.67966	-0.6634055	0.0100563	-0.64408	-
0.026830667	-0.71279	-0.69837	0.016212493	-0.67874	-0.6624854	0.0099035	-0.64316	0.6275209
0.026487156	-0.71279	-0.6974499	0.016003933	-0.67782	-0.6615653	0.0097496	-0.64224	-
0.026094572	-0.71187	-0.6962231	0.015758568	-0.67659	-0.6603385	0.0095895	-0.64132	0.6266008
0.025701987	-0.71095	-0.695303	0.015519337	-0.67567	-0.6594183	0.0094447	-0.6404	-
0.02533394	-0.70972	-0.6943829	0.015323045	-0.67475	-0.6584982	0.009292	-0.63918	0.6235337
0.024959758	-0.7091	-0.693156	0.015157424	-0.67383	-0.6572714	0.0091889	-0.63826	-
0.024573308	-0.70788	-0.6925426	0.014918193	-0.67291	-0.6563513	0.0090288	-0.63734	0.6226136
0.024199126	-0.70696	-0.6913158	0.014728035	-0.67169	-0.6554312	0.0088816	-0.63642	-
0.02389242	-0.70604	-0.6903957	0.014507206	-0.67077	-0.654511	0.0087405	-0.63519	0.6213868
0.023616384	-0.70512	-0.6894756	0.014292512	-0.66985	-0.6535909	0.0086	-0.63427	-
0.023266739	-0.7042	-0.6885554	0.014090085	-0.66893	-0.6523641	0.00847	-0.63335	0.6204666
0.022917094	-0.70328	-0.6873286	0.014476538	-0.66801	-0.651444	0.0083258	-0.63243	-
0.022579717	-0.70205	-0.6864085	0.014271658	-0.66678	-0.6505239	0.0081872	-0.6312	0.6195465
0.022285279	-0.70113	-0.6854884	0.014068005	-0.66586	-0.6496037	0.0080474	-0.63028	-
0.02196017	-0.70021	-0.6845683	0.013870487	-0.66494	-0.6483769	0.0079247	-0.62936	0.6186264
0.021720939	-0.69929	-0.6833414	0.013671127	-0.66402	-0.6474568	0.0077934	-0.62813	-
								0.6173996
								-
								0.6164794
								-
								0.6155593
								-
								0.6143325
								-
								0.6134124
								-
								0.6124923
								-
								0.6115721

Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)
0.007155458	-0.62323	-0.6066648	0.003903144	-0.58949	-0.5723137	0.0019445	-0.55575	-0.538576
0.007039523	-0.62231	-0.605438	0.003829534	-0.58857	-0.5717003	0.001901	-0.55483	-
0.006915614	-0.62139	-0.6045179	0.003761446	-0.58734	-0.5704735	0.0018623	-0.5536	0.5376559
0.006801519	-0.62047	-0.6035978	0.003687836	-0.58642	-0.5695534	0.0018224	-0.55268	-
0.006686811	-0.61924	-0.602371	0.003614227	-0.5855	-0.5686333	0.0017807	-0.55176	0.5367358
0.006573943	-0.61832	-0.6014508	0.003544297	-0.58458	-0.5674064	0.0017396	-0.55084	-
0.006461075	-0.6174	-0.6005307	0.003482956	-0.58336	-0.5664863	0.001701	-0.54962	0.5336687
0.006344526	-0.61648	-0.5996106	0.003409347	-0.58274	-0.5655662	0.0016617	-0.5487	-
0.006239019	-0.61525	-0.5983838	0.003353526	-0.58151	-0.5646461	0.0016243	-0.54778	0.5327486
0.006147008	-0.61433	-0.5974637	0.003286051	-0.58059	-0.5634193	0.0015863	-0.54686	-
0.006034753	-0.61341	-0.5965435	0.003219802	-0.57967	-0.5624991	0.0015507	-0.54563	0.5306017
0.005926792	-0.61249	-0.5953167	0.003146806	-0.57845	-0.561579	0.0015151	-0.54471	-
0.005821285	-0.61127	-0.5943966	0.003088532	-0.57753	-0.5606589	0.0014808	-0.54379	0.5296816
0.005718845	-0.61035	-0.5934765	0.003027191	-0.57661	-0.5594321	0.0014464	-0.54287	-
								0.5287614
								-
								0.5275346
								-
								0.5266145
								-
								0.5256944

0.005617632	-0.60943	-0.5925564	0.002965849	-0.57569	-0.558512	0.0014121	-0.54164	- 0.5247743
0.005521327	-0.60851	-0.5916362	0.002905735	-0.57446	-0.5575918	0.0013801	-0.54072	- 0.5235474
0.005428701	-0.60728	-0.5904094	0.002847461	-0.57354	-0.556365	0.0013482	-0.5398	- 0.5226273
0.005329942	-0.60636	-0.5894893	0.00279164	-0.57262	-0.5554449	0.0013153	-0.53888	- 0.5217072
0.00523609	-0.60544	-0.5885692	0.002732139	-0.5717	-0.5545248	0.0012861	-0.53766	- 0.5207871
0.005141011	-0.60452	-0.5873423	0.002676932	-0.57047	-0.5536047	0.0012561	-0.53674	- 0.5195602
0.005052679	-0.60329	-0.5864222	0.002621111	-0.56955	-0.5523778	0.0012254	-0.53582	- 0.5186401
0.004961894	-0.60237	-0.5855021	0.002565904	-0.56863	-0.5514577	0.0011966	-0.5349	- 0.51772
0.004871109	-0.60145	-0.584582	0.002514991	-0.56771	-0.5505376	0.0011692	-0.53367	- 0.5164932
0.004791365	-0.60053	-0.5836619	0.002465918	-0.56649	-0.5496175	0.0011423	-0.53275	- 0.5155731
0.00469874	-0.5993	-0.582435	0.002410097	-0.56557	-0.5486973	0.0011113	-0.53183	- 0.5146529
0.004612249	-0.59838	-0.5815149	0.002357344	-0.56465	-0.5474705	0.0010834	-0.53091	- 0.5137328
0.004532505	-0.59746	-0.5805948	0.002310111	-0.56342	-0.5465504	0.0010593	-0.52968	- 0.5128127
0.004442947	-0.59654	-0.579368	0.002261038	-0.56281	-0.5456303	0.0010331	-0.52876	- 0.5115859
0.004363817	-0.59562	-0.5784479	0.002211352	-0.56158	-0.5447102	0.0010068	-0.52784	- 0.5106658
0.004280393	-0.5944	-0.5775277	0.002162279	-0.56066	-0.5434833	0.0009805	-0.52692	- 0.5097456
0.004200649	-0.59348	-0.5766076	0.002115659	-0.55974	-0.5425632	0.0009559	-0.52569	- 0.5088255
0.004129493	-0.59256	-0.5753808	0.002075174	-0.55851	-0.5416431	0.0009333	-0.52477	- 0.5075987

Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)
0.00405159	-0.59133	-0.5744607	0.000366269	-0.49564	-0.4787683	0.0001423	-0.46435	- 0.4465641
0.00397246	-0.59041	-0.5735406	0.000351792	-0.49472	-0.4775415	0.0001577	-0.46374	-0.445644
0.002031622	-0.55759	-0.540723	0.000337684	-0.4938	-0.4766214	0.0001731	-0.4619	- 0.4447239
0.00198807	-0.55667	-0.5394962	0.000322103	-0.49288	-0.4757012	0.0001984	-0.46067	- 0.4438038
0.0009092	-0.52385	-0.5066786	0.000305173	-0.49165	-0.4747811	0.000202	-0.45975	-0.442577
0.000884296	-0.52263	-0.5057585	0.000288856	-0.49073	-0.473861	0.0002225	-0.45883	- 0.4416568
0.000860311	-0.52171	-0.5048383	0.000272662	-0.48981	-0.4726342	0.0002428	-0.45791	- 0.4407367
0.000835713	-0.52079	-0.5036115	0.000256897	-0.48858	-0.4717141	0.000264	-0.45669	- 0.4395099
0.000813446	-0.51987	-0.5026914	0.000240887	-0.48797	-0.4707939	0.0002848	-0.45577	- 0.4385898
0.000790382	-0.51864	-0.5017713	0.000226042	-0.48674	-0.4695671	0.0003066	-0.45485	- 0.4376697
0.000769649	-0.51772	-0.5005445	0.000210216	-0.48582	-0.468647	0.0003279	-0.45393	- 0.4367495
0.000749836	-0.5168	-0.4996243	0.000195556	-0.4849	-0.4677269	0.0003506	-0.4527	- 0.4355227
0.000728734	-0.51588	-0.4987042	0.000180343	-0.48368	-0.4668068	0.0003717	-0.45178	- 0.4346026

0.000708001	-0.51465	-0.4977841	0.000164456	-0.48276	-0.4655799	0.0003939	-0.45086	- 0.4336825
0.000687697	-0.51373	-0.4965573	0.000149121	-0.48184	-0.4646598	0.0004162	-0.44994	- 0.4327624
0.000670399	-0.51281	-0.4956372	0.00013262	-0.48092	-0.4637397	0.0004387	-0.44871	- 0.4318422
0.000651321	-0.51189	-0.494717	0.000117058	-0.47969	-0.4628196	0.0004625	-0.44779	- 0.4306154
0.000630588	-0.51067	-0.4937969	0.000100962	-0.47877	-0.4615927	0.000486	-0.44687	- 0.4296953
0.000609977	-0.50975	-0.4925701	8.77E-05	-0.47785	-0.4606726	0.0005117	-0.44595	- 0.4287752
0.000592004	-0.50883	-0.49165	7.32E-05	-0.47662	-0.4597525	0.0005362	-0.44472	- 0.4278551
0.000573663	-0.5076	-0.4907299	5.73E-05	-0.47601	-0.4588324	0.0005606	-0.4438	- 0.4266282
0.000555874	-0.50668	-0.4898097	4.15E-05	-0.47478	-0.4576056	0.0005864	-0.44288	- 0.4257081
0.000536491	-0.50576	-0.4885829	2.45E-05	-0.47386	-0.4566854	0.0006126	-0.44166	- 0.4244813
0.000518824	-0.50484	-0.4876628	1.63E-06	-0.47294	-0.4557653	0.0006406	-0.44074	- 0.4235612
0.000501342	-0.50392	-0.4867427	2.86E-07	-0.47171	-0.4551519	0.0006676	-0.43982	-0.422641
0.000484412	-0.50269	-0.4858225	1.77E-06	-0.47079	-0.4545385	0.0006947	-0.4389	- 0.4217209
0.000467359	-0.50177	-0.4849024	5.11E-06	-0.46987	-0.4526983	0.0007227	-0.43798	- 0.4204941
0.00045049	-0.50085	-0.4836756	2.01E-06	-0.46865	-0.4517781	0.0007512	-0.43675	-0.419574
0.000433744	-0.49962	-0.4827555	1.47E-05	-0.46773	-0.450858	0.000782	-0.43583	- 0.4186539
0.000415403	-0.4987	-0.4815287	1.79E-05	-0.46681	-0.4496312	0.0008121	-0.43491	- 0.4177337
0.000398473	-0.49778	-0.4806085	2.01E-05	-0.46589	-0.4487111	0.0008434	-0.43399	- 0.4168136
0.000381297	-0.49686	-0.4796884	0.000126197	-0.46497	-0.4474843	0.0008742	-0.43276	- 0.4155868

Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)
0.000905459	-0.43184	-0.4146667	0.002280669	-0.39994	-0.3827692	0.0039933	-0.36805	- 0.3508718
0.000937601	-0.43092	-0.4134399	0.00233465	-0.39902	-0.3815424	0.0040393	-0.36713	- 0.3496449
0.000970664	-0.4297	-0.4125197	0.00238679	-0.3981	-0.3806223	0.0040847	-0.36621	- 0.3487248
0.001005874	-0.42878	-0.4115996	0.002440157	-0.39688	-0.3797022	0.004127	-0.36498	- 0.3478047
0.001040287	-0.42786	-0.4106795	0.002497204	-0.39596	-0.378782	0.0041718	-0.36406	- 0.3468846
0.001075987	-0.42693	-0.4097594	0.002552411	-0.39504	-0.3778619	0.0042135	-0.36314	- 0.3459645
0.001110952	-0.42571	-0.4088393	0.002607005	-0.39381	-0.3766351	0.0042559	-0.36222	- 0.3447376
0.001146284	-0.42479	-0.4076124	0.002662212	-0.39289	-0.375715	0.0042963	-0.36099	- 0.3438175
0.001184071	-0.42387	-0.4066923	0.002717419	-0.39197	-0.3747949	0.0043338	-0.36007	- 0.3428974
0.001222409	-0.42295	-0.4057722	0.002775693	-0.39105	-0.373568	0.0043742	-0.35915	- 0.3416706
0.001262158	-0.42172	-0.4045454	0.002831514	-0.38982	-0.3726479	0.0044129	-0.35823	- 0.3407505
0.001300374	-0.4208	-0.4036252	0.002886108	-0.3889	-0.3717278	0.0044546	-0.35731	- 0.3398303

0.001339141	-0.41988	-0.4027051	0.002940701	-0.38798	-0.3708077	0.0044945	-0.35609	- 0.3389102
0.001381221	-0.41896	-0.4014783	0.002996522	-0.38706	-0.3698876	0.0045276	-0.35517	- 0.3376834
0.001423486	-0.41804	-0.4008649	0.003054183	-0.38584	-0.3686607	0.004562	-0.35425	- 0.3367633
0.001464952	-0.41681	-0.3996381	0.003108776	-0.38492	-0.3677406	0.0045951	-0.35302	- 0.3358431
0.001506542	-0.41589	-0.3987179	0.003162757	-0.384	-0.3668205	0.0046362	-0.3521	- 0.3346163
0.001550155	-0.41497	-0.3974911	0.00321735	-0.38308	-0.3655937	0.0047122	-0.35118	- 0.3336962
0.001595425	-0.41375	-0.396571	0.003273784	-0.38185	-0.3646735	0.0047337	-0.35026	- 0.3327761
0.001638793	-0.41283	-0.3956509	0.003329605	-0.38093	-0.3637534	0.0047564	-0.34903	-0.331856
0.001682039	-0.41191	-0.3947308	0.003382972	-0.38001	-0.3628333	0.0047828	-0.34811	- 0.3306291
0.001728229	-0.41099	-0.3938106	0.003435725	-0.37909	-0.3619132	0.0048128	-0.34719	-0.329709
0.001775646	-0.40976	-0.3928905	0.003490319	-0.37817	-0.3606864	0.0048392	-0.34627	- 0.3287889
0.001823799	-0.40884	-0.3916637	0.003542459	-0.37694	-0.3597662	0.0048723	-0.34535	- 0.3278688
0.001871523	-0.40792	-0.3907436	0.003597666	-0.37602	-0.3585394	0.0048999	-0.34412	-0.326642
0.001919369	-0.407	-0.3898235	0.003649193	-0.3751	-0.3576193	0.0049257	-0.3432	- 0.3257218
0.001969056	-0.40577	-0.3885966	0.003701946	-0.37418	-0.3566992	0.0049551	-0.34228	- 0.3248017
0.002020582	-0.40485	-0.3876765	0.00375102	-0.37295	-0.3557791	0.0049791	-0.34106	- 0.3238816
0.002072109	-0.40393	-0.3867564	0.003800093	-0.37203	-0.3548589	0.0050079	-0.34014	- 0.3226548
0.002122409	-0.40301	-0.3858363	0.003849166	-0.37111	-0.3536321	0.0050367	-0.33922	- 0.3217347
0.002172709	-0.40179	-0.3849162	0.003900079	-0.37019	-0.352712	0.0050705	-0.3383	- 0.3208145
0.002226689	-0.40086	-0.3836893	0.003948538	-0.36897	-0.3517919	0.0050987	-0.33738	- 0.3198944

Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)	Current Density (A/cm ²)	CWZ Potential (V)	SAWZ Potential (V)
0.005126291	-0.33615	-0.3186676	0.00746646	-0.30456	-0.2867701	0.0177896	-0.27328	- 0.2548727
0.005152054	-0.33523	-0.3177475	0.007637602	-0.30333	-0.28585	0.0182343	-0.27235	- 0.2536458
0.005186405	-0.33431	-0.3168274	0.007814265	-0.30272	-0.2846232	0.0177215	-0.27143	- 0.2527257
0.00524652	-0.33339	-0.3159072	0.007999516	-0.30149	-0.2837031	0.0181386	-0.27051	- 0.2518056
0.005275963	-0.33216	-0.3146804	0.008201329	-0.30057	-0.282783	0.018568	-0.26929	- 0.2508855
0.005298046	-0.33124	-0.3137603	0.008413569	-0.29965	-0.2818628	0.0190158	-0.26837	- 0.2496587
0.00532565	-0.33032	-0.3128402	0.008641145	-0.29873	-0.280636	0.0194575	-0.26745	- 0.2487385
0.005355707	-0.3294	-0.3119201	0.008873629	-0.2975	-0.2797159	0.0199052	-0.26653	- 0.2478184
0.005393739	-0.32818	-0.3106932	0.009120221	-0.29658	-0.2787958	0.0203592	-0.26561	- 0.2468983
0.005434224	-0.32726	-0.3097731	0.009379694	-0.29566	-0.2778757	0.0208192	-0.26438	- 0.2456715
0.005473482	-0.32634	-0.308853	0.009647142	-0.29444	-0.2766488	0.0212916	-0.26346	- 0.2447514

0.005517648	-0.32542	-0.3079329	0.009930539	-0.29382	-0.2757287	0.0217578	-0.26254	-
								0.2438312
0.005560587	-0.3245	-0.306706	0.010222523	-0.2929	-0.2748086	0.0222301	-0.26162	-
								0.2429111
0.005648305	-0.32327	-0.3057859	0.010524936	-0.29168	-0.2738885	0.0227085	-0.2607	-
								0.2416843
0.005698605	-0.32235	-0.3048658	0.010837163	-0.29076	-0.2726616	0.0231931	-0.25978	-
								0.2407642
0.005739703	-0.32143	-0.303639	0.011157978	-0.28984	-0.2717415	0.0236839	-0.25886	-
								0.2398441
0.005794911	-0.3202	-0.3027189	0.011490447	-0.28861	-0.2708214	0.0241746	-0.25794	-
								0.2389239
0.005856865	-0.31928	-0.3017987	0.011830278	-0.28769	-0.2695946	0.0246715	-0.25702	-
								0.2376971
0.005924954	-0.31836	-0.3008786	0.012180537	-0.28677	-0.2689812	0.0251745	-0.2561	-
								0.236777
0.005988749	-0.31744	-0.2996518	0.012541223	-0.28585	-0.2677543	0.0256836	-0.25487	-
								0.2358569
0.006061745	-0.31621	-0.2987317	0.012909884	-0.28493	-0.2668342	0.0261927	-0.25395	-
								0.2349368
0.006138422	-0.31529	-0.2978116	0.013293881	-0.28401	-0.2659141	0.026708	-0.25303	-
								0.2340166
0.006224299	-0.31437	-0.2968914	0.01367665	-0.28278	-0.2646873	0.0272294	-0.25211	-
								0.2327898
0.006340234	-0.31345	-0.2956646	0.014056966	-0.28217	-0.2637672	0.0277508	-0.25211	-
								0.2318697
0.006425499	-0.31223	-0.2947445	0.014450777	-0.28094	-0.262847	0.0282906	-0.25119	-
								0.2309496
0.006523031	-0.31131	-0.2938244	0.014842134	-0.28002	-0.2619269	0.028812	-0.25027	-
								0.2297228
0.006634059	-0.31039	-0.2925976	0.015243306	-0.2791	-0.2607001	0.0293579	-0.24935	-
								0.2288026
0.006749381	-0.30947	-0.2916774	0.015654293	-0.27818	-0.25978	0.0298977	-0.24843	-
								0.2278825
0.006872063	-0.30855	-0.2907573	0.016067119	-0.27726	-0.2588599	0.0304253	-0.24751	-
								0.2269624
0.007006401	-0.30732	-0.2898372	0.01648608	-0.27604	-0.257633	0.0309589	-0.24659	-
								0.2257356
0.007149326	-0.3064	-0.2886104	0.016911175	-0.27512	-0.2567129	0.0315294	-0.24567	-
								0.2248155
0.007305133	-0.30548	-0.2876903	0.017345471	-0.2742	-0.2557928	0.0320692	-0.24475	-
								0.2238953

Table B.7: Open Circuit Potential (OCP) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Parent Metal of the Samples Immersed in 1M NaCl Environment

Table of the Solution Parameters			Table of the Sample Parameters			Table of the Environment Parameters		
Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)	Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)	Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1	- 0.4698738	- 0.46343299	33	-0.4683403	-0.4640464	65	- 0.4671135	- 0.4637397
2	- 0.4698738	- 0.46343299	34	-0.4680336	-0.4640464	66	- 0.4671135	- 0.4637397
3	- 0.4695671	- 0.46343299	35	-0.4680336	-0.4640464	67	- 0.4671135	- 0.4637397
4	- 0.4695671	- 0.46343299	36	-0.4680336	-0.4640464	68	- 0.4671135	- 0.4637397
5	- 0.4695671	- 0.46343299	37	-0.4680336	- 0.46435311	69	- 0.4671135	- 0.4637397
6	- 0.4695671	- 0.46373969	38	-0.4680336	-0.4640464	70	- 0.4668068	- 0.4637397
7	- 0.4695671	- 0.46373969	39	-0.4680336	-0.4640464	71	- 0.4668068	- 0.4637397
8	- 0.4692604	- 0.46373969	40	-0.4680336	-0.4640464	72	- 0.4668068	- 0.4637397
9	- 0.4692604	- 0.46373969	41	-0.4677269	-0.4640464	73	- 0.4668068	- 0.4637397
10	- 0.4692604	- 0.46373969	42	-0.4677269	-0.4640464	74	- 0.4668068	- 0.4637397
11	- 0.4692604	- 0.46373969	43	-0.4677269	-0.4640464	75	- 0.4668068	- 0.4637397

12	- 0.4692604	- 0.46373969
13	- 0.4692604	- 0.46373969
14	- 0.4689537	- 0.46373969
15	- 0.4689537	-0.4640464
16	- 0.4689537	- 0.46373969
17	-0.468647	-0.4640464
18	- 0.4689537	- 0.46373969
19	-0.468647	-0.4640464
20	-0.468647	-0.4640464
21	-0.468647	-0.4640464
22	-0.468647	-0.4640464
23	-0.468647	-0.4640464
24	-0.468647	-0.4640464
25	-0.468647	-0.4640464
26	-0.468647	-0.4640464
27	- 0.4683403	-0.4640464
28	- 0.4683403	-0.4640464
29	- 0.4683403	-0.4640464
30	- 0.4683403	-0.4640464
31	- 0.4683403	-0.4640464
32	- 0.4683403	-0.4640464

44	-0.4677269	-0.4640464
45	-0.4677269	- 0.46435311
46	-0.4677269	-0.4640464
47	-0.4677269	-0.4640464
48	-0.4677269	-0.4640464
49	-0.4677269	-0.4640464
50	-0.4677269	-0.4640464
51	-0.4677269	- 0.46373969
52	-0.4674202	- 0.46373969
53	-0.4674202	- 0.46373969
54	-0.4674202	- 0.46373969
55	-0.4674202	-0.4640464
56	-0.4674202	- 0.46373969
57	-0.4671135	- 0.46373969
58	-0.4674202	- 0.46373969
59	-0.4671135	-0.4640464
60	-0.4674202	- 0.46373969
61	-0.4671135	- 0.46373969
62	-0.4671135	- 0.46373969
63	-0.4671135	- 0.46373969
64	-0.4671135	- 0.46373969

76	- 0.4668068	- 0.4637397
77	- 0.4668068	- 0.4637397
78	- 0.4668068	- 0.4637397
79	- 0.4668068	- 0.4637397
80	- 0.4668068	- 0.4640464
81	- 0.4668068	- 0.4637397
82	- 0.4668068	- 0.4637397
83	-0.4665	- 0.4637397
84	-0.4665	- 0.4637397
85	-0.4665	- 0.4637397
86	-0.4665	- 0.4637397
87	-0.4665	- 0.4637397
88	-0.4665	- 0.4637397
89	-0.4665	- 0.4637397
90	-0.4665	- 0.4637397
91	-0.4665	- 0.4637397
92	-0.4665	- 0.4637397
93	-0.4665	- 0.4637397
94	-0.4665	- 0.4637397
95	-0.4665	- 0.4637397
96	- 0.4661933	- 0.4637397

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
97	- 0.4661933	- 0.46373969
98	- 0.4661933	- 0.46373969
99	- 0.4661933	- 0.46373969
100	- 0.4661933	- 0.46373969
101	- 0.4661933	- 0.46373969
102	- 0.4661933	- 0.46373969
103	- 0.4661933	- 0.46373969
104	- 0.4661933	- 0.46373969
105	- 0.4661933	- 0.46373969
106	- 0.4661933	- 0.46373969
107	- 0.4661933	- 0.46373969

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
129	-0.4655799	- 0.46373969
130	-0.4655799	- 0.46373969
131	-0.4655799	- 0.46373969
132	-0.4652732	- 0.46343299
133	-0.4655799	- 0.46373969
134	-0.4652732	- 0.46373969
135	-0.4655799	- 0.46373969
136	-0.4655799	- 0.46343299
137	-0.4655799	- 0.46343299
138	-0.4652732	- 0.46343299
139	-0.4652732	- 0.46343299

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
161	- 0.4649665	-0.463433
162	- 0.4649665	-0.463433
163	- 0.4649665	-0.463433
164	- 0.4649665	-0.463433
165	- 0.4649665	-0.463433
166	- 0.4649665	-0.463433
167	- 0.4649665	-0.463433
168	- 0.4649665	-0.463433
169	- 0.4649665	-0.463433
170	- 0.4649665	-0.463433
171	- 0.4649665	-0.463433

108	- 0.4661933	- 0.46373969
109	- 0.4658866	- 0.46373969
110	- 0.4661933	- 0.46373969
111	- 0.4661933	- 0.46373969
112	- 0.4658866	- 0.46373969
113	- 0.4658866	- 0.46373969
114	- 0.4658866	- 0.46373969
115	- 0.4658866	- 0.46373969
116	- 0.4658866	- 0.46373969
117	- 0.4658866	- 0.46373969
118	- 0.4658866	- 0.46373969
119	- 0.4658866	- 0.46373969
120	- 0.4658866	- 0.46373969
121	- 0.4658866	- 0.46373969
122	- 0.4658866	- 0.46373969
123	- 0.4658866	- 0.46373969
124	- 0.4658866	- 0.46343299
125	- 0.4655799	- 0.46373969
126	- 0.4655799	- 0.46373969
127	- 0.4655799	- 0.46373969
128	- 0.4655799	- 0.46373969

140	-0.4652732	- 0.46343299
141	-0.4652732	- 0.46373969
142	-0.4652732	- 0.46343299
143	-0.4652732	- 0.46343299
144	-0.4652732	- 0.46343299
145	-0.4652732	- 0.46343299
146	-0.4652732	- 0.46343299
147	-0.4652732	- 0.46343299
148	-0.4652732	- 0.46343299
149	-0.4652732	- 0.46343299
150	-0.4652732	- 0.46343299
151	-0.4652732	- 0.46343299
152	-0.4652732	- 0.46343299
153	-0.4652732	- 0.46343299
154	-0.4652732	- 0.46343299
155	-0.4652732	- 0.46343299
156	-0.4649665	- 0.46343299
157	-0.4649665	- 0.46343299
158	-0.4649665	- 0.46343299
159	-0.4652732	- 0.46343299
160	-0.4649665	- 0.46343299

172	- 0.4649665	-0.463433
173	- 0.4649665	-0.463433
174	- 0.4649665	-0.463433
175	- 0.4649665	-0.463433
176	- 0.4649665	-0.463433
177	- 0.4649665	-0.463433
178	- 0.4649665	-0.463433
179	- 0.4649665	-0.463433
180	- 0.4649665	-0.463433
181	- 0.4649665	-0.463433
182	- 0.4649665	-0.463433
183	- 0.4649665	-0.463433
184	- 0.4649665	-0.463433
185	- 0.4649665	-0.463433
186	- 0.4649665	-0.463433
187	- 0.4649665	-0.463433
188	- 0.4649665	-0.463433
189	- 0.4649665	-0.463433
190	- 0.4649665	-0.463433
191	- 0.4649665	-0.463433
192	- 0.4649665	-0.463433

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
193	- 0.4649665	- 0.46343299
194	- 0.4649665	- 0.46343299
195	- 0.4649665	- 0.46343299
196	- 0.4649665	- 0.46312628
197	- 0.4649665	- 0.46343299
198	- 0.4649665	- 0.46312628
199	- 0.4649665	- 0.46312628
200	- 0.4649665	- 0.46312628
201	- 0.4649665	- 0.46312628
202	- 0.4649665	- 0.46312628
203	- 0.4649665	- 0.46343299

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
225	-0.4649665	- 0.46312628
226	-0.4649665	- 0.46312628
227	-0.4649665	- 0.46312628
228	-0.4649665	- 0.46312628
229	-0.4649665	- 0.46312628
230	-0.4649665	- 0.46312628
231	-0.4649665	- 0.46312628
232	-0.4649665	- 0.46312628
233	-0.4649665	- 0.46312628
234	-0.4649665	- 0.46312628
235	-0.4649665	- 0.46312628

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
257	- 0.4649665	- 0.4628196
258	- 0.4649665	- 0.4628196
259	- 0.4652732	- 0.4631263
260	- 0.4649665	- 0.4631263
261	- 0.4649665	- 0.4628196
262	- 0.4649665	- 0.4631263
263	- 0.4649665	- 0.4628196
264	- 0.4652732	- 0.4631263
265	- 0.4652732	- 0.4631263
266	- 0.4652732	- 0.4631263
267	- 0.4652732	- 0.4628196

204	- 0.4649665	- 0.46343299
205	- 0.4649665	- 0.46312628
206	- 0.4649665	- 0.46312628
207	- 0.4649665	- 0.46312628
208	- 0.4649665	- 0.46343299
209	- 0.4649665	- 0.46343299
210	- 0.4649665	- 0.46312628
211	- 0.4649665	- 0.46312628
212	- 0.4649665	- 0.46312628
213	- 0.4649665	- 0.46312628
214	- 0.4649665	- 0.46312628
215	- 0.4649665	- 0.46312628
216	- 0.4649665	- 0.46312628
217	- 0.4649665	- 0.46312628
218	- 0.4649665	- 0.46343299
219	- 0.4649665	- 0.46312628
220	- 0.4649665	- 0.46312628
221	- 0.4649665	- 0.46312628
222	- 0.4649665	- 0.46312628
223	- 0.4649665	- 0.46312628
224	- 0.4649665	- 0.46312628

236	-0.4649665	- 0.46312628
237	-0.4649665	0.46312628
238	-0.4649665	- 0.46312628
239	-0.4649665	0.46312628
240	-0.4649665	- 0.46312628
241	-0.4649665	- 0.46312628
242	-0.4649665	0.46312628
243	-0.4649665	- 0.46312628
244	-0.4649665	0.46312628
245	-0.4649665	- 0.46312628
246	-0.4649665	- 0.46312628
247	-0.4649665	0.46312628
248	-0.4649665	0.46312628
249	-0.4649665	0.46312628
250	-0.4649665	0.46312628
251	-0.4649665	- 0.46312628
252	-0.4649665	- 0.46312628
253	-0.4649665	- 0.46312628
254	-0.4649665	- 0.46312628
255	-0.4649665	0.46312628
256	-0.4649665	- 0.46312628

268	- 0.4649665	- 0.4628196
269	- 0.4649665	- 0.4628196
270	- 0.4652732	- 0.4628196
271	- 0.4652732	- 0.4628196
272	- 0.4652732	- 0.4628196
273	- 0.4649665	- 0.4628196
274	- 0.4652732	- 0.4628196
275	- 0.4652732	- 0.4628196
276	- 0.4652732	- 0.4628196
277	- 0.4652732	- 0.4628196
278	- 0.4652732	- 0.4628196
279	- 0.4652732	- 0.4628196
280	- 0.4652732	- 0.4628196
281	- 0.4652732	- 0.4628196
282	- 0.4652732	- 0.4628196
283	- 0.4652732	- 0.4628196
284	- 0.4652732	- 0.4628196
285	- 0.4652732	- 0.4628196
286	- 0.4652732	- 0.4628196
287	- 0.4652732	- 0.4628196
288	- 0.4652732	- 0.4628196

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
289	- 0.4652732	- 0.46281957
290	- 0.4652732	- 0.46281957
291	- 0.4652732	- 0.46281957
292	- 0.4652732	- 0.46281957
293	- 0.4652732	- 0.46281957
294	- 0.4652732	- 0.46281957
295	- 0.4652732	- 0.46281957
296	- 0.4652732	- 0.46281957
297	- 0.4652732	- 0.46281957
298	- 0.4652732	- 0.46281957
299	- 0.4652732	- 0.46281957

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
321	-0.4655799	- 0.46281957
322	-0.4655799	0.46281957
323	-0.4655799	- 0.46281957
324	-0.4655799	- 0.46281957
325	-0.4655799	- 0.46281957
326	-0.4655799	- 0.46281957
327	-0.4655799	0.46281957
328	-0.4655799	- 0.46281957
329	-0.4655799	- 0.46281957
330	-0.4655799	- 0.46281957
331	-0.4655799	- 0.46251287

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
353	- 0.4655799	- 0.4628196
354	- 0.4655799	- 0.4625129
355	- 0.4655799	- 0.4625129
356	- 0.4655799	- 0.4625129
357	- 0.4658866	- 0.4625129
358	- 0.4655799	- 0.4625129
359	- 0.4658866	- 0.4628196
360	- 0.4658866	- 0.4628196
361	- 0.4655799	- 0.4628196
362	- 0.4658866	- 0.4625129
363	- 0.4658866	- 0.4628196

300	- 0.4652732	- 0.46281957
301	- 0.4652732	- 0.46281957
302	- 0.4652732	- 0.46281957
303	- 0.4652732	- 0.46281957
304	- 0.4652732	- 0.46281957
305	- 0.4655799	- 0.46281957
306	- 0.4652732	- 0.46281957
307	- 0.4652732	- 0.46281957
308	- 0.4652732	- 0.46281957
309	- 0.4652732	- 0.46281957
310	- 0.4652732	- 0.46281957
311	- 0.4655799	- 0.46281957
312	- 0.4655799	- 0.46281957
313	- 0.4655799	- 0.46281957
314	- 0.4652732	- 0.46281957
315	- 0.4655799	- 0.46281957
316	- 0.4655799	- 0.46281957
317	- 0.4655799	- 0.46281957
318	- 0.4655799	- 0.46281957
319	- 0.4655799	- 0.46281957
320	- 0.4655799	- 0.46281957

332	-0.4655799	- 0.46281957
333	-0.4655799	- 0.46281957
334	-0.4655799	- 0.46281957
335	-0.4655799	- 0.46281957
336	-0.4655799	- 0.46281957
337	-0.4655799	- 0.46281957
338	-0.4655799	- 0.46281957
339	-0.4655799	- 0.46281957
340	-0.4655799	- 0.46281957
341	-0.4655799	- 0.46281957
342	-0.4655799	- 0.46281957
343	-0.4655799	- 0.46281957
344	-0.4655799	- 0.46281957
345	-0.4655799	- 0.46281957
346	-0.4655799	- 0.46281957
347	-0.4655799	- 0.46281957
348	-0.4655799	- 0.46281957
349	-0.4655799	- 0.46251287
350	-0.4655799	- 0.46251287
351	-0.4655799	- 0.46251287
352	-0.4655799	- 0.46251287

364	- 0.4658866	- 0.4625129
365	- 0.4658866	- 0.4625129
366	- 0.4658866	- 0.4625129
367	- 0.4658866	- 0.4625129
368	- 0.4658866	- 0.4625129
369	- 0.4658866	- 0.4625129
370	- 0.4658866	- 0.4625129
371	- 0.4658866	- 0.4625129
372	- 0.4658866	- 0.4625129
373	- 0.4658866	- 0.4625129
416	- 0.4661933	- 0.4625129
417	- 0.4661933	- 0.4625129
418	- 0.4661933	- 0.4622062
419	- 0.4661933	- 0.4625129
420	- 0.4661933	- 0.4625129
421	- 0.4661933	- 0.4625129
422	- 0.4661933	- 0.4625129
423	- 0.4661933	- 0.4625129
424	- 0.4661933	- 0.4625129
425	- 0.4661933	- 0.4625129
426	- 0.4661933	- 0.4625129

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
427	- 0.4661933	- 0.46251287
428	-0.4665	- 0.46251287
429	-0.4665	- 0.46251287
430	- 0.4661933	- 0.46251287
431	- 0.4661933	- 0.46251287
432	- 0.4661933	- 0.46220616
433	- 0.4661933	- 0.46220616
434	-0.4665	- 0.46220616
435	-0.4665	- 0.46251287
436	-0.4665	- 0.46220616
437	- 0.4661933	- 0.46251287

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
501	-0.4668068	- 0.46220616
502	-0.4668068	- 0.46220616
503	-0.4668068	- 0.46220616
504	-0.4668068	- 0.46220616
505	-0.4668068	- 0.46220616
506	-0.4668068	- 0.46220616
507	-0.4668068	- 0.46220616
508	-0.4665	- 0.46220616
509	-0.4665	- 0.46220616
510	-0.4668068	- 0.46220616
511	-0.4668068	- 0.46220616

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
533	- 0.4668068	- 0.4622062
534	- 0.4668068	- 0.4622062
535	- 0.4668068	- 0.4618995
536	- 0.4668068	- 0.4622062
537	- 0.4668068	- 0.4622062
538	- 0.4668068	- 0.4618995
539	- 0.4668068	- 0.4618995
540	- 0.4668068	- 0.4618995
541	- 0.4668068	- 0.4618995
584	- 0.4668068	- 0.4618995
585	- 0.4668068	- 0.4618995

438	- 0.4661933	- 0.46251287
439	-0.4665	0.46220616
440	-0.4665	- 0.46220616
441	-0.4665	- 0.46220616
442	-0.4665	- 0.46251287
443	- 0.4661933	- 0.46220616
444	-0.4665	0.46220616
445	-0.4665	- 0.46220616
446	- 0.4661933	- 0.46251287
447	-0.4665	- 0.46220616
448	-0.4665	- 0.46220616
449	-0.4665	0.46220616
450	-0.4665	- 0.46220616
451	-0.4665	- 0.46220616
452	-0.4665	0.46220616
453	-0.4665	- 0.46220616
454	-0.4665	- 0.46220616
455	-0.4665	- 0.46220616
456	-0.4665	- 0.46220616
457	-0.4665	0.46220616
500	- 0.4668068	- 0.46220616

512	-0.4668068	- 0.46220616
513	-0.4668068	0.46220616
514	-0.4668068	- 0.46189945
515	-0.4668068	0.46220616
516	-0.4668068	- 0.46220616
517	-0.4668068	- 0.46220616
518	-0.4668068	- 0.46220616
519	-0.4668068	- 0.46220616
520	-0.4668068	- 0.46220616
521	-0.4668068	- 0.46220616
522	-0.4668068	- 0.46220616
523	-0.4668068	- 0.46220616
524	-0.4668068	- 0.46220616
525	-0.4668068	- 0.46220616
526	-0.4668068	- 0.46220616
527	-0.4668068	- 0.46189945
528	-0.4668068	- 0.46220616
529	-0.4668068	- 0.46220616
530	-0.4668068	- 0.46220616
531	-0.4668068	- 0.46220616
532	-0.4668068	- 0.46220616

586	- 0.4668068	- 0.4618995
587	- 0.4668068	- 0.4618995
588	- 0.4668068	- 0.4618995
589	- 0.4668068	- 0.4618995
590	- 0.4668068	- 0.4618995
591	- 0.4668068	- 0.4618995
592	- 0.4668068	- 0.4618995
593	- 0.4668068	- 0.4618995
594	- 0.4668068	- 0.4618995
595	- 0.4668068	- 0.4618995
596	- 0.4668068	- 0.4618995
597	- 0.4668068	- 0.4618995
598	- 0.4668068	- 0.4618995
599	- 0.4668068	- 0.4618995
600	- 0.4668068	- 0.4618995
603	- 0.7164657	- 0.7069578
606	- 0.7149322	- 0.7054243
609	- 0.7140121	- 0.7045042
612	- 0.7130919	- 0.7038908
615	- 0.7121718	- 0.7029706
618	- 0.7112517	- 0.7020505

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
621	- 0.7103316	-0.7011304
624	- 0.7094115	- 0.70021028
627	- 0.7084914	- 0.69929016
630	- 0.7075712	- 0.69837004
633	- 0.7063444	- 0.69744992
636	- 0.7054243	-0.6965298
639	- 0.7045042	- 0.69560969
642	- 0.7035841	- 0.69468957
645	- 0.7026639	- 0.69376945
648	- 0.7017438	- 0.69284933
651	- 0.7008237	- 0.69192921

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
843	-0.6385623	- 0.63181477
846	-0.6376422	0.63089465
849	-0.6367221	- 0.62997453
852	-0.6354952	-0.6287477
855	-0.6345751	- 0.62782758
858	-0.633655	- 0.62690747
861	-0.6327349	- 0.62598735
864	-0.6318148	- 0.62506723
867	-0.6305879	-0.6238404
870	-0.6296678	- 0.62292028
873	-0.6287477	- 0.62200016

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1065	- 0.5652595	- 0.5588187
1068	- 0.5640327	- 0.5578985
1071	- 0.5631125	- 0.5566717
1074	- 0.5621924	- 0.5557516
1077	- 0.5612723	- 0.5548315
1080	- 0.5603522	- 0.5539114
1083	- 0.5591254	- 0.5529912
1086	- 0.5582052	- 0.5517644
1089	- 0.5572851	-0.551151
1092	- 0.5560583	- 0.5499242
1095	- 0.5551382	- 0.5490041

654	- 0.6995969	- 0.69100909
657	- 0.6995969	- 0.69008897
660	- 0.6986767	- 0.68916885
663	- 0.6974499	- 0.68824873
666	- 0.6968365	- 0.68732861
669	- 0.6956097	- -0.6864085
672	- 0.6946896	- 0.68548838
675	- 0.6937694	- 0.68456826
804	- -0.651444	- 0.64438973
807	- 0.6505239	- 0.64346961
810	- 0.6496037	- 0.64254949
813	- 0.6483769	- 0.64132266
816	- 0.6474568	- 0.64040254
819	- 0.6465367	- 0.63948243
822	- 0.6456166	- 0.63856231
825	- 0.6443897	- 0.63764219
828	- 0.6434696	- 0.63672207
831	- 0.6425495	- 0.63549524
834	- 0.6416294	- 0.63457512
837	- 0.6407093	- 0.63365501
840	- 0.6397891	- 0.63273489

876	-0.6278276	- 0.62077334
879	-0.6269075	0.62015993
882	-0.6256806	-0.6189331
885	-0.6247605	- 0.61801298
888	-0.6238404	- 0.61709286
891	-0.6226136	- 0.61617274
894	-0.6216935	- 0.61494592
897	-0.6207733	-0.6140258
900	-0.6198532	- 0.61310568
903	-0.6186264	0.61218556
906	-0.6177063	- 0.61095874
909	-0.6167862	0.61034532
912	-0.615866	-0.6091185
915	-0.6149459	- 0.60819838
918	-0.6140258	0.60727826
921	-0.612799	- 0.60635814
924	-0.6118789	- 0.60513132
927	-0.6109587	-0.6042112
1056	-0.5680198	- 0.56157902
1059	-0.5670997	-0.5606589
1062	-0.5661796	- 0.55973878

1098	- 0.5542181	- 0.5477772
1101	- 0.5532979	- 0.5468571
1104	- 0.5523778	- -0.545937
1107	- -0.551151	- 0.5450169
1110	- 0.5502309	- 0.5440968
1113	- 0.5493108	- 0.5428699
1116	- 0.5483906	- 0.5419498
1119	- 0.5474705	- 0.5410297
1122	- 0.5462437	- 0.5401096
1125	- 0.5453236	- 0.5388828
1128	- 0.5444035	- 0.5379626
1131	- 0.5434833	- 0.5370425
1134	- 0.5422565	- 0.5361224
1137	- 0.5413364	- 0.5348956
1140	- 0.5404163	- 0.5339754
1143	- 0.5394962	- 0.5330553
1146	- 0.5382693	- 0.5321352
1149	- 0.5373492	- 0.5309084
1152	- 0.5364291	- 0.5299883
1155	- -0.535509	- 0.5290681
1158	- 0.5342822	- -0.528148

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1161	-0.533362	-0.5269212
1164	- 0.5324419	- 0.52600108
1167	- 0.5315218	- 0.52508096
1170	- 0.5306017	- 0.52385414
1173	- 0.5293748	- 0.52293402
1176	- 0.5284547	- -0.5220139
1179	- 0.5275346	- 0.52109378
1308	- 0.4845957	- 0.47815489
1311	- 0.4833689	- 0.47723477
1314	- 0.4824488	- 0.47631465
1317	- 0.4815287	- 0.47508783

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1383	-0.4597525	- 0.45361838
1386	-0.4591391	0.45331168
1389	-0.458219	- 0.45116473
1392	-0.4566854	- 0.45361838
1395	-0.4554586	-0.4496312
1398	-0.4545385	- 0.44901779
1401	-0.4536184	- 0.44809767
1404	-0.4523916	- 0.44625743
1407	-0.4514714	- 0.44533731
1410	-0.4505513	- 0.44441719
1413	-0.4496312	- 0.44319037

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1605	-0.386143	- 0.3797022
1608	- 0.3852229	- -0.378782
1611	- 0.3843028	- 0.3775552
1614	- 0.3830759	- 0.3766351
1617	- 0.3821558	- -0.375715
1620	- 0.3812357	- 0.3747949
1623	- 0.3803156	- -0.373568
1626	- 0.3793954	- 0.3726479
1629	- 0.3781686	- 0.3717278
1632	- 0.3772485	- 0.3708077
1635	- 0.3763284	- 0.3695809

1320	- 0.4806085	- 0.47416771
1323	- 0.4796884	- 0.47324759
1326	- 0.4784616	- 0.47232747
1329	- 0.4775415	- 0.47140735
1332	- 0.4766214	- 0.47018053
1335	- 0.4757012	- 0.46926041
1338	- 0.4744744	- 0.46834029
1341	- 0.4735543	- 0.46742017
1344	- 0.4726342	- 0.46619334
1347	- 0.4714074	- 0.46527322
1350	- 0.4704872	- 0.46435311
1353	- 0.4695671	- 0.46312628
1356	-0.468647	- 0.46220616
1359	- 0.4677269	- 0.46128604
1362	-0.4665	- 0.46036592
1365	- 0.4655799	-0.4591391
1368	- 0.4646598	- 0.45821898
1371	- 0.4637397	- 0.45729886
1374	- 0.4625129	- 0.45637874
1377	- 0.4631263	- 0.45515192
1380	- 0.4628196	-0.4542318

1416	-0.4487111	- 0.44227025
1419	-0.4474843	- 0.44104342
1422	-0.4465641	-0.4401233
1425	-0.445644	- 0.43920319
1428	-0.4447239	- 0.43828307
1431	-0.4434971	- 0.43736295
1560	-0.4008649	- 0.39442406
1563	-0.3999448	- 0.39350394
1566	-0.3990247	- 0.39258382
1569	-0.3977978	-0.391357
1572	-0.3968777	- 0.39074358
1575	-0.3959576	- 0.38951676
1578	-0.3950375	- 0.38859664
1581	-0.3941174	- 0.38767652
1584	-0.3931972	- 0.38644969
1587	-0.3919704	- 0.38552958
1590	-0.3910503	- 0.38460946
1593	-0.3901302	- 0.38338263
1596	-0.3892101	- 0.38246251
1599	-0.3879832	- 0.38154239
1602	-0.3870631	- 0.38062227

1638	- 0.3754083	- 0.3686607
1641	- 0.3744881	- 0.3677406
1644	-0.373568	- 0.3668205
1647	- 0.3723412	- 0.3655937
1650	- 0.3714211	- 0.3646735
1653	-0.370501	- 0.3637534
1656	- 0.3695808	- 0.3628333
1659	- 0.3686607	- 0.3616065
1662	- 0.3674339	- 0.3606864
1665	- 0.3665138	- 0.3597662
1668	- 0.3655937	- 0.3588461
1671	- 0.3646735	- 0.3576193
1674	- 0.3637534	- 0.3566992
1677	- 0.3625266	- 0.3557791
1680	- 0.3616065	- 0.3548589
1683	- 0.3606864	- 0.3536321
1812	- 0.3186676	- 0.3109999
1815	- 0.3177475	- 0.3100798
1818	- 0.3165206	-0.308853
1821	- 0.3156005	- 0.3079329
1824	- 0.3146804	- 0.3070128

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1827	- 0.3137603	- 0.30609263
1830	- 0.3128402	- 0.30486581
1833	- 0.3116133	- 0.30394569
1836	- 0.3109999	- 0.30302557
1839	- 0.3097731	- 0.30210545
1842	-0.308853	- 0.30118533
1845	-0.308853	- 0.29995851
1848	- 0.3079329	- 0.29903839
1851	- 0.3070128	- 0.29811827
1854	- 0.3060926	- 0.29719815

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
1923	-0.2833964	- 0.27450188
1926	-0.2824762	- 0.27358176
1929	-0.2815561	- 0.27266164
1932	-0.280636	- 0.27174152
1935	-0.2797159	-0.2708214
1938	-0.2787958	- 0.26990129
1941	-0.2775689	- 0.26898117
1944	-0.2766488	- 0.26806105
1947	-0.2757287	- 0.26683422
1950	-0.2748086	-0.2659141

Elapsed Time (s)	CPM Potential (V)	SAPM Potential (V)
2019	- 0.2521123	- 0.2456715
2022	- 0.2511922	- 0.2444447
2025	- 0.2499654	- 0.2438313
2028	- 0.2490453	- 0.2429111
2031	- 0.2481251	- 0.2416843
2034	- 0.2468983	- 0.2410709
2037	- 0.2462849	- 0.2401508
2040	- 0.2450581	- 0.2392307
2043	-0.244138	- 0.2383105
2046	- 0.2432178	- 0.2373904

1857	- 0.3048658	- 0.29597132	1953	-0.2738885	- 0.26499398	2049	-0.241991	- 0.2364703
1860	- 0.3039457	- 0.29505121	1956	-0.2726616	- 0.26407387	2052	- 0.2410709	- 0.2355502
1863	- 0.3030256	- 0.29413109	1959	-0.2717415	- 0.26315375	2055	- 0.2401508	- 0.2349368
1866	- 0.3021055	- 0.29321097	1962	-0.2708214	- 0.26223363	2058	- 0.2389239	- 0.2340166
1869	- 0.3011853	- 0.29198414	1965	-0.2699013	- 0.26131351	2061	- 0.2383105	- 0.2330965
1872	- 0.3002652	- 0.29106402	1968	-0.2689812	- 0.26039339	2064	- 0.2370837	- 0.2321764
1875	- 0.2990384	-0.2901439	1971	-0.2677543	- 0.25947327	2067	- 0.2361636	- 0.2312563
1878	- 0.2981183	- 0.28922379	1974	-0.2668342	- 0.25824644	2070	- 0.2352435	- 0.2303362
1881	- 0.2971981	- 0.28830367	1977	-0.2659141	- 0.25732633	2073	- 0.2340166	- 0.2294161
1884	-0.296278	- 0.28707684	1980	-0.264994	- 0.25640621	2076	- 0.2330965	- 0.2284959
1887	- 0.2953579	- 0.28615672	1983	-0.2640739	- 0.25548609	2079	- 0.2321764	- 0.2275758
1890	- 0.2941311	-0.2852366	1986	-0.262847	- 0.25456597	2082	- 0.2312563	- 0.2266557
1893	-0.293211	- 0.28431648	1989	-0.2619269	- 0.25456597	2085	- 0.2300295	- 0.2257356
1896	- 0.2922908	- 0.28339636	1992	-0.2610068	- 0.25364585	2088	- 0.2291093	- 0.2248155
1899	- 0.2913707	- 0.28216954	1995	-0.2600867	- 0.25272573	2091	- 0.2281892	- 0.2238953
1902	- 0.2904506	- 0.28124942	1998	-0.2588599	- 0.25180561	2094	- 0.2269624	- 0.2229752
1905	- 0.2895305	-0.2803293	2001	-0.2579397	- 0.25088549	2097	- 0.2260423	- 0.2223618
1908	- 0.2883037	- 0.27940918	2004	-0.2570196	- 0.24996537	2100	- 0.2248155	- 0.2214417
1911	- 0.2873835	- 0.27848906	2007	-0.2560995	- 0.24904525	2103	- 0.2238953	- 0.2205216

Table B.8: Open Circuit Potential (OCP) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1M NaCl Environment

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)	Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)	Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
1	- 0.4821421	- 0.48275549	33	- 0.48183537	- 0.48091525	65	-0.481222	- 0.4793817
2	- 0.4821421	- 0.48244878	34	- 0.48183537	- 0.48091525	66	-0.481222	- 0.4793817
3	- 0.4821421	- 0.48244878	35	- 0.48183537	- 0.48091525	67	-0.481222	-0.479075
4	- 0.4821421	- 0.48244878	36	- 0.48183537	- 0.48091525	68	-0.481222	-0.479075
5	- 0.4821421	- 0.48244878	37	- 0.48183537	- 0.48060854	69	-0.481222	-0.479075
6	- 0.4821421	- 0.48244878	38	- 0.48183537	- 0.48060854	70	- 0.4809153	-0.479075
7	- 0.4821421	- 0.48244878	39	- 0.48183537	- 0.48060854	71	-0.481222	-0.479075
8	- 0.4821421	- 0.48214207	40	- 0.48183537	- 0.48060854	72	-0.481222	-0.479075
9	- 0.4821421	- 0.48214207	41	- 0.48183537	- 0.48060854	73	- 0.4809153	-0.479075
10	- 0.4821421	- 0.48214207	42	- 0.48183537	- 0.48030183	74	- 0.4809153	-0.479075

11	- 0.4821421	- 0.48214207
12	- 0.4821421	- 0.48214207
13	- 0.4821421	- 0.48214207
14	- 0.4821421	- 0.48183537
15	- 0.4821421	- 0.48183537
16	- 0.4821421	- 0.48183537
17	- 0.4821421	- 0.48183537
18	- 0.4821421	- 0.48183537
19	- 0.4821421	- 0.48152866
20	- 0.4821421	- 0.48152866
21	- 0.4821421	- 0.48152866
22	- 0.4821421	- 0.48152866
23	- 0.4821421	- 0.48152866
24	- 0.4821421	- 0.48152866
25	- 0.4821421	- 0.48152866
26	- 0.4821421	- 0.48122195
27	- 0.4821421	- 0.48122195
28	- 0.4821421	- 0.48122195
29	- 0.4821421	- 0.48122195
30	- 0.4818354	- 0.48122195

43	- 0.48183537	- 0.48030183
44	- 0.48183537	- 0.48030183
45	- 0.48183537	- 0.48030183
46	- 0.48183537	- 0.48030183
47	- 0.48183537	- 0.47999513
48	- 0.48152866	- 0.47999513
49	- 0.48152866	- 0.47999513
50	- 0.48152866	- 0.47999513
51	- 0.48152866	- 0.47999513
52	- 0.48152866	- 0.47999513
53	- 0.48152866	- 0.47999513
54	- 0.48152866	- 0.47999513
55	- 0.48152866	- 0.47999513
56	- 0.48152866	- 0.47968842
57	- 0.48152866	- 0.47968842
58	- 0.48122195	- 0.47968842
59	- 0.48122195	- 0.47968842
60	- 0.48122195	- 0.47938172
61	- 0.48122195	- 0.47968842
62	- 0.48122195	- 0.47938172

75	- 0.4809153	-0.479075
76	- 0.4809153	- 0.4787683
77	- 0.4809153	- 0.4787683
78	- 0.4809153	- 0.4787683
120	- 0.4796884	- 0.4772348
121	- 0.4796884	- 0.4772348
122	- 0.4796884	- 0.4772348
123	- 0.4796884	- 0.4772348
124	- 0.4796884	- 0.4772348
125	- 0.4796884	- 0.4772348
126	- 0.4793817	- 0.4772348
127	- 0.4793817	- 0.4769281
128	- 0.4793817	- 0.4772348
129	- 0.4793817	- 0.4769281
130	- 0.4793817	- 0.4769281
131	- 0.4793817	- 0.4769281
132	- 0.4793817	- 0.4769281
133	- 0.4793817	- 0.4769281
134	-0.479075	- 0.4769281
135	-0.479075	- 0.4769281

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
138	-0.479075	- 0.47692807
139	-0.479075	- 0.47662136
140	-0.479075	- 0.47662136
141	-0.479075	- 0.47662136
142	-0.479075	- 0.47662136
143	-0.479075	- 0.47662136
144	-0.479075	- 0.47662136
145	-0.479075	- 0.47662136
146	-0.479075	- 0.47662136
147	-0.479075	- 0.47631465
148	- 0.4787683	- 0.47631465

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
211	- 0.47692807	- 0.47478112
212	- 0.47692807	- 0.47478112
213	- 0.47692807	- 0.47478112
214	- 0.47692807	- 0.47478112
215	- 0.47692807	- 0.47478112
216	- 0.47692807	- 0.47478112
217	- 0.47692807	- 0.47478112
218	- 0.47692807	- 0.47478112
219	- 0.47692807	- 0.47478112
220	- 0.47692807	- 0.47478112
221	- 0.47692807	- 0.47478112

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
284	- 0.4750878	- 0.4735543
285	- 0.4750878	- 0.4735543
286	- 0.4750878	- 0.4735543
287	- 0.4750878	- 0.4732476
288	- 0.4750878	- 0.4735543
289	- 0.4750878	- 0.4735543
290	- 0.4750878	- 0.4732476
291	- 0.4747811	- 0.4735543
292	- 0.4747811	- 0.4732476
293	- 0.4747811	- 0.4735543
294	- 0.4747811	- 0.4732476

149	-	-
	0.4787683	0.47631465
150	-	-
	0.4787683	0.47631465
151	-	-
	0.4787683	0.47631465
152	-	-
	0.4787683	0.47631465
153	-	-
	0.4787683	0.47631465
154	-	-
	0.4787683	0.47631465
155	-	-
	0.4787683	0.47631465
156	-	-
	0.4787683	0.47631465
157	-	-
	0.4787683	0.47631465
158	-	-
	0.4787683	0.47600795
159	-	-
	0.4784616	0.47600795
160	-	-
	0.4784616	0.47600795
202	-	-
	0.4772348	0.47508783
203	-	-
	0.4772348	0.47508783
204	-	-
	0.4772348	0.47508783
205	-	-
	0.4772348	0.47508783
206	-	-
	0.4772348	0.47508783
207	-	-
	0.4772348	0.47478112
208	-	-
	0.4772348	0.47508783
209	-	-
	0.4772348	0.47478112
210	-	-
	0.4772348	0.47478112

222	-	-
	0.47692807	0.47478112
223	-	-
	0.47662136	0.47478112
224	-	-
	0.47662136	0.47447441
225	-	-
	0.47662136	0.47478112
226	-	-
	0.47662136	0.47447441
227	-	-
	0.47662136	0.47447441
228	-	-
	0.47662136	0.47447441
229	-	-
	0.47662136	0.47447441
230	-	-
	0.47662136	0.47447441
231	-	-
	0.47662136	0.47447441
232	-	-
	0.47662136	0.47447441
233	-	-
	0.47662136	0.47447441
234	-	-
	0.47631465	0.47447441
235	-	-
	0.47662136	0.47447441
236	-	-
	0.47631465	0.47447441
237	-	-
	0.47631465	0.47447441
238	-	-
	0.47631465	0.47416771
239	-	-
	0.47631465	0.47447441
240	-	-
	0.47631465	0.47416771
241	-	-
	0.47631465	0.47416771
242	-	-
	0.47631465	0.47416771

295	-	-
	0.4747811	0.4732476
296	-	-
	0.4747811	0.4732476
297	-	-
	0.4747811	0.4732476
298	-	-
	0.4747811	0.4732476
299	-	-
	0.4747811	0.4732476
300	-	-
	0.4747811	0.4732476
301	-	-
	0.4747811	0.4732476
302	-	-
	0.4747811	0.4732476
303	-	-
	0.4747811	0.4732476
304	-	-
	0.4747811	0.4732476
305	-	-
	0.4744744	0.4732476
306	-	-
	0.4744744	0.4732476
307	-	-
	0.4744744	0.4729409
308	-	-
	0.4744744	0.4729409
309	-	-
	0.4744744	0.4729409
310	-	-
	0.4744744	0.4729409
311	-	-
	0.4744744	0.4729409
312	-	-
	0.4744744	0.4729409
313	-	-
	0.4744744	0.4729409
314	-	-
	0.4744744	0.4729409
315	-	-
	0.4744744	0.4729409

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
316	-	-
	0.4744744	0.47294088
317	-	-
	0.4744744	0.47294088
318	-	-
	0.4741677	0.47294088
319	-	-
	0.4744744	0.47294088
320	-	-
	0.4741677	0.47294088
321	-	-
	0.4741677	0.47294088
322	-	-
	0.4741677	0.47294088
323	-	-
	0.4741677	0.47294088
324	-	-
	0.4741677	0.47294088
366	-	-
	0.4732476	0.47232747
367	-	-
	0.4732476	0.47232747

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
389	-	-
	0.47294088	0.47202076
390	-	-
	0.47294088	0.47202076
391	-	-
	0.47294088	0.47202076
392	-	-
	0.47294088	0.47202076
393	-	-
	0.47294088	0.47202076
394	-	-
	0.47294088	0.47202076
395	-	-
	0.47294088	0.47202076
396	-	-
	0.47294088	0.47202076
397	-	-
	0.47294088	0.47171406
398	-	-
	0.47294088	0.47171406
399	-	-
	0.47294088	0.47202076

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
462	-	-
	0.4717141	0.4711006
463	-	-
	0.4717141	0.4714074
464	-	-
	0.4720208	0.4714074
465	-	-
	0.4717141	0.4714074
466	-	-
	0.4717141	0.4711006
467	-	-
	0.4717141	0.4714074
468	-	-
	0.4717141	0.4711006
469	-	-
	0.4717141	0.4711006
470	-	-
	0.4717141	0.4711006
471	-	-
	0.4717141	0.4711006
472	-	-
	0.4717141	0.4711006

368	- 0.4732476	- 0.47232747
369	- 0.4732476	- 0.47232747
370	- 0.4732476	- 0.47232747
371	- 0.4732476	- 0.47232747
372	- 0.4732476	- 0.47232747
373	- 0.4732476	- 0.47232747
374	- 0.4732476	- 0.47232747
375	- 0.4732476	- 0.47202076
376	- 0.4732476	- 0.47232747
377	- 0.4729409	- 0.47202076
378	- 0.4732476	- 0.47202076
379	- 0.4732476	- 0.47232747
380	- 0.4729409	- 0.47202076
381	- 0.4732476	- 0.47202076
382	- 0.4729409	- 0.47202076
383	- 0.4729409	- 0.47202076
384	- 0.4729409	- 0.47202076
385	- 0.4729409	- 0.47202076
386	- 0.4729409	- 0.47202076
387	- 0.4729409	- 0.47202076
388	- 0.4729409	- 0.47202076

400	- 0.47263418	- 0.47171406
401	- 0.47263418	- 0.47171406
402	- 0.47294088	- 0.47171406
403	- 0.47263418	- 0.47171406
404	- 0.47263418	- 0.47171406
405	- 0.47263418	- 0.47171406
406	- 0.47263418	- 0.47171406
448	- 0.47202076	- 0.47140735
449	- 0.47202076	- 0.47140735
450	- 0.47202076	- 0.47140735
451	- 0.47202076	- 0.47140735
452	- 0.47202076	- 0.47140735
453	- 0.47202076	- 0.47110064
454	- 0.47202076	- 0.47140735
455	- 0.47202076	- 0.47140735
456	- 0.47202076	- 0.47140735
457	- 0.47202076	- 0.47110064
458	- 0.47202076	- 0.47140735
459	- 0.47202076	- 0.47140735
460	- 0.47202076	- 0.47110064
461	- 0.47202076	- 0.47140735

473	- 0.4717141	- 0.4711006
474	- 0.4717141	- 0.4711006
475	- 0.4717141	- 0.4711006
476	- 0.4717141	- 0.4711006
477	- 0.4717141	- 0.4711006
478	- 0.4717141	- 0.4711006
479	- 0.4717141	- 0.4711006
480	- 0.4717141	- 0.4711006
481	- 0.4717141	- 0.4711006
482	- 0.4717141	- 0.4711006
483	- 0.4717141	- 0.4711006
484	- 0.4714074	- 0.4711006
485	- 0.4717141	- 0.4711006
486	- 0.4714074	- 0.4711006
487	- 0.4714074	- 0.4711006
488	- 0.4717141	- 0.4711006
530	- 0.4711006	- 0.4707939
531	- 0.4711006	- 0.4707939
532	- 0.4711006	- 0.4707939
533	- 0.4711006	- 0.4707939
534	- 0.4711006	- 0.4704872

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
535	- 0.4711006	- 0.47079394
536	- 0.4711006	- 0.47048723
537	- 0.4711006	- 0.47048723
538	- 0.4711006	- 0.47048723
539	- 0.4711006	- 0.47079394
540	- 0.4711006	- 0.47079394
541	- 0.4711006	- 0.47048723
542	- 0.4711006	- 0.47048723
543	- 0.4707939	- 0.47079394
544	- 0.4711006	- 0.47048723
545	- 0.4711006	- 0.47048723

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
567	- 0.47079394	- 0.47048723
568	- 0.47079394	- 0.47048723
569	- 0.47079394	- 0.47048723
570	- 0.47079394	- 0.47048723
612	-0.7158523	- 0.71922607
613	- 0.71493219	- 0.71861266
614	- 0.71401207	- 0.71830595
615	- 0.71309195	- 0.71769254
616	- 0.71217183	- 0.71738584
617	- 0.71125171	- 0.71677242
618	- 0.71033159	- 0.71646572

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
640	- 0.6891689	- 0.7066511
641	- 0.6882487	- 0.7060377
642	- 0.6873286	- 0.7054243
643	- 0.6864085	- 0.7051176
644	- 0.6854884	- 0.7048109
645	- 0.6842616	- 0.7041975
646	- 0.6833414	- 0.7038908
647	-0.682728	- 0.7032773
648	- 0.6815012	- 0.7026639
649	- 0.6805811	- 0.7023572
650	-0.679661	- 0.7017438

546	- 0.4711006	- 0.47048723
547	- 0.4711006	- 0.47048723
548	- 0.4711006	- 0.47048723
549	- 0.4711006	- 0.47048723
550	- 0.4707939	- 0.47048723
551	- 0.4707939	- 0.47048723
552	- 0.4707939	- 0.47048723
553	- 0.4707939	- 0.47048723
554	- 0.4707939	- 0.47048723
555	- 0.4707939	- 0.47048723
556	- 0.4707939	- 0.47048723
557	- 0.4707939	- 0.47048723
558	- 0.4707939	- 0.47048723
559	- 0.4707939	- 0.47048723
560	- 0.4707939	- 0.47048723
561	- 0.4707939	- 0.47048723
562	- 0.4707939	- 0.47048723
563	- 0.4707939	- 0.47048723
564	- 0.4707939	- 0.47048723
565	- 0.4707939	- 0.47048723
566	- 0.4707939	- 0.47048723

619	- 0.70941147	-0.7158523
620	- 0.70849135	-0.7155456
621	- 0.70757123	- 0.71523889
622	- 0.70634441	- 0.71462548
623	- 0.70542429	- 0.71431877
624	- 0.70450417	- 0.71370536
625	- 0.70358405	- 0.71339865
626	- 0.70266393	- 0.71278524
627	- 0.70174381	- 0.71247853
628	- 0.70082369	- 0.71217183
629	- 0.69990357	- 0.71155842
630	- 0.69898346	-0.710945
631	- 0.69806334	-0.7106383
632	- 0.69683651	- 0.71002488
633	- 0.69591639	- 0.70971818
634	- 0.69499627	- 0.70910476
635	- 0.69407615	- 0.70879806
636	- 0.69284933	- 0.70818465
637	- 0.69223592	- 0.70787794
638	- -0.6913158	- 0.70726453
639	- 0.69008897	- 0.70695782

651	- 0.6787408	- 0.7014371
652	- -0.677514	- 0.7008237
694	- 0.6373355	- 0.6811945
695	- 0.6364154	- 0.6808878
696	- 0.6354952	- 0.6802744
697	- 0.6345751	- 0.6799677
698	- -0.633655	- 0.6793543
699	- 0.6327349	- 0.6790475
700	- 0.6315081	- 0.6784341
701	- 0.6305879	- 0.6781274
702	- 0.6296678	- -0.677514
703	- 0.6287477	- 0.6772073
704	- 0.6275209	- 0.6765939
705	- 0.6266008	- 0.6762872
706	- 0.6256806	- 0.6756738
707	- 0.6247605	- 0.6753671
708	- 0.6238404	- 0.6747537
709	- 0.6226136	- -0.674447
710	- 0.6216935	- 0.6738335
711	- 0.6207733	- 0.6732201
712	- 0.6198532	- 0.6729134

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
713	- 0.6186264	-0.6723
714	- 0.6177063	-0.6719933
715	- 0.6167862	- 0.67137988
716	- -0.615866	- 0.67107318
717	- 0.6146392	- 0.67045977
718	- 0.6137191	- 0.67015306
719	- -0.612799	- 0.66953965
720	- 0.6118789	- 0.66892623
721	- -0.610652	- 0.66861953
722	- 0.6100386	- 0.66800612
723	- 0.6091185	- 0.66769941

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
786	-0.5465504	-0.6382556
787	- 0.54563029	- 0.63794889
788	- 0.54440346	- 0.63733548
789	- 0.54348334	- 0.63672207
790	- 0.54256322	- 0.63641536
791	- -0.5413364	- 0.63580195
792	- 0.54041628	- 0.63518854
793	- 0.53949616	- 0.63488183
794	- 0.53857604	- 0.63426842
795	- 0.53765592	- 0.63396171
796	- -0.5364291	- -0.6333483

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
859	-0.473861	-0.602371
860	- 0.4726342	- 0.6020643
861	- 0.4717141	- 0.6014508
862	- 0.4707939	- 0.6011441
863	- 0.4695671	- 0.6005307
864	- -0.468647	- 0.5999173
865	- 0.4677269	- 0.5996106
866	- 0.4668068	- 0.5989972
867	- 0.4658866	- 0.5986905
868	- 0.4646598	- 0.5980771
869	- 0.4637397	- 0.5974637

724	- 0.6078917	-0.667086
725	- 0.6069716	-0.66677929
726	- 0.6060514	-0.66616588
727	- 0.6051313	-0.66585917
728	- 0.6039045	-0.66524576
729	- 0.6029844	-0.66493905
730	- 0.6020643	-0.66432564
731	- 0.6011441	-0.66401893
732	- 0.5999173	-0.66340552
733	- 0.5989972	-0.66279211
734	- 0.5980771	-0.6624854
776	-0.556365	-0.6431629
777	- 0.5554449	-0.64254949
778	- 0.5545248	-0.64224278
779	- 0.5536047	-0.64162937
780	- 0.5523778	-0.64132266
781	- 0.5514577	-0.64070925
782	- 0.5505376	-0.64009584
783	- 0.5493108	-0.63978913
784	- 0.5483906	-0.63917572
785	- 0.5474705	-0.63886901

797	- 0.53550898	-0.63304159
798	- 0.53458886	-0.63242818
799	- 0.53366874	-0.63212147
800	- 0.53274862	-0.63150806
801	- 0.53152179	-0.63089465
802	- 0.53060167	-0.63058794
803	- 0.52968156	-0.62997453
804	- 0.52845473	-0.62966782
805	- 0.52753461	-0.62905441
806	- 0.52661449	-0.628441
807	- 0.52569437	-0.62813429
808	- 0.52446755	-0.62752088
809	- 0.52354743	-0.62721417
810	- 0.52262731	-0.62660076
811	- 0.52170719	-0.62629405
812	- 0.52048037	-0.62568064
813	- 0.51956025	-0.62506723
814	- 0.51864013	-0.62476052
815	- 0.51772001	-0.62414711
816	- 0.51679989	-0.6235337
858	- 0.47478112	-0.60298437

870	- 0.4628196	-0.597157
871	- 0.4618995	-0.5965435
872	- 0.4606726	-0.5962368
873	- 0.4597525	-0.5956234
874	- 0.4588324	-0.59501
875	- 0.4579123	-0.5947033
876	- 0.4566855	-0.5940899
877	- 0.4557653	-0.5934765
878	- 0.4548452	-0.5931698
879	- 0.4539251	-0.5925564
880	- 0.4526983	-0.5922497
881	- 0.4517782	-0.5916362
882	-0.450858	-0.5910228
883	- 0.4496312	-0.5907161
884	- 0.4487111	-0.5901027
885	-0.447791	-0.589796
886	- 0.4468708	-0.5891826
887	-0.445644	-0.5888759
888	- 0.4447239	-0.5882625
889	- 0.4438038	-0.5876491
890	- 0.4428837	-0.5873424

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
891	- 0.4416568	-0.58672893
892	- 0.4407367	-0.58642223
893	- 0.4398166	-0.58580882
894	- 0.4388965	-0.5851954
895	- 0.4376697	-0.5848887
896	- 0.4367495	-0.58427528
897	- 0.4358294	-0.58366187
898	- 0.4346026	-0.58335517
940	- 0.3931972	-0.56249913
941	- 0.3922771	-0.56188572
942	-0.391357	-0.56157902

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
964	- 0.36988755	-0.55084429
965	- 0.36866073	-0.55023088
966	- 0.36774061	-0.54961747
967	- 0.36682049	-0.54900406
968	- 0.36590037	-0.54869735
969	- 0.36498025	-0.54808394
970	- 0.36375343	-0.54747052
971	- 0.36283331	-0.54716382
972	- 0.36191319	-0.5465504
973	- 0.36099307	-0.5462437
974	- 0.36007295	-0.54563029

Elapsed Time (s)	CHAZ Potential (V)	SAHAZ Potential (V)
1070	- 0.2646873	-0.4977841
1071	- 0.2637672	-0.4971707
1072	-0.262847	-0.496864
1073	- 0.2616202	-0.4962506
1074	- 0.2607001	-0.4959439
1075	-0.25978	-0.4953305
1076	- 0.2588599	-0.494717
1077	- 0.2579397	-0.4944103
1078	- 0.2570196	-0.4937969
1079	- 0.2557928	-0.4934902
1080	- 0.2548727	-0.4928768

943	-	-0.5609656	975	-	-	1081	-	-
	0.3904369			0.35884612	0.54532358		0.2539526	0.4922634
944	-	-0.5606589	976	-	-	1082	-	-
	0.3895168			0.35792601	0.54471017		0.2530324	0.4919567
945	-	-	977	-	-	1083	-	-
	0.3882899	0.56004548		0.35700589	0.54440346		0.2521123	0.4913433
946	-	-	978	-	-	1084	-	-
	0.3873698	0.55943207		0.35608577	0.54379005		0.2521123	0.4910366
947	-	-	979	-	-	1085	-	-
	0.3864497	0.55912536		0.35485894	0.54317663		0.2511922	0.4904231
948	-	-	980	-	-	1086	-	-
	0.3855296	0.55851195		0.35393882	0.54256322		0.2502721	0.4898097
949	-	-	1022	-	-	1087	-0.249352	-0.489503
	0.3846095	0.55789854		0.31222676	0.52170719		-	-
950	-	-	1023	-	-	1088	-	-
	0.3833826	0.55759183		0.31130664	0.52140048		0.2481251	0.4888896
951	-	-	1024	-	-	1089	-0.247205	-
	0.3824625	0.55697842		0.31038652	0.52078707		-	0.4882762
952	-	-	1025	-0.3091597	-	1090	-	-
	0.3815424	0.55636501		-	0.52017366		0.2462849	0.4879695
953	-	-0.5560583	1026	-	-	1091	-	-
	0.3806223			0.30823958	0.51986695		0.2453648	0.4873561
954	-	-	1027	-	-	1092	-	-
	0.3797022	0.55544489		0.30731946	0.51925354		0.2444447	0.4870494
955	-	-	1028	-	-	1093	-	-0.486436
	0.3784753	0.55513818		0.30639934	0.51894683		0.2435245	
956	-	-	1029	-	-	1094	-	-
	0.3775552	0.55452477		0.30517251	0.51833342		0.2426044	0.4858226
957	-	-	1030	-0.3042524	-	1095	-	-
	0.3766351	0.55391136		-	0.51772001		0.2416843	0.4855158
958	-0.375715	-	1031	-	-0.5174133	1096	-	-
	-	0.55360465		0.30333228			0.2404575	0.4849024
959	-	-	1032	-	-	1097	-	-0.484289
	0.3747949	0.55299124		0.30241216	0.51679989		0.2395374	
960	-0.373568	-	1033	-	-	1098	-	-
	-	0.55268453		0.30118533	0.51618648		0.2386172	0.4839823
961	-	-	1034	-	-	1099	-	-
	0.3726479	0.55207112		0.30026521	0.51587977		0.2376971	0.4833689
962	-	-	1035	-	-	1100	-0.236777	-
	0.3717278	0.55176441		0.29934509	0.51526636		-	0.4827555
963	-	-0.551151	1036	-	-	1101	-	-
	0.3708077			0.29842498	0.51495965		0.2358569	0.4824488

Table B.9: Open Circuit Potential (OCP) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Welded Zone (WZ) of the Samples Immersed in 1M NaCl Environment

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)	Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)	Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1	-	-	33	-	-	65	-	-
	0.4818354	0.46465981		0.47754148	0.46343299		0.4747811	0.46159275
2	-	-	34	-	-	66	-	-
	0.4818354	0.46465981		0.47754148	0.46312628		0.4744744	0.46159275
3	-	-	35	-	-	67	-	-
	0.4815287	0.46465981		0.47754148	0.46343299		0.4744744	0.46128604
4	-	-	36	-	-	68	-	-
	0.4815287	0.46465981		0.47723477	0.46312628		0.4744744	0.46159275
5	-0.481222	-	37	-	-	69	-	-
	-	0.46465981		0.47723477	0.46312628		0.4741677	0.46159275
6	-0.481222	-	38	-	-	70	-	-
	-	0.46465981		0.47723477	0.46312628		0.4741677	0.46128604
7	-	-	39	-	-	71	-	-
	0.4809152	0.46435311		0.47692807	0.46312628		0.4741677	0.46128604
8	-	-	40	-	-	72	-	-
	0.4809152	0.46435311		0.47692807	0.46312628		0.4741677	0.46128604
9	-	-	41	-	-	73	-0.473861	-
	0.4806085	0.46435311		0.47692807	0.46312628		-	0.46128604
10	-	-	42	-	-	74	-0.473861	-
	0.4806085	0.46435311		0.47662136	0.46281957		-	0.46128604

11	-	-
	0.4803018	0.46435311
12	-	-
	0.4803018	0.46435311
13	-	-
	0.4799951	0.46435311
14	-	-
	0.4799951	-0.4640464
15	-	-
	0.4799951	-0.4640464
16	-	-
	0.4796884	-0.4640464
17	-	-
	0.4796884	-0.4640464
18	-	-
	0.4796884	-0.4640464
19	-	-
	0.4793817	-0.4640464
20	-	-
	0.4793817	0.46373969
21	-	-
	0.4793817	0.46373969
22	-	-
	-0.479075	0.46373969
23	-	-
	-0.479075	0.46373969
24	-	-
	0.4787683	0.46373969
25	-	-
	0.4787683	0.46373969
26	-	-
	0.4787683	0.46343299
27	-	-
	0.4784616	0.46343299
28	-	-
	0.4781549	0.46343299
29	-	-
	0.4781549	0.46343299
30	-	-
	0.4781549	0.46343299

43	-	-
	0.47662136	0.46281957
44	-	-
	0.47662136	0.46281957
45	-	-
	0.47631465	0.46281957
46	-	-
	0.47631465	0.46251287
47	-	-
	0.47631465	0.46251287
48	-	-
	0.47600795	0.46251287
49	-	-
	0.47600795	0.46251287
50	-	-
	0.47600795	0.46251287
51	-	-
	0.47600795	0.46220616
52	-	-
	0.47570124	0.46220616
53	-	-
	0.47570124	0.46220616
54	-	-
	0.47570124	0.46220616
55	-	-
	0.47539453	0.46220616
56	-	-
	0.47539453	0.46220616
57	-	-
	0.47539453	0.46189946
58	-	-
	0.47508783	0.46189946
59	-	-
	0.47508783	0.46189946
60	-	-
	0.47508783	0.46189946
61	-	-
	0.47478112	0.46189946
62	-	-
	0.47508783	0.46189946

75	-	-
	-0.473861	0.46128604
76	-	-
	0.4735543	0.46097934
77	-	-
	0.4735543	0.46097934
78	-	-
	0.4735543	0.46097934
79	-	-
	0.4735543	0.46097934
80	-	-
	0.4732476	0.46097934
81	-	-
	0.4732476	0.46097934
82	-	-
	0.4732476	0.46067263
83	-	-
	0.4729409	0.46067263
84	-	-
	0.4729409	0.46067263
85	-	-
	0.4729409	0.46036592
86	-	-
	0.4729409	0.46036592
87	-	-
	0.4729409	0.46036592
88	-	-
	0.4726342	0.46036592
89	-	-
	0.4726342	0.46036592
90	-	-
	0.4726342	0.46036592
91	-	-
	0.4723275	0.46036592
92	-	-
	0.4723275	0.46036592
93	-	-
	0.4723275	0.46005922
94	-	-
	0.4723275	0.46005922

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
97	-	-
	0.4720208	0.46005922
98	-	-
	0.4720208	0.46005922
99	-	-
	0.4717141	0.46005922
100	-	-
	0.4717141	0.46005922
101	-	-
	0.4717141	0.46005922
102	-	-
	0.4717141	0.45975251
103	-	-
	0.4714074	0.45975251
104	-	-
	0.4714074	0.45975251
105	-	-
	0.4714074	0.45975251
106	-	-
	0.4711006	0.45975251
107	-	-
	0.4711006	0.45975251

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
170	-	-
	0.46772688	0.46097934
171	-	-
	0.46772688	0.46128604
172	-	-
	0.46772688	0.46128604
173	-	-
	0.46772688	0.46128604
174	-	-
	0.46742017	0.46128604
175	-	-
	0.46742017	0.46128604
176	-	-
	0.46742017	0.46159275
177	-	-
	0.46742017	0.46159275
178	-	-
	0.46742017	0.46159275
179	-	-
	0.46742017	0.46159275
180	-	-
	0.46711346	0.46159275

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
243	-	-
	0.4661933	0.46435311
244	-	-
	0.4665001	0.46435311
245	-	-
	0.4661933	0.46435311
246	-	-
	0.4661933	0.46465981
247	-	-
	0.4661933	0.46435311
248	-	-
	0.4661933	0.46435311
249	-	-
	0.4661933	0.46435311
250	-	-
	0.4661933	0.46435311
251	-	-
	0.4661933	0.46435311
252	-	-
	0.4661933	0.46465981
253	-	-
	0.4661933	0.46435311

108	- 0.4711006	- 0.45975251
109	- 0.4711006	- 0.45975251
110	- 0.4707939	- 0.45975251
111	- 0.4707939	-0.4594458
112	- 0.4707939	-0.4594458
113	- 0.4707939	-0.4594458
114	- 0.4707939	-0.4594458
115	- 0.4704872	-0.4594458
116	- 0.4704872	-0.4594458
117	- 0.4704872	-0.4594458
118	- 0.4701805	-0.4594458
119	- 0.4701805	-0.4594458
161	- 0.4680336	- 0.46036592
162	- 0.4680336	- 0.46036592
163	- 0.4680336	- 0.46067263
164	- 0.4680336	- 0.46067263
165	- 0.4677269	- 0.46067263
166	- 0.4677269	- 0.46067263
167	- 0.4677269	- 0.46097934
168	- 0.4677269	- 0.46097934
169	- 0.4677269	- 0.46097934

181	- 0.46711346	- 0.46189946
182	- 0.46711346	- 0.46189946
183	- 0.46711346	- 0.46189946
184	- 0.46711346	- 0.46189946
185	- 0.46711346	- 0.46220616
186	- 0.46711346	- 0.46220616
187	- 0.46711346	- 0.46220616
188	- 0.46711346	- 0.46220616
189	- 0.46711346	- 0.46220616
190	- 0.46711346	- 0.46220616
191	- 0.46680676	- 0.46251287
192	- 0.46680676	- 0.46251287
193	- 0.46680676	- 0.46251287
194	- 0.46680676	- 0.46251287
195	- 0.46680676	- 0.46251287
196	- 0.46680676	- 0.46251287
197	- 0.46680676	- 0.46281957
198	- 0.46680676	- 0.46281957
199	- 0.46680676	- 0.46281957
200	- 0.46680676	- 0.46281957
201	- 0.46650005	- 0.46312628

254	- 0.4661933	- 0.46465981
255	- 0.4661933	- 0.46435311
256	- 0.4661933	- 0.46435311
257	- 0.4661933	- 0.46435311
258	- 0.4661933	- 0.46435311
259	- 0.4661933	- 0.46435311
260	- 0.4661933	- 0.46435311
261	- 0.4661933	- 0.46435311
262	- 0.4661933	- 0.46435311
263	- 0.4661933	- 0.46435311
264	- 0.4661933	- 0.46435311
265	- 0.4661933	- 0.46435311
266	- 0.4661933	- 0.46435311
267	- 0.4661933	- 0.46435311
268	- 0.4661933	- 0.46435311
269	- 0.4661933	- 0.46435311
270	- 0.4661933	- 0.46435311
271	- 0.4661933	- 0.46435311
272	- 0.4661933	-0.4640464
273	- 0.4661933	-0.4640464
274	- 0.4661933	-0.4640464

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
275	- 0.4661933	-0.4640464
276	- 0.4661933	-0.4640464
277	- 0.4661933	-0.4640464
278	- 0.4661933	-0.4640464
279	- 0.4661933	-0.4640464
280	- 0.4661933	-0.4640464
281	- 0.4661933	-0.4640464
282	- 0.4661933	-0.4640464
283	- 0.4661933	-0.4640464
325	- 0.4661933	- 0.46281957
326	- 0.4661933	- 0.46281957

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
348	- 0.46619334	- 0.46251287
349	- 0.46619334	- 0.46251287
350	- 0.46619334	- 0.46251287
351	- 0.46619334	- 0.46251287
352	- 0.46619334	- 0.46251287
353	- 0.46619334	- 0.46251287
354	- 0.46619334	- 0.46251287
355	- 0.46619334	- 0.46251287
356	- 0.46619334	- 0.46251287
357	- 0.46619334	- 0.46220616
358	- 0.46619334	- 0.46251287

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
421	- 0.4668068	- 0.46036592
422	- 0.4668068	- 0.46036592
423	- 0.4668068	- 0.46036592
424	- 0.4668068	- 0.46036592
425	- 0.4668068	- 0.46036592
426	- 0.4668068	- 0.46036592
427	- 0.4668068	- 0.46036592
428	- 0.4668068	- 0.46036592
429	- 0.4671135	- 0.46036592
430	- 0.4668068	- 0.46036592
431	- 0.4668068	- 0.46036592

327	-	-
	0.4661933	0.46281957
328	-	-
	0.4661933	0.46281957
329	-	-
	0.4661933	0.46281957
330	-	-
	0.4661933	0.46281957
331	-	-
	0.4661933	0.46281957
332	-	-
	0.4661933	0.46281957
333	-	-
	0.4661933	0.46281957
334	-	-
	0.4661933	0.46281957
335	-	-
	0.4661933	0.46251287
336	-	-
	0.4661933	0.46281957
337	-	-
	0.4658866	0.46251287
338	-	-
	0.4661933	0.46281957
339	-	-
	0.4661933	0.46281957
340	-	-
	0.4661933	0.46251287
341	-	-
	0.4661933	0.46281957
342	-	-
	0.4661933	0.46251287
343	-	-
	0.4661933	0.46251287
344	-	-
	0.4661933	0.46251287
345	-	-
	0.4661933	0.46251287
346	-	-
	0.4661933	0.46251287
347	-	-
	0.4661933	0.46251287

359	-	-
	0.46619334	0.46220616
360	-	-
	0.46619334	0.46251287
361	-	-
	0.46619334	0.46220616
362	-	-
	0.46619334	0.46220616
363	-	-
	0.46619334	0.46220616
364	-	-
	0.46619334	0.46220616
365	-	-
	0.46619334	0.46220616
407	-	-
	0.46650005	0.46067263
408	-	-
	0.46650005	0.46067263
409	-	-
	0.46680676	0.46067263
410	-	-
	0.46680676	0.46067263
411	-	-
	0.46680676	0.46067263
412	-	-
	0.46680676	0.46067263
413	-	-
	0.46680676	0.46067263
414	-	-
	0.46680676	0.46067263
415	-	-
	0.46680676	0.46036592
416	-	-
	0.46680676	0.46067263
417	-	-
	0.46680676	0.46036592
418	-	-
	0.46680676	0.46036592
419	-	-
	0.46680676	0.46036592
420	-	-
	0.46680676	0.46036592

432	-	-
	0.4668068	0.46036592
433	-	-
	0.4668068	0.46036592
434	-	-
	0.4668068	0.46036592
435	-	-
	0.4671135	0.46036592
436	-	-
	0.4668068	0.46036592
437	-	-
	0.4668068	0.46036592
438	-	-
	0.4668068	0.46005922
439	-	-
	0.4668068	0.46036592
440	-	-
	0.4668068	0.46036592
441	-	-
	0.4668068	0.46036592
442	-	-
	0.4668068	0.46036592
443	-	-
	0.4668068	0.46036592
444	-	-
	0.4671135	0.46036592
445	-	-
	0.4671135	0.46036592
446	-	-
	0.4668068	0.46005922
447	-	-
	0.4668068	0.46036592
489	-	-
	0.4671135	0.45975251
490	-	-
	0.4671135	0.45975251
491	-	-
	0.4671135	0.45975251
492	-	-
	0.4674202	0.45975251
493	-	-
	0.4674202	0.45975251

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
494	-	-
	0.4671135	0.45975251
495	-	-
	0.4674202	0.45975251
496	-	-
	0.4671135	0.45975251
497	-	-
	0.4671135	0.45975251
498	-	-
	0.4674202	0.45975251
499	-	-
	0.4674202	0.45975251
500	-	-
	0.4674202	0.45975251
501	-	-
	0.4671135	0.45975251
502	-	-
	0.4674202	0.45975251
503	-	-
	0.4674202	0.45975251
504	-	-
	0.4674202	0.45975251

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
571	-	-
	0.46772688	-0.4591391
572	-	-
	0.46772688	0.45883239
573	-	-
	0.46772688	0.45852569
574	-	-
	0.46772688	0.45852569
575	-	-
	0.46772688	0.45852569
576	-	-
	0.46772688	0.45852569
577	-	-
	0.46772688	0.45852569
578	-	-
	0.46772688	0.45852569
579	-	-
	0.46772688	0.45852569
580	-	-
	0.46772688	0.45852569
581	-	-
	0.46772688	0.45852569

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
621	-	-
	0.7222931	0.70849135
624	-	-
	-0.721373	0.70726453
627	-	-
	0.7204529	0.70634441
630	-	-
	0.7195328	0.70542429
633	-	-
	0.7186127	0.70450417
759	-	-
	0.6787408	-0.6624854
762	-	-
	0.6778207	0.66156528
765	-	-
	0.6765939	0.66033846
768	-	-
	0.6756738	0.65941834
771	-	-
	0.6747537	0.65849822
774	-	-
	0.6738335	0.65727139

505	- 0.4674202	-0.4594458
506	- 0.4674202	- 0.45975251
507	- 0.4674202	- 0.45975251
508	- 0.4674202	- 0.45975251
509	- 0.4674202	- 0.45975251
510	- 0.4674202	- 0.45975251
511	- 0.4674202	-0.4594458
512	- 0.4674202	- 0.45975251
513	- 0.4674202	- 0.45975251
514	- 0.4674202	-0.4594458
515	- 0.4674202	-0.4594458
516	- 0.4674202	- 0.45975251
517	- 0.4674202	- 0.45975251
518	- 0.4674202	- 0.45975251
519	- 0.4674202	- 0.45975251
520	- 0.4674202	-0.4594458
521	- 0.4674202	-0.4594458
522	- 0.4674202	-0.4594458
523	- 0.4674202	-0.4594458
524	- 0.4674202	-0.4594458

582	- 0.46772688	- 0.45883239
583	- 0.46772688	- 0.45852569
584	- 0.46772688	- 0.45883239
585	- 0.46772688	- 0.45883239
586	- 0.46772688	- 0.45883239
587	- 0.46772688	- 0.45883239
588	- 0.46803358	- 0.45883239
589	- 0.46772688	- 0.45883239
590	- 0.46772688	- 0.45883239
591	- 0.46803358	- 0.45883239
592	- 0.46772688	- 0.45883239
593	- 0.46803358	- 0.45883239
594	- 0.46803358	- 0.45883239
595	- 0.46803358	- 0.45883239
596	- 0.46803358	- 0.45883239
597	- 0.46803358	- 0.45883239
598	- 0.46803358	- 0.45883239
599	- 0.46772688	- 0.45883239
600	- 0.46803358	- 0.45883239
603	- 0.72812056	- 0.71431877

777	- 0.6729134	- 0.65635127
780	- 0.6716866	- 0.65543116
783	- 0.6707665	- 0.65451104
786	- 0.6698464	- 0.65359092
789	- 0.6689262	- 0.65236409
792	- 0.6680061	- 0.65144397
795	- 0.6667793	- 0.65052385
798	- 0.6658592	- 0.64960374
801	- 0.6649391	- 0.64837691
804	- 0.6640189	- 0.64745679
807	- 0.6630988	- 0.64653667
810	-0.661872	- 0.64530985
813	- 0.6609519	- 0.64438973
816	- 0.6600318	- 0.64346961
819	- 0.6588049	- 0.64254949
822	- 0.6581915	- 0.64162937
825	- 0.6569647	- 0.64040255
828	- 0.6560446	- 0.63948243
831	- 0.6551244	- 0.63856231
834	- 0.6542043	- 0.63733548

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
852	- 0.6480702	- 0.63150806
855	- 0.6471501	- 0.63058794
858	-0.64623	- 0.62936112
861	- 0.6453098	-0.628441
864	-0.644083	- 0.62752088
867	- 0.6431629	- 0.62660076
870	- 0.6422428	- 0.62537393
873	- 0.6413227	- 0.62445382
876	- 0.6404025	-0.6235337
879	- 0.6391757	- 0.62261358
1005	- 0.5974637	- 0.58059481

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1083	- 0.57170032	- 0.55452477
1086	-0.5704735	- 0.55360465
1089	- 0.56955338	- 0.55237783
1092	- 0.56863326	- 0.55145771
1095	- 0.56771314	- 0.55053759
1098	- 0.56648632	- 0.54961747
1101	-0.5655662	- 0.54869735
1104	- 0.56464608	- 0.54747052
1107	- 0.56341925	-0.5465504
1110	- 0.56280584	- 0.54563029
1113	- 0.56157902	- 0.54471017

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1314	-0.494717	- 0.47754148
1317	- 0.4937969	- 0.47662136
1320	- 0.4928768	- 0.47570124
1323	-0.49165	- 0.47478112
1326	- 0.4907299	-0.473861
1329	- 0.4898097	- 0.47263418
1332	- 0.4885829	- 0.47171406
1335	- 0.4879695	- 0.47079394
1338	- 0.4867427	- 0.46956711
1341	- 0.4858225	- 0.46864699
1344	- 0.4849024	- 0.46772688

1008	- 0.5965435	- 0.57936798
1011	- 0.5956234	- 0.57844786
1014	- 0.5943966	- 0.57752775
1017	- 0.5934765	- 0.57660763
1020	- 0.5925564	- -0.5753808
1023	- 0.5913295	- 0.57446068
1026	- 0.5904094	- 0.57354056
1029	- 0.5894893	- 0.57231374
1032	- 0.5885692	- 0.57170032
1035	- 0.5873423	- -0.5704735
1038	- 0.5864222	- 0.56955338
1041	- 0.5855021	- 0.56863326
1044	- -0.584582	- 0.56740644
1047	- 0.5833552	- 0.56648632
1050	- 0.5827418	- -0.5655662
1053	- 0.5815149	- 0.56464608
1056	- 0.5805948	- 0.56341925
1059	- 0.5796747	- 0.56249913
1062	- 0.5784479	- 0.56157902
1065	- 0.5775277	- -0.5606589
1068	- 0.5766076	- 0.55943207

1116	- -0.5606589	- 0.54348334
1119	- 0.55973878	- 0.54256322
1122	- 0.55851195	- -0.5416431
1125	- 0.55759183	- 0.54072298
1251	- 0.51587977	- 0.49870422
1254	- 0.51465295	- -0.4977841
1257	- 0.51373283	- 0.49655727
1260	- 0.51281271	- 0.49563715
1263	- 0.51189259	- 0.49471703
1266	- 0.51066576	- 0.49379691
1269	- 0.50974564	- 0.49257009
1272	- 0.50882553	- 0.49164997
1275	- -0.5075987	- 0.49072985
1278	- 0.50667858	- 0.48980973
1281	- 0.50575846	- 0.48858291
1284	- 0.50483834	- 0.48766279
1287	- 0.50391822	- 0.48674267
1290	- -0.5026914	- 0.48582255
1293	- 0.50177128	- 0.48490243
1296	- 0.50085116	- 0.48367561
1299	- 0.49962433	- 0.48275549

1347	- 0.4836756	- 0.46680676
1350	- 0.4827555	- 0.46557993
1353	- 0.4818354	- 0.46465981
1356	- 0.4809152	- 0.46373969
1359	- 0.4796884	- 0.46281957
1362	- 0.4787683	- 0.46159275
1365	- 0.4778482	- 0.46067263
1368	- 0.4766214	- 0.45975251
1371	- 0.4760079	- 0.45883239
1497	- 0.4339892	- 0.41681362
1500	- 0.4327624	- -0.4155868
1503	- 0.4318422	- 0.41466668
1506	- 0.4309221	- 0.41343985
1509	- 0.4296953	- 0.41251973
1512	- 0.4287752	- 0.41159962
1515	- 0.4278551	- -0.4106795
1518	- 0.4269349	- 0.40975938
1521	- 0.4257081	- 0.40883926
1524	- -0.424788	- 0.40761243
1527	- 0.4238679	- 0.40669231
1530	- 0.4229477	- 0.40577219

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1545	- 0.4180404	- 0.40086489
1548	- 0.4168136	- 0.39963807
1551	- 0.4158935	- 0.39871795
1554	- 0.4149734	- 0.39749112
1557	- 0.4137466	- -0.396571
1560	- 0.4128264	- 0.39565089
1563	- 0.4119063	- 0.39473077
1566	- 0.4109862	- 0.39381065
1569	- 0.4097594	- 0.39289053
1572	- 0.4088393	- -0.3916637
1575	- 0.4079191	- 0.39074358

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1764	- 0.34535105	- 0.32786878
1767	- 0.34412422	- 0.32664196
1770	- -0.3432041	- 0.32572184
1773	- 0.34228398	- 0.32480172
1776	- 0.34105716	- -0.3238816
1779	- 0.34013704	- 0.32265478
1782	- 0.33921692	- 0.32173466
1785	- -0.3382968	- 0.32081454
1788	- 0.33737668	- 0.31989442
1791	- 0.33614986	- 0.31866759
1794	- 0.33522974	- 0.31774748

Elapsed Time (s)	CWZ Potential (V)	SAWZ Potential (V)
1956	- 0.2821695	- 0.26376716
1959	- 0.2809427	- 0.26284704
2016	- 0.2625403	- 0.24383125
2019	- 0.2616202	- 0.24291113
2022	- 0.2607001	- -0.2416843
2025	- -0.25978	- 0.24076418
2028	- 0.2588599	- 0.23984406
2031	- 0.2579397	- 0.23892395
2034	- 0.2570196	- 0.23769712
2037	- 0.2560995	- -0.236777
2040	- 0.2548727	- 0.23585688

1578	-0.406999	-	0.38982347	1797	-	-	2043	-	-
1581	-	-	-	1800	0.33430962	0.31682736	2046	0.2539526	0.23493676
1584	0.4057722	0.38859664	-	1803	-0.3333895	0.31590724	2049	0.2530324	0.23401664
1587	-	-	-	1806	-	-	2052	-	-
1590	0.4048521	0.38767652	-	1809	0.33216267	0.31468041	2055	0.2521123	0.23278982
1593	-0.403932	-0.3867564	-	1812	0.33124255	0.31376029	2058	0.2521123	-0.2318697
1596	-	-	-	1815	-	-	2061	-	-
1599	0.4030118	0.38583628	-	1818	0.33032244	0.31284017	2064	0.2511922	0.23094958
1602	-0.401785	-	-	1821	0.32940232	0.31192005	2067	0.2502721	0.22972276
1605	-	0.38491616	-	1824	-	-	2070	-0.249352	0.22880264
1608	0.4008649	0.38368934	-	1827	0.32817549	0.31069323	2073	-	-
1611	-	-	-	1830	-	-	2076	0.2456715	0.22481545
1614	0.3999448	0.38276922	-	1833	0.32725537	0.30977311	2079	0.2447514	0.22389534
1617	-	-	-	1836	0.32633525	0.30885299	2082	-	-
1743	0.3990247	0.38154239	-	1839	0.32541513	0.30793287	2085	0.2429111	0.22174839
1746	-	-	-	1842	0.32449501	0.30670605	2088	0.2416843	0.22082827
1749	0.3981045	0.38062227	-	1845	-	-	2091	-	-
1752	-	-	-	1848	0.32326819	0.30578593	2094	0.2398441	0.21898803
1755	0.3968777	0.37970216	-	1851	0.32234807	0.30486581	2097	-	-
1758	-	-	-	1854	-	-	2100	0.2389239	0.21776121
1761	0.3959576	0.37878204	-	1857	0.32142795	0.30363898	2103	0.2383105	0.21684109
	-	-	-		0.32020113	0.30271886		0.2370837	0.21592097
	0.3511785	-0.3336962	-		0.31928101	0.30179875		-	-
	-	-	-		0.31836089	0.30087863		0.2364703	0.21500085
	0.3502583	0.33277609	-		0.31744077	-0.2996518			
	-	-	-		0.31621394	0.29873168			
	0.3490315	0.33185597	-		0.31529382	0.29781156			
	-	-	-		-	-			
	0.3481114	0.33062914	-		-	-			
	-	-	-		-	-			
	0.3471913	0.32970902	-		-	-			
	-	-	-		-	-			
	0.3462712	-0.3287889	-		-	-			

Table B.10: Electrochemical Current Noise (ECN) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Parent Metal (PM) of the Samples Immersed in 1M NaCl Environment

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)	Elapsed Time (s)	CPM Current (A)	SAPM Current (A)	Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.00E-01	3.19E-08	3.54E-08	3.30E+00	-4.90E-08	5.08E-08	1.49E+01	6.19E-08	5.51E-08
2.00E-01	1.43E-08	2.53E-08	3.40E+00	-3.16E-08	5.74E-08	1.50E+01	4.62E-08	4.43E-08
3.00E-01	-4.89E-09	1.56E-08	3.50E+00	-1.48E-08	6.17E-08	1.51E+01	2.85E-08	3.37E-08
4.00E-01	-1.98E-08	3.48E-09	3.60E+00	7.05E-10	6.30E-08	1.52E+01	1.08E-08	2.35E-08
5.00E-01	-3.31E-08	-5.34E-09	3.70E+00	1.31E-08	6.18E-08	1.53E+01	-8.50E-09	1.40E-08
6.00E-01	-4.70E-08	-1.44E-08	3.80E+00	2.04E-08	5.78E-08	1.54E+01	-1.98E-08	1.76E-09
7.00E-01	-6.01E-08	-1.98E-08	1.23E+01	2.04E-08	-4.66E-08	1.55E+01	-3.67E-08	-7.94E-09
8.00E-01	-7.28E-08	-2.91E-08	1.24E+01	3.67E-08	-5.47E-08	1.56E+01	-5.07E-08	-1.62E-08
9.00E-01	-7.94E-08	-3.71E-08	1.25E+01	4.97E-08	-6.22E-08	1.57E+01	-6.38E-08	-1.98E-08
1.00E+00	-7.55E-08	-4.50E-08	1.26E+01	6.18E-08	-6.97E-08	1.58E+01	-7.63E-08	-3.18E-08
1.10E+00	-5.75E-08	-5.22E-08	1.27E+01	6.54E-08	-7.69E-08	1.59E+01	-7.87E-08	-4.00E-08

1.20E+00	-3.91E-08	-5.99E-08
1.30E+00	-2.24E-08	-6.65E-08
1.40E+00	-6.11E-09	-7.36E-08
1.50E+00	6.48E-09	-7.85E-08
1.60E+00	2.04E-08	-8.05E-08
1.70E+00	3.66E-08	-7.97E-08
1.80E+00	4.94E-08	-7.59E-08
1.90E+00	6.13E-08	-6.62E-08
2.00E+00	6.48E-08	-5.60E-08
2.10E+00	5.81E-08	-4.61E-08
2.20E+00	4.07E-08	-3.67E-08
2.30E+00	2.29E-08	-2.75E-08
2.40E+00	6.01E-09	-1.86E-08
2.50E+00	-1.27E-08	-9.76E-09
2.60E+00	-1.98E-08	-3.51E-09
2.70E+00	-4.00E-08	4.77E-09
2.80E+00	-5.32E-08	1.24E-08
2.90E+00	-6.61E-08	2.01E-08
3.00E+00	-7.74E-08	2.94E-08
3.10E+00	-7.87E-08	3.70E-08
3.20E+00	-6.78E-08	4.39E-08

1.28E+01	5.74E-08	-8.10E-08
1.29E+01	3.99E-08	-8.00E-08
1.30E+01	2.21E-08	-7.74E-08
1.31E+01	4.96E-09	-6.74E-08
1.32E+01	-1.36E-08	-5.68E-08
1.33E+01	-1.98E-08	-4.61E-08
1.34E+01	-4.04E-08	-3.60E-08
1.35E+01	-5.37E-08	-2.54E-08
1.36E+01	-6.67E-08	-1.59E-08
1.37E+01	-7.77E-08	-6.64E-09
1.38E+01	-7.81E-08	-1.86E-10
1.39E+01	-6.60E-08	4.07E-09
1.40E+01	-4.77E-08	1.70E-08
1.41E+01	-3.01E-08	2.04E-08
1.42E+01	-1.37E-08	3.51E-08
1.43E+01	2.18E-09	4.29E-08
1.44E+01	1.45E-08	5.03E-08
1.45E+01	2.04E-08	5.72E-08
1.46E+01	4.40E-08	6.16E-08
1.47E+01	5.68E-08	6.31E-08
1.48E+01	6.44E-08	6.10E-08

1.60E+01	-6.90E-08	-4.83E-08
1.61E+01	-5.02E-08	-5.57E-08
1.62E+01	-3.21E-08	-6.33E-08
1.63E+01	-1.51E-08	-7.01E-08
1.64E+01	8.71E-10	-7.74E-08
2.49E+01	5.44E-09	1.40E-08
2.50E+01	2.04E-08	2.04E-08
2.51E+01	3.63E-08	3.31E-08
2.52E+01	4.98E-08	4.14E-08
2.53E+01	6.18E-08	4.90E-08
2.54E+01	6.50E-08	5.62E-08
2.55E+01	5.57E-08	6.24E-08
2.56E+01	3.83E-08	6.32E-08
2.57E+01	2.00E-08	6.12E-08
2.58E+01	2.78E-09	5.47E-08
2.59E+01	-1.58E-08	4.38E-08
2.60E+01	-1.98E-08	3.22E-08
2.61E+01	-4.33E-08	2.17E-08
2.62E+01	-5.71E-08	1.11E-08
2.63E+01	-7.00E-08	-1.64E-09
2.64E+01	-7.91E-08	-1.13E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
2.65E+01	-7.64E-08	-1.98E-08
2.66E+01	-5.98E-08	-2.71E-08
2.67E+01	-4.16E-08	-3.63E-08
2.68E+01	-2.39E-08	-4.52E-08
2.69E+01	-7.44E-09	-5.35E-08
2.70E+01	5.72E-09	-6.14E-08
2.71E+01	2.04E-08	-6.92E-08
2.72E+01	3.69E-08	-7.65E-08
2.73E+01	4.98E-08	-8.02E-08
2.74E+01	6.18E-08	-7.99E-08
2.75E+01	6.49E-08	-7.60E-08
2.76E+01	5.59E-08	-6.63E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
3.84E+01	1.23E-08	-6.54E-08
3.85E+01	-7.18E-09	-5.46E-08
3.86E+01	-1.98E-08	-4.40E-08
3.87E+01	-3.57E-08	-3.39E-08
3.88E+01	-4.97E-08	-2.39E-08
3.89E+01	-6.32E-08	-1.43E-08
3.90E+01	-7.58E-08	-4.78E-09
3.91E+01	-7.90E-08	1.25E-09
3.92E+01	-6.97E-08	4.07E-09
3.93E+01	-5.07E-08	1.84E-08
3.94E+01	-3.25E-08	2.89E-08
3.95E+01	-1.57E-08	3.70E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
5.03E+01	3.78E-08	4.71E-08
5.04E+01	5.13E-08	5.48E-08
5.05E+01	6.32E-08	6.08E-08
5.06E+01	6.42E-08	6.27E-08
5.07E+01	5.34E-08	6.17E-08
5.08E+01	3.50E-08	5.58E-08
5.09E+01	1.65E-08	4.53E-08
5.10E+01	-2.80E-09	3.38E-08
5.11E+01	-1.95E-08	2.26E-08
5.12E+01	-3.22E-08	1.21E-08
5.13E+01	-4.64E-08	-6.08E-10
5.14E+01	-6.00E-08	-3.97E-09

2.77E+01	3.83E-08	-5.41E-08	3.96E+01	2.58E-10	4.44E-08	5.15E+01	-7.31E-08	-1.98E-08
2.78E+01	1.98E-08	-4.30E-08	3.97E+01	1.31E-08	5.20E-08	5.16E+01	-7.90E-08	-2.66E-08
2.79E+01	3.03E-09	-3.31E-08	3.98E+01	2.04E-08	5.87E-08	5.17E+01	-7.41E-08	-3.57E-08
2.80E+01	-1.61E-08	-2.24E-08	3.99E+01	4.35E-08	6.26E-08	5.18E+01	-5.50E-08	-4.39E-08
2.81E+01	-1.98E-08	-1.27E-08	4.00E+01	5.65E-08	6.27E-08	5.19E+01	-3.70E-08	-5.22E-08
2.82E+01	-4.33E-08	-4.50E-09	4.01E+01	6.51E-08	6.06E-08	5.20E+01	-1.94E-08	-6.03E-08
2.83E+01	-5.67E-08	3.04E-09	4.02E+01	6.19E-08	5.24E-08	5.21E+01	-3.17E-09	-6.78E-08
2.84E+01	-6.97E-08	1.18E-08	4.03E+01	4.69E-08	4.18E-08	5.22E+01	9.82E-09	-7.53E-08
2.85E+01	-7.89E-08	2.02E-08	4.04E+01	2.82E-08	3.07E-08	5.23E+01	2.04E-08	-7.99E-08
2.86E+01	-7.68E-08	3.11E-08	4.05E+01	1.00E-08	2.00E-08	5.24E+01	4.06E-08	-8.02E-08
2.87E+01	-6.09E-08	3.91E-08	4.06E+01	-8.92E-09	1.00E-08	5.25E+01	5.36E-08	-7.72E-08
2.88E+01	-4.19E-08	4.69E-08	4.07E+01	-1.98E-08	-2.06E-09	5.26E+01	6.45E-08	-6.86E-08
2.89E+01	-2.49E-08	5.36E-08	4.08E+01	-3.74E-08	-1.15E-08	5.27E+01	6.38E-08	-5.73E-08
2.90E+01	-8.37E-09	6.07E-08	4.09E+01	-5.10E-08	-1.98E-08	5.28E+01	5.10E-08	-4.67E-08
3.75E+01	-1.03E-09	-4.01E-08	4.10E+01	-6.44E-08	-2.71E-08	5.29E+01	3.18E-08	-3.61E-08
3.76E+01	1.14E-08	-4.79E-08	4.11E+01	-7.66E-08	-3.57E-08	5.30E+01	1.35E-08	-2.63E-08
3.77E+01	2.04E-08	-5.59E-08	4.12E+01	-7.88E-08	-4.42E-08	5.31E+01	-6.08E-09	-1.62E-08
3.78E+01	4.20E-08	-6.34E-08	4.13E+01	-6.80E-08	-5.17E-08	5.32E+01	-1.98E-08	-6.56E-09
3.79E+01	5.49E-08	-7.10E-08	4.14E+01	-4.95E-08	-5.95E-08	5.33E+01	-3.50E-08	3.06E-10
3.80E+01	6.49E-08	-7.77E-08	4.15E+01	-3.14E-08	-6.68E-08	5.34E+01	-4.91E-08	4.07E-09
3.81E+01	6.36E-08	-8.08E-08	4.16E+01	-1.46E-08	-7.44E-08	5.35E+01	-6.30E-08	1.76E-08
3.82E+01	4.95E-08	-7.96E-08	5.01E+01	7.13E-09	3.08E-08	5.36E+01	-7.58E-08	2.04E-08
3.83E+01	3.01E-08	-7.59E-08	5.02E+01	2.04E-08	3.91E-08	5.37E+01	-7.91E-08	3.64E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)	Elapsed Time (s)	CPM Current (A)	SAPM Current (A)	Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
5.38E+01	-6.95E-08	4.40E-08	6.59E+01	-4.04E-08	-4.97E-08	7.80E+01	6.12E-08	-3.59E-09
5.39E+01	-5.03E-08	5.12E-08	6.60E+01	-5.40E-08	-5.82E-08	7.81E+01	4.55E-08	5.18E-09
5.40E+01	-3.24E-08	5.86E-08	6.61E+01	-6.67E-08	-6.66E-08	7.82E+01	2.75E-08	1.36E-08
5.41E+01	-1.50E-08	6.20E-08	6.62E+01	-7.83E-08	-7.44E-08	7.83E+01	1.01E-08	2.04E-08
5.42E+01	1.34E-09	6.22E-08	6.63E+01	-7.84E-08	-7.92E-08	7.84E+01	-8.21E-09	3.20E-08
6.27E+01	2.04E-08	-5.74E-08	6.64E+01	-6.61E-08	-8.00E-08	7.85E+01	-1.98E-08	3.98E-08
6.28E+01	3.96E-08	-6.55E-08	6.65E+01	-4.76E-08	-7.69E-08	7.86E+01	-3.58E-08	4.68E-08
6.29E+01	5.25E-08	-7.35E-08	6.66E+01	-2.97E-08	-6.73E-08	7.87E+01	-4.96E-08	5.37E-08
6.30E+01	6.35E-08	-7.95E-08	6.67E+01	-1.34E-08	-5.51E-08	7.88E+01	-6.24E-08	5.96E-08
6.31E+01	6.44E-08	-8.03E-08	6.68E+01	2.00E-09	-4.41E-08	7.89E+01	-7.49E-08	6.22E-08
6.32E+01	5.35E-08	-7.76E-08	7.53E+01	5.19E-09	6.23E-08	7.90E+01	-7.92E-08	6.22E-08

6.33E+01	3.51E-08	-6.77E-08
6.34E+01	1.72E-08	-5.50E-08
6.35E+01	3.19E-10	-4.36E-08
6.36E+01	-1.74E-08	-3.22E-08
6.37E+01	-1.98E-08	-2.10E-08
6.38E+01	-4.43E-08	-1.04E-08
6.39E+01	-5.83E-08	-3.26E-09
6.40E+01	-7.11E-08	6.94E-09
6.41E+01	-7.94E-08	1.59E-08
6.42E+01	-7.59E-08	2.04E-08
6.43E+01	-5.92E-08	3.63E-08
6.44E+01	-4.10E-08	4.51E-08
6.45E+01	-2.34E-08	5.30E-08
6.46E+01	-7.81E-09	6.02E-08
6.47E+01	5.22E-09	6.28E-08
6.48E+01	1.97E-08	6.20E-08
6.49E+01	3.55E-08	5.61E-08
6.50E+01	4.86E-08	4.43E-08
6.51E+01	6.09E-08	3.22E-08
6.52E+01	6.56E-08	2.05E-08
6.53E+01	5.79E-08	9.32E-09
6.54E+01	4.04E-08	-3.70E-09
6.55E+01	2.25E-08	-1.41E-08
6.56E+01	5.39E-09	-1.98E-08
6.57E+01	-1.31E-08	-3.14E-08
6.58E+01	-1.98E-08	-4.05E-08

7.54E+01	1.99E-08	5.96E-08
7.55E+01	3.59E-08	5.09E-08
7.56E+01	4.91E-08	4.01E-08
7.57E+01	6.12E-08	2.89E-08
7.58E+01	6.48E-08	1.85E-08
7.59E+01	5.69E-08	8.43E-09
7.60E+01	3.94E-08	-3.58E-09
7.61E+01	2.11E-08	-1.24E-08
7.62E+01	3.93E-09	-1.98E-08
7.63E+01	-1.44E-08	-2.84E-08
7.64E+01	-1.98E-08	-3.66E-08
7.65E+01	-4.16E-08	-4.46E-08
7.66E+01	-5.55E-08	-5.27E-08
7.67E+01	-6.83E-08	-6.01E-08
7.68E+01	-7.84E-08	-6.77E-08
7.69E+01	-7.78E-08	-7.50E-08
7.70E+01	-6.35E-08	-7.92E-08
7.71E+01	-4.50E-08	-7.99E-08
7.72E+01	-2.76E-08	-7.76E-08
7.73E+01	-1.14E-08	-7.07E-08
7.74E+01	1.56E-09	-5.96E-08
7.75E+01	4.07E-09	-4.93E-08
7.76E+01	2.04E-08	-3.90E-08
7.77E+01	4.56E-08	-2.89E-08
7.78E+01	5.78E-08	-1.91E-08
7.79E+01	6.54E-08	-1.01E-08

7.91E+01	-7.32E-08	5.98E-08
7.92E+01	-5.50E-08	5.14E-08
7.93E+01	-3.73E-08	4.11E-08
7.94E+01	-2.09E-08	3.10E-08
8.79E+01	-3.66E-08	-5.73E-08
8.80E+01	-1.95E-08	-6.46E-08
8.81E+01	-3.83E-09	-7.17E-08
8.82E+01	9.05E-09	-7.81E-08
8.83E+01	2.04E-08	-7.99E-08
8.84E+01	3.93E-08	-7.95E-08
8.85E+01	5.20E-08	-7.53E-08
8.86E+01	6.37E-08	-6.56E-08
8.87E+01	6.43E-08	-5.47E-08
8.88E+01	5.33E-08	-4.48E-08
8.89E+01	3.53E-08	-3.44E-08
8.90E+01	1.73E-08	-2.46E-08
8.91E+01	2.76E-10	-1.52E-08
8.92E+01	-1.77E-08	-6.37E-09
8.93E+01	-1.98E-08	1.41E-10
8.94E+01	-4.47E-08	4.07E-09
8.95E+01	-5.82E-08	1.71E-08
8.96E+01	-7.07E-08	2.04E-08
8.97E+01	-7.93E-08	3.53E-08
8.98E+01	-7.65E-08	4.29E-08
8.99E+01	-5.99E-08	4.99E-08
9.00E+01	-4.17E-08	5.67E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
9.01E+01	-2.47E-08	6.17E-08
9.02E+01	-7.94E-09	6.27E-08
9.03E+01	4.80E-09	6.15E-08
9.04E+01	1.91E-08	5.60E-08
9.05E+01	3.53E-08	4.53E-08
9.06E+01	4.82E-08	3.43E-08
9.07E+01	6.04E-08	2.39E-08
9.08E+01	6.54E-08	1.39E-08
9.09E+01	5.91E-08	1.68E-09
9.10E+01	4.19E-08	-7.79E-09
9.11E+01	2.36E-08	-1.68E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.02E+02	-3.51E-08	3.93E-08
1.02E+02	-4.88E-08	2.88E-08
1.02E+02	-6.21E-08	1.89E-08
1.03E+02	-7.46E-08	9.24E-09
1.03E+02	-7.90E-08	-2.51E-09
1.03E+02	-7.25E-08	-1.15E-08
1.03E+02	-5.39E-08	-1.98E-08
1.03E+02	-3.62E-08	-2.64E-08
1.03E+02	-1.95E-08	-3.45E-08
1.03E+02	-3.64E-09	-4.24E-08
1.03E+02	8.92E-09	-5.01E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.14E+02	6.48E-08	1.24E-08
1.14E+02	5.43E-08	5.12E-10
1.15E+02	3.52E-08	-3.97E-09
1.15E+02	1.67E-08	-1.76E-08
1.15E+02	-3.45E-09	-1.98E-08
1.15E+02	-1.97E-08	-3.16E-08
1.15E+02	-3.29E-08	-3.99E-08
1.15E+02	-4.80E-08	-4.77E-08
1.15E+02	-6.19E-08	-5.52E-08
1.15E+02	-7.52E-08	-6.24E-08
1.15E+02	-7.90E-08	-6.97E-08

9.12E+01	6.93E-09	-1.98E-08	1.03E+02	2.04E-08	-5.76E-08	1.15E+02	-6.98E-08	-7.64E-08
9.13E+01	-1.19E-08	-3.20E-08	1.03E+02	3.90E-08	-6.45E-08	1.16E+02	-5.02E-08	-7.99E-08
9.14E+01	-1.98E-08	-4.01E-08	1.04E+02	5.14E-08	-7.16E-08	1.16E+02	-3.12E-08	-7.90E-08
9.15E+01	-3.92E-08	-4.85E-08	1.04E+02	6.33E-08	-7.79E-08	1.16E+02	-1.42E-08	-7.71E-08
9.16E+01	-5.25E-08	-5.63E-08	1.04E+02	6.50E-08	-8.04E-08	1.16E+02	2.37E-09	-6.99E-08
9.17E+01	-6.55E-08	-6.40E-08	1.04E+02	5.52E-08	-7.88E-08	1.16E+02	1.55E-08	-5.92E-08
9.18E+01	-7.71E-08	-7.15E-08	1.04E+02	3.75E-08	-7.62E-08	1.16E+02	2.04E-08	-4.89E-08
9.19E+01	-7.93E-08	-7.79E-08	1.04E+02	1.99E-08	-6.72E-08	1.16E+02	4.64E-08	-3.87E-08
9.20E+01	-6.80E-08	-7.96E-08	1.04E+02	2.47E-09	-5.64E-08	1.16E+02	5.93E-08	-2.92E-08
1.01E+02	-7.84E-08	-3.50E-08	1.04E+02	-1.56E-08	-4.68E-08	1.16E+02	6.55E-08	-2.03E-08
1.01E+02	-6.51E-08	-2.56E-08	1.04E+02	-1.98E-08	-3.67E-08	1.16E+02	5.84E-08	-1.07E-08
1.01E+02	-4.71E-08	-1.70E-08	1.04E+02	-4.21E-08	-2.72E-08	1.17E+02	4.03E-08	-4.20E-09
1.01E+02	-2.91E-08	-7.51E-09	1.05E+02	-5.56E-08	-1.79E-08	1.17E+02	2.13E-08	4.05E-09
1.01E+02	-1.28E-08	-1.18E-09	1.05E+02	-6.84E-08	-9.21E-09	1.17E+02	3.39E-09	1.23E-08
1.01E+02	2.84E-09	7.20E-09	1.13E+02	-6.69E-08	3.31E-08	1.17E+02	-1.56E-08	2.00E-08
1.01E+02	1.50E-08	1.48E-08	1.13E+02	-7.80E-08	4.06E-08	1.17E+02	-1.98E-08	3.03E-08
1.01E+02	2.04E-08	2.04E-08	1.13E+02	-7.76E-08	4.75E-08	1.17E+02	-4.40E-08	3.76E-08
1.01E+02	4.44E-08	3.30E-08	1.13E+02	-6.35E-08	5.37E-08	1.17E+02	-5.82E-08	4.50E-08
1.01E+02	5.70E-08	4.09E-08	1.14E+02	-4.41E-08	6.03E-08	1.17E+02	-7.15E-08	5.17E-08
1.02E+02	6.54E-08	4.75E-08	1.14E+02	-2.61E-08	6.22E-08	1.26E+02	-5.83E-08	3.55E-08
1.02E+02	6.20E-08	5.44E-08	1.14E+02	-8.93E-09	6.18E-08	1.26E+02	-3.96E-08	2.63E-08
1.02E+02	4.70E-08	6.03E-08	1.14E+02	4.46E-09	5.95E-08	1.26E+02	-2.22E-08	1.70E-08
1.02E+02	2.86E-08	6.25E-08	1.14E+02	1.96E-08	5.19E-08	1.26E+02	-5.70E-09	7.87E-09
1.02E+02	1.14E-08	6.22E-08	1.14E+02	3.64E-08	4.19E-08	1.26E+02	7.84E-09	-3.07E-09
1.02E+02	-7.41E-09	5.92E-08	1.14E+02	4.98E-08	3.14E-08	1.26E+02	2.04E-08	-1.17E-08
1.02E+02	-1.98E-08	5.00E-08	1.14E+02	6.25E-08	2.18E-08	1.26E+02	3.92E-08	-1.98E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.26E+02	5.23E-08	-2.53E-08
1.27E+02	6.40E-08	-3.32E-08
1.27E+02	6.37E-08	-4.06E-08
1.27E+02	5.17E-08	-4.79E-08
1.27E+02	3.26E-08	-5.46E-08
1.27E+02	1.42E-08	-6.14E-08
1.27E+02	-5.39E-09	-6.79E-08
1.27E+02	-1.98E-08	-7.44E-08
1.27E+02	-3.49E-08	-7.96E-08
1.27E+02	-4.92E-08	-8.00E-08
1.27E+02	-6.29E-08	-7.85E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.39E+02	2.04E-08	-4.37E-08
1.39E+02	4.02E-08	-5.10E-08
1.39E+02	5.32E-08	-5.81E-08
1.39E+02	6.47E-08	-6.52E-08
1.39E+02	6.32E-08	-7.20E-08
1.39E+02	4.96E-08	-7.82E-08
1.39E+02	2.99E-08	-8.03E-08
1.39E+02	1.20E-08	-7.91E-08
1.39E+02	-7.87E-09	-7.59E-08
1.39E+02	-1.98E-08	-6.77E-08
1.40E+02	-3.66E-08	-5.73E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.42E+02	-4.47E-08	-3.07E-08
1.42E+02	-2.69E-08	-3.87E-08
1.42E+02	-1.04E-08	-4.65E-08
1.51E+02	4.33E-09	-5.80E-08
1.51E+02	1.90E-08	-4.78E-08
1.51E+02	3.56E-08	-3.78E-08
1.51E+02	4.89E-08	-2.77E-08
1.51E+02	6.13E-08	-1.89E-08
1.51E+02	6.47E-08	-9.71E-09
1.52E+02	5.72E-08	-3.52E-09
1.52E+02	3.92E-08	5.21E-09

1.28E+02	-7.60E-08	-7.51E-08	1.40E+02	-5.09E-08	-4.73E-08	1.52E+02	2.13E-08	1.35E-08
1.28E+02	-7.92E-08	-6.59E-08	1.40E+02	-6.47E-08	-3.76E-08	1.52E+02	4.04E-09	2.04E-08
1.28E+02	-6.94E-08	-5.56E-08	1.40E+02	-7.71E-08	-2.80E-08	1.52E+02	-1.50E-08	3.16E-08
1.28E+02	-5.00E-08	-4.63E-08	1.40E+02	-7.85E-08	-1.91E-08	1.52E+02	-1.98E-08	3.91E-08
1.28E+02	-3.16E-08	-3.69E-08	1.40E+02	-6.74E-08	-9.66E-09	1.52E+02	-4.23E-08	4.66E-08
1.28E+02	-1.45E-08	-2.83E-08	1.40E+02	-4.86E-08	-3.80E-09	1.52E+02	-5.60E-08	5.31E-08
1.28E+02	1.83E-09	-1.95E-08	1.40E+02	-3.00E-08	4.76E-09	1.52E+02	-6.91E-08	5.96E-08
1.28E+02	1.46E-08	-1.06E-08	1.40E+02	-1.31E-08	1.27E-08	1.52E+02	-7.93E-08	6.21E-08
1.28E+02	2.04E-08	-4.97E-09	1.40E+02	3.33E-09	2.04E-08	1.53E+02	-7.73E-08	6.18E-08
1.28E+02	4.50E-08	3.04E-09	1.41E+02	1.58E-08	3.07E-08	1.53E+02	-6.14E-08	5.94E-08
1.29E+02	5.77E-08	1.10E-08	1.41E+02	2.04E-08	3.83E-08	1.53E+02	-4.26E-08	5.16E-08
1.29E+02	6.52E-08	1.87E-08	1.41E+02	4.61E-08	4.54E-08	1.53E+02	-2.54E-08	4.12E-08
1.29E+02	6.09E-08	2.84E-08	1.41E+02	5.86E-08	5.21E-08	1.53E+02	-8.89E-09	3.10E-08
1.29E+02	4.36E-08	3.56E-08	1.41E+02	6.52E-08	5.88E-08	1.53E+02	4.24E-09	2.10E-08
1.29E+02	2.47E-08	4.24E-08	1.41E+02	6.02E-08	6.18E-08	1.53E+02	1.93E-08	1.10E-08
1.29E+02	6.98E-09	4.91E-08	1.41E+02	4.28E-08	6.25E-08	1.53E+02	3.57E-08	-1.37E-09
1.29E+02	-1.20E-08	5.57E-08	1.41E+02	2.39E-08	6.01E-08	1.53E+02	4.87E-08	-1.04E-08
1.29E+02	-1.98E-08	6.10E-08	1.41E+02	6.36E-09	5.39E-08	1.53E+02	6.12E-08	-1.90E-08
1.29E+02	-4.05E-08	6.25E-08	1.41E+02	-1.26E-08	4.40E-08	1.54E+02	6.48E-08	-2.51E-08
1.29E+02	-5.45E-08	6.13E-08	1.42E+02	-1.98E-08	3.36E-08	1.54E+02	5.69E-08	-3.37E-08
1.30E+02	-6.78E-08	5.83E-08	1.42E+02	-4.08E-08	2.38E-08	1.54E+02	3.90E-08	-4.14E-08
1.30E+02	-7.85E-08	5.04E-08	1.42E+02	-5.44E-08	1.37E-08	1.54E+02	2.06E-08	-4.91E-08
1.30E+02	-7.72E-08	4.02E-08	1.42E+02	-6.78E-08	2.50E-09	1.54E+02	3.07E-09	-5.69E-08
1.30E+02	-6.19E-08	3.05E-08	1.42E+02	-7.89E-08	-6.68E-09	1.54E+02	-1.54E-08	-6.45E-08
1.38E+02	-4.55E-09	-2.79E-08	1.42E+02	-7.76E-08	-1.62E-08	1.54E+02	-1.98E-08	-7.15E-08
1.38E+02	8.70E-09	-3.57E-08	1.42E+02	-6.37E-08	-1.98E-08	1.54E+02	-4.30E-08	-7.79E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
1.54E+02	-5.69E-08	-7.99E-08
1.54E+02	-7.00E-08	-7.91E-08
1.55E+02	-7.89E-08	-7.61E-08
1.55E+02	-7.64E-08	-6.72E-08
1.55E+02	-5.96E-08	-5.64E-08
1.55E+02	-4.10E-08	-4.62E-08
1.55E+02	-2.35E-08	-3.61E-08
1.55E+02	-6.80E-09	-2.66E-08
1.97E+02	2.93E-08	-1.18E-08
1.97E+02	1.16E-08	-3.13E-09
1.97E+02	-7.90E-09	2.95E-09

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
2.00E+02	-7.75E-08	-7.86E-08
200.1	-6.24E-08	-7.99E-08
200.2	-4.37E-08	-7.83E-08
200.3	-2.58E-08	-7.41E-08
200.4	-9.23E-09	-6.32E-08
200.5	4.11E-09	-5.32E-08
200.6	1.91E-08	-4.30E-08
200.7	3.56E-08	-3.36E-08
200.8	4.91E-08	-2.42E-08
200.9	6.17E-08	-1.51E-08
201	6.52E-08	-6.17E-09

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
237.3	6.11E-08	-7.72E-08
237.4	4.34E-08	-6.99E-08
237.5	2.41E-08	-5.88E-08
237.6	6.44E-09	-4.80E-08
237.7	-1.30E-08	-3.78E-08
237.8	-1.98E-08	-2.79E-08
237.9	-4.10E-08	-1.83E-08
238	-5.52E-08	-8.69E-09
238.1	-6.83E-08	-2.23E-09
238.2	-7.84E-08	6.69E-09
238.3	-7.71E-08	1.49E-08

1.97E+02	-1.98E-08	1.13E-08
1.98E+02	-3.65E-08	1.93E-08
1.98E+02	-5.10E-08	2.93E-08
1.98E+02	-6.43E-08	3.64E-08
1.98E+02	-7.69E-08	4.37E-08
1.98E+02	-7.88E-08	5.05E-08
1.98E+02	-6.77E-08	5.75E-08
1.98E+02	-4.84E-08	6.16E-08
1.98E+02	-3.06E-08	6.26E-08
1.98E+02	-1.33E-08	6.09E-08
1.98E+02	2.64E-09	5.61E-08
1.99E+02	1.54E-08	4.61E-08
1.99E+02	2.04E-08	3.56E-08
1.99E+02	4.61E-08	2.54E-08
1.99E+02	5.86E-08	1.56E-08
1.99E+02	6.54E-08	3.70E-09
1.99E+02	6.05E-08	-5.35E-09
1.99E+02	4.29E-08	-1.43E-08
1.99E+02	2.44E-08	-1.98E-08
1.99E+02	6.61E-09	-2.89E-08
1.99E+02	-1.23E-08	-3.72E-08
2.00E+02	-1.98E-08	-4.50E-08
2.00E+02	-4.04E-08	-5.24E-08
2.00E+02	-5.45E-08	-5.99E-08
2.00E+02	-6.75E-08	-6.71E-08
2.00E+02	-7.85E-08	-7.41E-08

201.1	5.64E-08	1.47E-10
201.2	3.86E-08	4.07E-09
234.9	4.04E-08	4.26E-08
235	5.37E-08	4.91E-08
235.1	6.45E-08	5.61E-08
235.2	6.36E-08	6.13E-08
235.3	5.01E-08	6.22E-08
235.4	3.08E-08	6.09E-08
235.5	1.26E-08	5.71E-08
235.6	-7.22E-09	4.72E-08
235.7	-1.98E-08	3.68E-08
235.8	-3.62E-08	2.65E-08
235.9	-5.06E-08	1.61E-08
236	-6.38E-08	3.97E-09
236.1	-7.69E-08	-5.33E-09
236.2	-7.86E-08	-1.45E-08
236.3	-6.85E-08	-1.98E-08
236.4	-4.92E-08	-2.92E-08
236.5	-3.12E-08	-3.76E-08
236.6	-1.41E-08	-4.59E-08
236.7	1.92E-09	-5.37E-08
236.8	1.47E-08	-6.12E-08
236.9	2.04E-08	-6.82E-08
237	4.51E-08	-7.54E-08
237.1	5.80E-08	-7.88E-08
237.2	6.43E-08	-7.89E-08

238.4	-6.14E-08	2.04E-08
238.5	-4.24E-08	3.34E-08
238.6	-2.47E-08	4.12E-08
238.7	-7.59E-09	4.84E-08
238.8	6.03E-09	5.51E-08
238.9	2.04E-08	6.06E-08
239	3.76E-08	6.14E-08
276.9	-7.88E-08	-1.12E-08
277	-7.19E-08	-3.80E-09
277.1	-5.05E-08	5.33E-09
277.2	-3.11E-08	1.41E-08
277.3	-1.25E-08	2.04E-08
277.4	4.85E-09	3.38E-08
277.5	1.90E-08	4.19E-08
277.6	3.66E-08	4.89E-08
277.7	5.07E-08	5.66E-08
277.8	6.35E-08	6.16E-08
277.9	6.31E-08	6.20E-08
278	4.88E-08	6.02E-08
278.1	2.82E-08	5.35E-08
278.2	8.85E-09	4.30E-08
278.3	-1.18E-08	3.14E-08
278.4	-1.98E-08	2.07E-08
278.5	-4.24E-08	1.02E-08
278.6	-5.75E-08	-1.66E-09
278.7	-7.15E-08	-1.20E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
278.8	-7.87E-08	-1.98E-08
278.9	-7.37E-08	-2.79E-08
279	-5.28E-08	-3.64E-08
279.1	-3.27E-08	-4.49E-08
279.2	-1.43E-08	-5.31E-08
279.3	2.71E-09	-6.11E-08
279.4	1.69E-08	-6.88E-08
279.5	2.04E-08	-7.59E-08
279.6	4.91E-08	-7.95E-08
279.7	6.23E-08	-7.89E-08
279.8	6.40E-08	-7.64E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
290.9	3.66E-08	-2.71E-08
291	5.11E-08	-1.71E-08
291.1	6.31E-08	-7.11E-09
291.2	6.33E-08	-7.72E-11
291.3	4.85E-08	4.07E-09
291.4	2.82E-08	1.77E-08
291.5	8.42E-09	2.04E-08
291.6	-1.20E-08	3.73E-08
291.7	-1.98E-08	4.52E-08
291.8	-4.28E-08	5.21E-08
291.9	-5.79E-08	5.92E-08

Elapsed Time (s)	CPM Current (A)	SAPM Current (A)
296.4	-1.98E-09	-3.97E-09
296.5	1.18E-08	-1.95E-08
296.6	2.04E-08	-2.60E-08
296.7	4.41E-08	-3.47E-08
296.8	5.76E-08	-4.28E-08
296.9	6.51E-08	-5.08E-08
297	5.98E-08	-5.84E-08
297.1	4.08E-08	-6.59E-08
297.2	2.11E-08	-7.27E-08
297.3	2.63E-09	-7.83E-08
297.4	-1.76E-08	-7.88E-08

279.9	5.15E-08	-6.82E-08	292	-7.22E-08	6.20E-08	297.5	-1.98E-08	-7.77E-08
280	3.11E-08	-5.69E-08	292.1	-7.90E-08	6.17E-08	297.6	-4.66E-08	-7.40E-08
280.1	1.17E-08	-4.58E-08	292.2	-7.21E-08	5.87E-08	297.7	-6.12E-08	-6.31E-08
280.2	-9.08E-09	-3.56E-08	292.3	-5.08E-08	4.87E-08	297.8	-7.50E-08	-5.21E-08
280.3	-1.98E-08	-2.55E-08	292.4	-3.11E-08	3.73E-08	297.9	-7.89E-08	-4.25E-08
280.4	-4.01E-08	-1.58E-08	292.5	-1.28E-08	2.65E-08	298	-6.87E-08	-3.26E-08
280.5	-5.50E-08	-6.13E-09	292.6	4.56E-09	1.59E-08	298.1	-4.85E-08	-2.33E-08
280.6	-6.94E-08	2.74E-10	292.7	1.84E-08	3.02E-09	298.2	-2.93E-08	-1.39E-08
280.7	-7.85E-08	4.07E-09	292.8	3.63E-08	-7.19E-09	298.3	-1.14E-08	-5.18E-09
280.8	-7.52E-08	1.77E-08	292.9	5.04E-08	-1.67E-08	298.4	2.92E-09	9.10E-10
280.9	-5.53E-08	2.04E-08	293	6.35E-08	-1.98E-08	298.5	1.90E-08	4.07E-09
281	-3.54E-08	3.63E-08	293.1	6.37E-08	-3.27E-08	298.6	3.62E-08	1.72E-08
289.5	2.90E-08	-1.98E-08	293.2	4.98E-08	-4.15E-08	298.7	5.01E-08	2.04E-08
289.6	9.51E-09	-3.26E-08	293.3	2.90E-08	-5.00E-08	298.8	6.28E-08	3.49E-08
289.7	-1.18E-08	-4.14E-08	293.4	9.53E-09	-5.82E-08	298.9	6.44E-08	4.24E-08
289.8	-1.98E-08	-4.97E-08	293.5	-1.09E-08	-6.58E-08	299	5.20E-08	4.91E-08
289.9	-4.21E-08	-5.78E-08	293.6	-1.98E-08	-7.37E-08	299.1	3.20E-08	5.56E-08
290	-5.75E-08	-6.58E-08	293.7	-4.14E-08	-7.81E-08	299.2	1.28E-08	6.05E-08
290.1	-7.17E-08	-7.32E-08	293.8	-5.67E-08	-7.88E-08	299.3	-7.63E-09	6.19E-08
290.2	-7.90E-08	-7.81E-08	293.9	-7.11E-08	-7.70E-08	299.4	-1.98E-08	6.10E-08
290.3	-7.21E-08	-7.88E-08	294	-7.90E-08	-6.99E-08	299.5	-3.81E-08	5.81E-08
290.4	-5.10E-08	-7.71E-08	294.1	-7.39E-08	-5.87E-08	299.6	-5.29E-08	4.91E-08
290.5	-3.13E-08	-7.08E-08	294.2	-5.27E-08	-4.77E-08	299.7	-6.69E-08	3.91E-08
290.6	-1.28E-08	-5.92E-08	294.3	-3.31E-08	-3.72E-08	299.8	-7.81E-08	2.90E-08
290.7	4.87E-09	-4.81E-08	294.4	-1.46E-08	-2.69E-08	299.9	-7.73E-08	1.93E-08
290.8	1.91E-08	-3.74E-08	294.5	2.61E-09	-1.67E-08	300	-6.06E-08	9.86E-09

Table B.11: Electrochemical Current Noise (ECN) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Heat Affected Zone (HAZ) of the Samples Immersed in 1M NaCl Environment

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)	Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)	Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
0.1	4.90E-09	-2.96E-08	3.6	6.25E-08	-4.31E-08	15.7	-5.34E-08	-6.72E-08
0.2	6.36E-10	-1.33E-08	3.7	6.05E-08	-4.85E-08	15.8	-6.37E-08	-6.01E-08
0.3	4.91E-08	-6.84E-09	3.8	5.36E-08	-5.39E-08	15.9	-7.20E-08	-5.37E-08
0.4	6.90E-08	-3.21E-09	12.5	7.16E-10	6.58E-08	16	-7.51E-08	-4.72E-08
0.5	3.95E-08	2.75E-09	12.6	-3.97E-09	6.55E-08	16.1	-7.34E-08	-4.14E-08
0.6	4.93E-08	8.67E-09	12.7	-1.98E-08	6.05E-08	16.2	-6.41E-08	-3.50E-08
0.7	5.77E-08	1.43E-08	12.8	-3.26E-08	5.34E-08	16.3	-4.98E-08	-2.90E-08
0.8	6.16E-08	2.03E-08	12.9	-4.41E-08	4.62E-08	16.4	-3.55E-08	-2.30E-08
0.9	6.29E-08	2.84E-08	13	-5.49E-08	3.88E-08	16.5	-2.21E-08	-1.72E-08
1	5.68E-08	3.38E-08	13.1	-6.46E-08	3.22E-08	16.6	-9.38E-09	-1.17E-08

1.1	4.63E-08	3.88E-08
1.2	3.23E-08	4.38E-08
1.3	1.86E-08	4.89E-08
1.4	5.54E-09	5.40E-08
1.5	-9.33E-09	5.87E-08
1.6	-1.98E-08	6.28E-08
1.7	-3.07E-08	6.46E-08
1.8	-4.19E-08	6.57E-08
1.9	-5.22E-08	6.60E-08
2	-6.23E-08	6.07E-08
2.1	-7.10E-08	5.37E-08
2.2	-7.50E-08	4.65E-08
2.3	-7.47E-08	3.88E-08
2.4	-6.56E-08	3.17E-08
2.5	-5.25E-08	2.46E-08
2.6	-3.90E-08	1.76E-08
2.7	-2.58E-08	1.11E-08
2.8	-1.27E-08	1.96E-09
2.9	-6.26E-10	-4.35E-09
3	8.54E-09	-1.07E-08
3.1	1.94E-08	-1.67E-08
3.2	3.25E-08	-1.98E-08
3.3	4.28E-08	-2.62E-08
3.4	5.27E-08	-3.22E-08
3.5	5.98E-08	-3.77E-08

13.2	-7.17E-08	2.51E-08
13.3	-7.53E-08	1.82E-08
13.4	-7.37E-08	1.17E-08
13.5	-6.36E-08	2.91E-09
13.6	-4.89E-08	-3.68E-09
13.7	-3.51E-08	-9.77E-09
13.8	-2.24E-08	-1.59E-08
13.9	-9.88E-09	-1.98E-08
14	3.29E-10	-2.48E-08
14.1	4.07E-09	-3.01E-08
14.2	2.04E-08	-3.57E-08
14.3	3.57E-08	-4.09E-08
14.4	4.63E-08	-4.60E-08
14.5	5.63E-08	-5.11E-08
14.6	6.13E-08	-5.60E-08
14.7	6.27E-08	-6.12E-08
14.8	5.73E-08	-6.57E-08
14.9	4.85E-08	-7.02E-08
15	3.42E-08	-7.47E-08
15.1	1.98E-08	-7.85E-08
15.2	6.23E-09	-8.10E-08
15.3	-9.24E-09	-8.23E-08
15.4	-1.98E-08	-8.28E-08
15.5	-3.10E-08	-8.09E-08
15.6	-4.25E-08	-7.41E-08

16.7	1.04E-10	-6.10E-09
25.4	5.52E-08	1.47E-09
25.5	6.05E-08	-3.97E-09
25.6	6.31E-08	-9.58E-09
25.7	5.92E-08	-1.51E-08
25.8	5.09E-08	-1.98E-08
25.9	3.71E-08	-2.32E-08
26	2.34E-08	-2.84E-08
26.1	1.09E-08	-3.37E-08
26.2	-4.18E-09	-3.83E-08
26.3	-1.69E-08	-4.32E-08
26.4	-1.98E-08	-4.81E-08
26.5	-3.73E-08	-5.23E-08
26.6	-4.77E-08	-5.70E-08
26.7	-5.79E-08	-6.14E-08
26.8	-6.78E-08	-6.61E-08
26.9	-7.35E-08	-7.07E-08
27	-7.54E-08	-7.49E-08
27.1	-7.02E-08	-7.88E-08
27.2	-6.06E-08	-8.07E-08
27.3	-4.69E-08	-8.22E-08
27.4	-3.34E-08	-8.29E-08
27.5	-2.02E-08	-8.13E-08
27.6	-7.97E-09	-7.48E-08
27.7	1.08E-09	-6.80E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
27.8	4.07E-09	-6.13E-08
27.9	2.04E-08	-5.45E-08
28	3.64E-08	-4.83E-08
28.1	4.64E-08	-4.22E-08
28.2	5.53E-08	-3.60E-08
28.3	6.05E-08	-3.01E-08
28.4	6.29E-08	-2.40E-08
28.5	5.87E-08	-1.83E-08
28.6	5.05E-08	-1.26E-08
28.7	3.64E-08	-7.05E-09
28.8	2.24E-08	-3.93E-09

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
40.1	-5.88E-08	-3.60E-08
40.2	-6.90E-08	-2.95E-08
40.3	-7.41E-08	-2.31E-08
40.4	-7.58E-08	-1.72E-08
40.5	-6.77E-08	-1.11E-08
40.6	-5.53E-08	-7.61E-09
40.7	-4.14E-08	-1.88E-09
40.8	-2.75E-08	3.73E-09
40.9	-1.43E-08	9.22E-09
41	-1.30E-09	1.50E-08
41.1	8.35E-09	2.00E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
52.4	5.61E-08	-8.47E-09
52.5	6.11E-08	-5.12E-09
52.6	6.30E-08	6.24E-10
52.7	5.83E-08	4.07E-09
52.8	4.99E-08	1.17E-08
52.9	3.62E-08	1.73E-08
53	2.22E-08	2.04E-08
53.1	9.01E-09	3.01E-08
53.2	-5.95E-09	3.52E-08
53.3	-1.79E-08	4.02E-08
53.4	-2.71E-08	4.51E-08

28.9	9.15E-09	1.34E-09
29	-5.85E-09	4.07E-09
29.1	-1.79E-08	1.20E-08
29.2	-2.77E-08	1.69E-08
29.3	-3.92E-08	2.04E-08
29.4	-4.97E-08	2.91E-08
29.5	-5.97E-08	3.38E-08
29.6	-6.98E-08	3.87E-08
38.3	-6.59E-09	-4.13E-08
38.4	2.91E-09	-4.64E-08
38.5	1.43E-08	-5.15E-08
38.6	2.04E-08	-5.65E-08
38.7	3.99E-08	-6.13E-08
38.8	5.01E-08	-6.61E-08
38.9	5.83E-08	-7.06E-08
39	6.18E-08	-7.54E-08
39.1	6.19E-08	-7.95E-08
39.2	5.47E-08	-8.16E-08
39.3	4.18E-08	-8.29E-08
39.4	2.64E-08	-8.26E-08
39.5	1.28E-08	-7.74E-08
39.6	-2.76E-09	-7.06E-08
39.7	-1.55E-08	-6.36E-08
39.8	-1.98E-08	-5.60E-08
39.9	-3.76E-08	-4.94E-08
40	-4.84E-08	-4.27E-08

41.2	1.96E-08	2.77E-08
41.3	3.26E-08	3.28E-08
41.4	4.32E-08	3.79E-08
41.5	5.35E-08	4.27E-08
41.6	6.04E-08	4.72E-08
41.7	6.29E-08	5.17E-08
41.8	5.89E-08	5.62E-08
41.9	5.07E-08	6.06E-08
42	3.77E-08	6.38E-08
42.1	2.35E-08	6.55E-08
42.2	8.89E-09	6.63E-08
42.3	-7.21E-09	6.54E-08
42.4	-1.95E-08	6.04E-08
42.5	-2.83E-08	5.42E-08
51.2	-7.55E-08	-8.30E-08
51.3	-7.10E-08	-8.14E-08
51.4	-6.09E-08	-7.45E-08
51.5	-4.69E-08	-6.74E-08
51.6	-3.34E-08	-6.05E-08
51.7	-2.04E-08	-5.36E-08
51.8	-8.07E-09	-4.68E-08
51.9	1.33E-09	-4.01E-08
52	4.07E-09	-3.36E-08
52.1	2.04E-08	-2.72E-08
52.2	3.64E-08	-2.06E-08
52.3	4.64E-08	-1.44E-08

53.5	-3.85E-08	4.97E-08
53.6	-4.90E-08	5.44E-08
53.7	-5.90E-08	5.89E-08
53.8	-6.88E-08	6.31E-08
53.9	-7.39E-08	6.52E-08
54	-7.58E-08	6.62E-08
54.1	-6.87E-08	6.60E-08
54.2	-5.76E-08	6.08E-08
54.3	-4.44E-08	5.47E-08
54.4	-3.13E-08	4.77E-08
54.5	-1.79E-08	4.00E-08
54.6	-5.49E-09	3.30E-08
54.7	3.74E-09	2.56E-08
54.8	1.48E-08	1.91E-08
54.9	2.04E-08	1.26E-08
55	3.85E-08	3.38E-09
55.1	4.84E-08	-3.00E-09
55.2	5.74E-08	-9.56E-09
55.3	6.12E-08	-1.59E-08
55.4	6.26E-08	-1.98E-08
64.1	1.59E-08	3.37E-08
64.2	9.39E-10	3.87E-08
64.3	-3.97E-09	4.34E-08
64.4	-1.98E-08	4.82E-08
64.5	-3.30E-08	5.29E-08
64.6	-4.35E-08	5.76E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
64.7	-5.35E-08	6.21E-08
64.8	-6.37E-08	6.42E-08
64.9	-7.21E-08	6.55E-08
65	-7.53E-08	6.60E-08
65.1	-7.33E-08	6.34E-08
65.2	-6.40E-08	5.69E-08
65.3	-5.10E-08	5.00E-08
65.4	-3.80E-08	4.24E-08
65.5	-2.47E-08	3.56E-08
65.6	-1.16E-08	2.87E-08
65.7	1.78E-10	2.16E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
77	2.09E-09	2.62E-08
77.1	1.34E-08	2.00E-08
77.2	2.04E-08	1.43E-08
77.3	3.78E-08	5.92E-09
77.4	4.77E-08	9.64E-11
77.5	5.68E-08	-3.97E-09
77.6	6.11E-08	-1.07E-08
77.7	6.29E-08	-1.63E-08
77.8	5.76E-08	-1.98E-08
77.9	4.75E-08	-2.45E-08
78	3.27E-08	-2.94E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
80.7	3.21E-08	-7.62E-09
80.8	1.77E-08	-1.73E-09
80.9	4.21E-09	3.36E-09
81	-1.08E-08	8.71E-09
81.1	-1.98E-08	1.42E-08
81.2	-3.18E-08	1.92E-08
94.2	6.32E-08	4.65E-08
94.3	6.08E-08	4.04E-08
94.4	5.27E-08	3.42E-08
94.5	3.99E-08	2.81E-08
94.6	2.59E-08	2.19E-08

65.8	8.81E-09	1.51E-08
65.9	1.99E-08	5.93E-09
66	3.32E-08	-4.50E-10
66.1	4.30E-08	-3.97E-09
66.2	5.24E-08	-1.27E-08
66.3	5.96E-08	-1.85E-08
66.4	6.25E-08	-2.21E-08
66.5	6.16E-08	-2.77E-08
66.6	5.45E-08	-3.37E-08
66.7	4.28E-08	-3.88E-08
66.8	2.87E-08	-4.44E-08
66.9	1.51E-08	-4.92E-08
67	3.60E-10	-5.42E-08
67.1	-3.97E-09	-5.94E-08
67.2	-1.98E-08	-6.43E-08
67.3	-3.22E-08	-6.97E-08
67.4	-4.30E-08	-7.43E-08
67.5	-5.32E-08	-7.89E-08
67.6	-6.30E-08	-8.12E-08
67.7	-7.13E-08	-8.30E-08
67.8	-7.48E-08	-8.30E-08
67.9	-7.44E-08	-7.87E-08
68	-6.58E-08	-7.12E-08
68.1	-5.35E-08	-6.39E-08
68.2	-4.03E-08	-5.69E-08
68.3	-2.76E-08	-4.96E-08

78.1	1.89E-08	-3.43E-08
78.2	6.09E-09	-3.91E-08
78.3	-9.12E-09	-4.46E-08
78.4	-1.98E-08	-4.93E-08
78.5	-3.17E-08	-5.38E-08
78.6	-4.24E-08	-5.83E-08
78.7	-5.27E-08	-6.28E-08
78.8	-6.34E-08	-6.72E-08
78.9	-7.23E-08	-7.17E-08
79	-7.53E-08	-7.59E-08
79.1	-7.23E-08	-7.96E-08
79.2	-6.23E-08	-8.13E-08
79.3	-4.89E-08	-8.27E-08
79.4	-3.52E-08	-8.29E-08
79.5	-2.12E-08	-8.02E-08
79.6	-7.69E-09	-7.37E-08
79.7	2.14E-09	-6.68E-08
79.8	1.34E-08	-6.00E-08
79.9	2.04E-08	-5.34E-08
80	3.75E-08	-4.71E-08
80.1	4.83E-08	-4.06E-08
80.2	5.75E-08	-3.44E-08
80.3	6.16E-08	-2.85E-08
80.4	6.28E-08	-2.26E-08
80.5	5.67E-08	-1.67E-08
80.6	4.65E-08	-1.09E-08

94.7	1.28E-08	1.62E-08
94.8	-2.29E-09	8.03E-09
94.9	-1.55E-08	2.73E-09
95	-1.98E-08	-2.60E-09
95.1	-3.59E-08	-8.30E-09
95.2	-4.66E-08	-1.34E-08
95.3	-5.72E-08	-1.83E-08
95.4	-6.71E-08	-2.08E-08
95.5	-7.32E-08	-2.59E-08
95.6	-7.54E-08	-3.09E-08
95.7	-6.96E-08	-3.54E-08
95.8	-5.95E-08	-4.01E-08
95.9	-4.58E-08	-4.47E-08
96	-3.21E-08	-4.91E-08
96.1	-1.86E-08	-5.33E-08
96.2	-6.51E-09	-5.78E-08
96.3	2.61E-09	-6.17E-08
96.4	1.37E-08	-6.56E-08
96.5	2.04E-08	-6.95E-08
96.6	3.81E-08	-7.35E-08
96.7	4.78E-08	-7.80E-08
96.8	5.66E-08	-8.05E-08
96.9	6.10E-08	-8.23E-08
97	6.34E-08	-8.28E-08
97.1	5.79E-08	-8.27E-08
97.2	4.84E-08	-7.95E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
97.3	3.41E-08	-7.33E-08
97.4	2.06E-08	-6.68E-08
97.5	8.08E-09	-6.07E-08
97.6	-7.01E-09	-5.51E-08
97.7	-1.97E-08	-4.91E-08
97.8	-2.89E-08	-4.28E-08
97.9	-3.99E-08	-3.73E-08
98	-5.04E-08	-3.16E-08
98.1	-6.07E-08	-2.62E-08
98.2	-7.02E-08	-2.05E-08
98.3	-7.42E-08	-1.50E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
113.9	-3.97E-09	4.03E-08
114	-1.98E-08	3.46E-08
114.1	-3.38E-08	2.85E-08
114.2	-4.51E-08	2.27E-08
114.3	-5.58E-08	1.69E-08
114.4	-6.59E-08	1.14E-08
114.5	-7.24E-08	3.05E-09
114.6	-7.53E-08	-2.34E-09
114.7	-7.10E-08	-7.45E-09
114.8	-6.09E-08	-1.28E-08
114.9	-4.68E-08	-1.79E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
130.5	-1.98E-08	4.32E-08
130.6	-3.78E-08	4.74E-08
130.7	-4.91E-08	5.20E-08
130.8	-5.95E-08	5.60E-08
130.9	-6.93E-08	6.01E-08
131	-7.37E-08	6.32E-08
131.1	-7.56E-08	6.47E-08
131.2	-6.80E-08	6.57E-08
131.3	-5.47E-08	6.56E-08
131.4	-4.03E-08	6.26E-08
131.5	-2.68E-08	5.67E-08

98.4	-7.55E-08	-9.66E-09
111.4	-3.80E-08	-8.45E-09
111.5	-4.88E-08	-6.11E-09
111.6	-5.91E-08	-1.32E-09
111.7	-6.86E-08	3.32E-09
111.8	-7.36E-08	7.85E-09
111.9	-7.55E-08	1.21E-08
112	-6.85E-08	1.69E-08
112.1	-5.68E-08	2.04E-08
112.2	-4.24E-08	2.79E-08
112.3	-2.93E-08	3.20E-08
112.4	-1.59E-08	3.62E-08
112.5	-3.53E-09	4.04E-08
112.6	5.53E-09	4.47E-08
112.7	1.69E-08	4.87E-08
112.8	2.04E-08	5.26E-08
112.9	4.07E-08	5.66E-08
113	5.05E-08	6.02E-08
113.1	5.89E-08	6.33E-08
113.2	6.23E-08	6.51E-08
113.3	6.22E-08	6.57E-08
113.4	5.48E-08	6.57E-08
113.5	4.33E-08	6.40E-08
113.6	2.95E-08	5.81E-08
113.7	1.55E-08	5.27E-08
113.8	-3.77E-10	4.67E-08

115	-3.31E-08	-2.05E-08
115.1	-2.07E-08	-2.57E-08
115.2	-7.87E-09	-3.08E-08
115.3	1.78E-09	-3.56E-08
115.4	1.35E-08	-4.03E-08
115.5	2.04E-08	-4.50E-08
115.6	3.70E-08	-4.96E-08
128.6	-5.56E-08	-6.16E-08
128.7	-4.20E-08	-5.53E-08
128.8	-2.82E-08	-4.87E-08
128.9	-1.49E-08	-4.21E-08
129	-2.44E-09	-3.58E-08
129.1	6.84E-09	-2.96E-08
129.2	1.81E-08	-2.37E-08
129.3	2.04E-08	-1.78E-08
129.4	4.23E-08	-1.22E-08
129.5	5.21E-08	-6.35E-09
129.6	5.96E-08	-3.09E-09
129.7	6.24E-08	2.33E-09
129.8	6.08E-08	7.04E-09
129.9	5.35E-08	1.22E-08
130	4.07E-08	1.71E-08
130.1	2.56E-08	2.04E-08
130.2	1.18E-08	2.93E-08
130.3	-3.69E-09	3.42E-08
130.4	-1.60E-08	3.87E-08

131.6	-1.41E-08	5.05E-08
131.7	-1.30E-09	4.44E-08
131.8	8.43E-09	3.80E-08
131.9	1.99E-08	3.19E-08
132	3.28E-08	2.56E-08
132.1	4.34E-08	1.96E-08
132.2	5.38E-08	1.38E-08
132.3	6.04E-08	5.93E-09
132.4	6.28E-08	4.85E-10
132.5	5.90E-08	-3.97E-09
132.6	5.08E-08	-1.05E-08
132.7	3.71E-08	-1.58E-08
132.8	2.23E-08	-1.98E-08
145.8	4.82E-08	-4.69E-08
145.9	3.38E-08	-5.19E-08
146	1.94E-08	-5.71E-08
146.1	6.25E-09	-6.20E-08
146.2	-8.99E-09	-6.68E-08
146.3	-1.98E-08	-7.17E-08
146.4	-3.09E-08	-7.63E-08
146.5	-4.21E-08	-8.00E-08
146.6	-5.28E-08	-8.15E-08
146.7	-6.30E-08	-8.26E-08
146.8	-7.17E-08	-8.21E-08
146.9	-7.51E-08	-7.66E-08
147	-7.36E-08	-6.92E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
147.1	-6.41E-08	-6.16E-08
147.2	-5.00E-08	-5.47E-08
147.3	-3.65E-08	-4.75E-08
147.4	-2.31E-08	-4.08E-08
147.5	-1.02E-08	-3.40E-08
147.6	-3.79E-10	-2.73E-08
147.7	4.07E-09	-2.09E-08
147.8	2.04E-08	-1.44E-08
147.9	3.58E-08	-8.08E-09
148	4.63E-08	-4.49E-09
148.1	5.63E-08	1.33E-09

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
168	-4.07E-08	-4.26E-08
168.1	-5.19E-08	-4.82E-08
168.2	-6.20E-08	-5.36E-08
168.3	-7.06E-08	-5.87E-08
168.4	-7.47E-08	-6.38E-08
168.5	-7.49E-08	-6.88E-08
168.6	-6.59E-08	-7.37E-08
168.7	-5.22E-08	-7.84E-08
168.8	-3.79E-08	-8.07E-08
168.9	-2.45E-08	-8.24E-08
169	-1.16E-08	-8.24E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
188.9	6.08E-08	4.70E-08
189	5.35E-08	3.92E-08
189.1	4.07E-08	3.18E-08
189.2	2.58E-08	2.43E-08
189.3	1.20E-08	1.74E-08
189.4	-3.50E-09	1.05E-08
189.5	-1.58E-08	1.12E-09
189.6	-1.98E-08	-3.97E-09
189.7	-3.71E-08	-1.19E-08
189.8	-4.83E-08	-1.82E-08
189.9	-5.87E-08	-2.20E-08

148.2	6.11E-08	4.07E-09
148.3	6.28E-08	1.24E-08
148.4	5.73E-08	1.79E-08
148.5	4.75E-08	2.04E-08
148.6	3.36E-08	3.11E-08
148.7	1.91E-08	3.62E-08
148.8	5.29E-09	4.12E-08
148.9	-1.01E-08	4.61E-08
149	-1.98E-08	5.10E-08
149.1	-3.19E-08	5.57E-08
149.2	-4.36E-08	6.04E-08
149.3	-5.46E-08	6.35E-08
149.4	-6.47E-08	6.50E-08
149.5	-7.20E-08	6.61E-08
149.6	-7.50E-08	6.48E-08
149.7	-7.17E-08	5.83E-08
149.8	-6.17E-08	5.18E-08
149.9	-4.71E-08	4.43E-08
150	-3.27E-08	3.70E-08
167.3	4.93E-08	-3.45E-09
167.4	3.53E-08	-9.61E-09
167.5	2.11E-08	-1.59E-08
167.6	7.48E-09	-1.98E-08
167.7	-7.69E-09	-2.57E-08
167.8	-1.98E-08	-3.13E-08
167.9	-2.93E-08	-3.70E-08

169.1	5.15E-10	-7.93E-08
169.2	1.00E-08	-7.17E-08
169.3	2.04E-08	-6.42E-08
169.4	3.49E-08	-5.67E-08
169.5	4.49E-08	-4.95E-08
169.6	5.47E-08	-4.25E-08
169.7	6.07E-08	-3.54E-08
169.8	6.30E-08	-2.85E-08
169.9	5.86E-08	-2.17E-08
170	4.98E-08	-1.53E-08
170.1	3.56E-08	-8.65E-09
170.2	2.17E-08	-5.35E-09
170.3	8.32E-09	6.74E-10
170.4	-7.42E-09	4.07E-09
170.5	-1.98E-08	1.23E-08
170.6	-2.95E-08	1.80E-08
170.7	-4.06E-08	2.04E-08
170.8	-5.12E-08	3.16E-08
170.9	-6.20E-08	3.67E-08
171	-7.11E-08	4.17E-08
171.1	-7.48E-08	4.69E-08
171.2	-7.46E-08	5.19E-08
171.3	-6.53E-08	5.68E-08
171.4	-5.22E-08	6.14E-08
171.5	-3.86E-08	6.37E-08
188.8	6.22E-08	5.45E-08

190	-6.86E-08	-2.81E-08
190.1	-7.37E-08	-3.40E-08
190.2	-7.56E-08	-3.98E-08
190.3	-6.86E-08	-4.52E-08
190.4	-5.61E-08	-5.09E-08
190.5	-4.17E-08	-5.61E-08
190.6	-2.83E-08	-6.15E-08
190.7	-1.52E-08	-6.68E-08
190.8	-2.62E-09	-7.16E-08
190.9	7.04E-09	-7.65E-08
191	1.87E-08	-8.00E-08
191.1	3.20E-08	-8.14E-08
191.2	4.23E-08	-8.26E-08
191.3	5.25E-08	-8.16E-08
191.4	5.98E-08	-7.44E-08
191.5	6.27E-08	-6.65E-08
191.6	6.02E-08	-5.88E-08
191.7	5.23E-08	-5.12E-08
191.8	3.93E-08	-4.41E-08
191.9	2.51E-08	-3.67E-08
192	1.09E-08	-2.99E-08
192.1	-4.84E-09	-2.28E-08
192.2	-1.74E-08	-1.64E-08
192.3	-1.98E-08	-1.03E-08
192.4	-3.79E-08	-6.47E-09
192.5	-4.92E-08	8.90E-11

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
192.6	-5.99E-08	4.07E-09
192.7	-6.97E-08	1.22E-08
192.8	-7.42E-08	1.81E-08
192.9	-7.53E-08	2.04E-08
193	-6.71E-08	3.16E-08
240.4	2.04E-08	4.07E-09
240.5	3.52E-08	1.09E-08
240.6	4.50E-08	1.61E-08
240.7	5.46E-08	2.04E-08
240.8	6.07E-08	2.90E-08
240.9	6.31E-08	3.42E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
243.6	6.07E-08	-4.73E-08
243.7	6.30E-08	-5.30E-08
243.8	5.90E-08	-5.84E-08
243.9	5.08E-08	-6.33E-08
244	3.71E-08	-6.85E-08
244.1	2.33E-08	-7.34E-08
244.2	1.03E-08	-7.79E-08
244.3	-4.83E-09	-8.06E-08
244.4	-1.70E-08	-8.24E-08
244.5	-1.98E-08	-8.25E-08
244.6	-3.75E-08	-7.88E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
264.5	-5.67E-08	2.52E-09
264.6	-6.93E-08	-3.56E-09
264.7	-7.37E-08	-9.20E-09
264.8	-7.55E-08	-1.52E-08
264.9	-6.95E-08	-1.98E-08
265	-5.90E-08	-2.42E-08
265.1	-4.54E-08	-2.96E-08
265.2	-3.27E-08	-3.52E-08
265.3	-2.06E-08	-4.01E-08
265.4	-8.65E-09	-4.51E-08
265.5	6.53E-10	-5.03E-08

241	5.94E-08	3.91E-08
241.1	5.15E-08	4.40E-08
241.2	3.84E-08	4.90E-08
241.3	2.50E-08	5.34E-08
241.4	1.15E-08	5.83E-08
241.5	-3.92E-09	6.22E-08
241.6	-1.61E-08	6.40E-08
241.7	-1.98E-08	6.56E-08
241.8	-3.64E-08	6.56E-08
241.9	-4.72E-08	6.17E-08
242	-5.76E-08	5.49E-08
242.1	-6.75E-08	4.83E-08
242.2	-7.33E-08	4.10E-08
242.3	-7.55E-08	3.38E-08
242.4	-7.00E-08	2.66E-08
242.5	-6.00E-08	1.95E-08
242.6	-4.63E-08	1.28E-08
242.7	-3.29E-08	4.11E-09
242.8	-1.99E-08	-2.52E-09
242.9	-7.75E-09	-8.58E-09
243	1.75E-09	-1.50E-08
243.1	1.27E-08	-1.98E-08
243.2	2.04E-08	-2.48E-08
243.3	3.67E-08	-3.05E-08
243.4	4.65E-08	-3.58E-08
243.5	5.56E-08	-4.15E-08

261.9	-7.51E-08	-5.64E-09
262	-7.38E-08	-6.01E-11
262.1	-6.44E-08	4.07E-09
262.2	-5.08E-08	1.09E-08
262.3	-3.75E-08	1.62E-08
262.4	-2.46E-08	2.04E-08
262.5	-1.30E-08	2.93E-08
262.6	-1.31E-09	3.45E-08
262.7	7.92E-09	3.92E-08
262.8	1.87E-08	4.41E-08
262.9	3.12E-08	4.87E-08
263	4.11E-08	5.34E-08
263.1	5.09E-08	5.81E-08
263.2	5.91E-08	6.20E-08
263.3	6.22E-08	6.41E-08
263.4	6.22E-08	6.53E-08
263.5	5.59E-08	6.60E-08
263.6	4.60E-08	6.38E-08
263.7	3.21E-08	5.76E-08
263.8	1.87E-08	5.07E-08
263.9	5.95E-09	4.37E-08
264	-8.62E-09	3.72E-08
264.1	-1.98E-08	3.02E-08
264.2	-2.91E-08	2.37E-08
264.3	-4.00E-08	1.74E-08
264.4	-5.03E-08	1.11E-08

265.6	4.07E-09	-5.50E-08
265.7	2.04E-08	-6.03E-08
265.8	3.46E-08	-6.50E-08
265.9	4.45E-08	-7.01E-08
266	5.40E-08	-7.45E-08
266.1	6.05E-08	-7.89E-08
274.8	6.29E-08	2.04E-08
274.9	5.63E-08	1.35E-08
275	4.78E-08	4.28E-09
275.1	3.46E-08	-2.33E-09
275.2	2.14E-08	-8.50E-09
275.3	8.81E-09	-1.45E-08
275.4	-9.11E-09	-1.98E-08
275.5	-1.74E-08	-2.44E-08
275.6	-1.98E-08	-3.04E-08
275.7	-3.67E-08	-3.60E-08
275.8	-4.71E-08	-4.13E-08
275.9	-5.68E-08	-4.67E-08
276	-6.63E-08	-5.20E-08
276.1	-7.27E-08	-5.70E-08
276.2	-7.57E-08	-6.21E-08
276.3	-7.34E-08	-6.69E-08
276.4	-6.39E-08	-7.17E-08
276.5	-5.13E-08	-7.63E-08
276.6	-3.83E-08	-7.98E-08
276.7	-2.77E-08	-8.18E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
276.8	-1.42E-08	-8.30E-08
276.9	-3.20E-09	-8.21E-08
277	6.57E-09	-7.64E-08
277.1	1.29E-08	-6.89E-08
277.2	2.04E-08	-6.16E-08
277.3	3.83E-08	-5.47E-08
277.4	4.95E-08	-4.83E-08
277.5	5.67E-08	-4.13E-08
277.6	6.30E-08	-3.49E-08
277.7	6.20E-08	-2.83E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
293.1	-5.61E-08	-6.90E-08
293.2	-6.57E-08	-7.39E-08
293.3	-7.24E-08	-7.85E-08
293.4	-7.47E-08	-8.09E-08
293.5	-7.24E-08	-8.25E-08
293.6	-6.40E-08	-8.25E-08
293.7	-5.20E-08	-7.75E-08
293.8	-3.90E-08	-6.95E-08
293.9	-2.59E-08	-6.14E-08
294	-1.36E-08	-5.40E-08

Elapsed Time (s)	CHAZ Current (A)	SAHAZ Current (A)
296.7	-4.27E-08	2.80E-08
296.8	-3.01E-08	2.05E-08
296.9	-1.83E-08	1.31E-08
297	-6.70E-09	3.70E-09
297.1	2.00E-09	-3.23E-09
297.2	1.29E-08	-9.78E-09
297.3	2.04E-08	-1.59E-08
297.4	3.52E-08	-1.98E-08
297.5	4.50E-08	-2.65E-08
297.6	5.43E-08	-3.25E-08

277.8	5.73E-08	-2.22E-08	294.1	-2.01E-09	-4.64E-08	297.7	6.02E-08	-3.80E-08
277.9	4.84E-08	-1.61E-08	294.2	6.65E-09	-3.89E-08	297.8	6.28E-08	-4.38E-08
278	3.48E-08	-1.01E-08	294.3	1.69E-08	-3.20E-08	297.9	6.09E-08	-5.00E-08
278.1	2.51E-08	-6.43E-09	294.4	2.04E-08	-2.50E-08	298	5.38E-08	-5.54E-08
278.2	8.97E-09	-6.97E-10	294.5	3.94E-08	-1.82E-08	298.1	4.24E-08	-6.09E-08
278.3	-5.85E-09	4.07E-09	294.6	4.86E-08	-1.14E-08	298.2	2.90E-08	-6.59E-08
278.4	-1.72E-08	1.01E-08	294.7	5.70E-08	-4.88E-09	298.3	1.62E-08	-7.10E-08
278.5	-1.98E-08	1.55E-08	294.8	6.10E-08	-4.94E-10	298.4	1.68E-09	-7.61E-08
278.6	-3.75E-08	2.04E-08	294.9	6.30E-08	4.07E-09	298.5	-1.05E-08	-8.00E-08
278.7	-4.81E-08	2.85E-08	295	5.81E-08	1.19E-08	298.6	-1.98E-08	-8.14E-08
278.8	-5.78E-08	3.33E-08	295.1	5.02E-08	1.77E-08	298.7	-3.00E-08	-8.26E-08
278.9	-6.72E-08	3.83E-08	295.2	3.71E-08	2.04E-08	298.8	-4.05E-08	-8.11E-08
279	-7.32E-08	4.33E-08	295.3	2.45E-08	3.14E-08	298.9	-5.09E-08	-7.38E-08
292	6.29E-08	-8.02E-09	295.4	1.19E-08	3.71E-08	299	-6.05E-08	-6.57E-08
292.1	5.77E-08	-1.48E-08	295.5	-2.51E-09	4.26E-08	299.1	-6.96E-08	-5.81E-08
292.2	4.92E-08	-1.98E-08	295.6	-1.44E-08	4.79E-08	299.2	-7.37E-08	-5.05E-08
292.3	3.57E-08	-2.46E-08	295.7	-1.98E-08	5.33E-08	299.3	-7.52E-08	-4.34E-08
292.4	2.23E-08	-3.07E-08	295.8	-3.36E-08	5.85E-08	299.4	-6.90E-08	-3.64E-08
292.5	1.02E-08	-3.63E-08	295.9	-4.36E-08	6.24E-08	299.5	-5.89E-08	-2.96E-08
292.6	-4.21E-09	-4.20E-08	296	-5.38E-08	6.50E-08	299.6	-4.53E-08	-2.26E-08
292.7	-1.62E-08	-4.77E-08	296.1	-6.35E-08	6.62E-08	299.7	-3.24E-08	-1.61E-08
292.8	-1.98E-08	-5.31E-08	296.2	-7.14E-08	6.52E-08	299.8	-2.02E-08	-9.46E-09
292.9	-3.65E-08	-5.86E-08	296.3	-7.45E-08	5.84E-08	299.9	-8.59E-09	-5.65E-09
293	-4.65E-08	-6.37E-08	296.4	-7.51E-08	5.13E-08	300	4.34E-10	6.06E-10

Table B.12: Electrochemical Current Noise (ECN) Results from Potentiostatic Corrosion Measurement for the Control and Solution Annealed Welded Zone (WZ)of the Samples Immersed in 1M NaCl Environment

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)	Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)	Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
0.1	6.09E-08	2.04E-08	3.5	4.02E-08	-1.37E-09	23.7	-2.24E-08	3.56E-09
0.2	6.33E-09	2.15E-08	3.6	2.93E-08	-6.52E-09	23.8	-1.32E-08	8.60E-09
0.3	-6.11E-09	1.91E-08	3.7	1.80E-08	-1.18E-08	23.9	-4.06E-09	1.30E-08
0.4	-1.52E-08	1.55E-08	3.8	8.80E-09	-1.66E-08	24	2.55E-09	1.66E-08
0.5	-1.98E-08	9.15E-09	20.7	3.46E-08	-1.12E-08	24.1	1.11E-08	1.91E-08
0.6	-3.07E-08	4.29E-09	20.8	4.25E-08	-8.65E-09	24.2	1.94E-08	2.28E-08
0.7	-3.93E-08	-9.84E-10	20.9	4.98E-08	-3.52E-09	24.3	3.02E-08	2.29E-08
0.8	-4.78E-08	-3.97E-09	21	5.70E-08	1.52E-09	24.4	3.77E-08	2.18E-08
0.9	-5.18E-08	-1.14E-08	21.1	6.32E-08	4.07E-09	24.5	4.52E-08	1.96E-08

1	-6.24E-08	-1.63E-08	21.2	6.41E-08	1.11E-08	24.6	5.23E-08	1.61E-08
1.1	-7.04E-08	-1.98E-08	21.3	6.31E-08	1.49E-08	24.7	5.97E-08	9.61E-09
1.2	-7.76E-08	-2.09E-08	21.4	5.82E-08	1.80E-08	24.8	6.40E-08	4.60E-09
1.3	-8.13E-08	-2.25E-08	21.5	4.83E-08	1.96E-08	41.7	-7.58E-08	-1.98E-08
1.4	-8.13E-08	-2.29E-08	21.6	3.74E-08	2.30E-08	41.8	-7.93E-08	-2.06E-08
1.5	-7.64E-08	-2.21E-08	21.7	2.68E-08	2.24E-08	41.9	-7.89E-08	-2.22E-08
1.6	-6.66E-08	-2.01E-08	21.8	1.67E-08	2.09E-08	42	-7.64E-08	-2.29E-08
1.7	-5.54E-08	-1.74E-08	21.9	6.60E-09	1.82E-08	42.1	-6.74E-08	-2.22E-08
1.8	-4.53E-08	-1.37E-08	22	-5.51E-09	1.45E-08	42.2	-5.72E-08	-2.03E-08
1.9	-3.46E-08	-9.13E-09	22.1	-1.47E-08	7.85E-09	42.3	-4.72E-08	-1.79E-08
2	-2.47E-08	-6.80E-09	22.2	-1.98E-08	2.58E-09	42.4	-3.75E-08	-1.42E-08
2.1	-1.52E-08	-1.87E-09	22.3	-2.99E-08	-2.88E-09	42.5	-2.75E-08	-9.80E-09
2.2	-5.97E-09	2.91E-09	22.4	-3.86E-08	-8.17E-09	42.6	-1.82E-08	-7.61E-09
2.3	1.60E-09	7.69E-09	22.5	-4.68E-08	-1.36E-08	42.7	-9.16E-09	-2.70E-09
2.4	4.07E-09	1.20E-08	22.6	-5.45E-08	-1.81E-08	42.8	-3.12E-09	2.11E-09
2.5	1.80E-08	1.56E-08	22.7	-6.25E-08	-1.95E-08	42.9	5.50E-09	6.87E-09
2.6	2.04E-08	1.84E-08	22.8	-6.98E-08	-2.18E-08	43	1.36E-08	1.14E-08
2.7	3.67E-08	2.24E-08	22.9	-7.63E-08	-2.28E-08	43.1	2.04E-08	1.50E-08
2.8	4.48E-08	2.30E-08	23	-7.86E-08	-2.23E-08	43.2	3.15E-08	1.81E-08
2.9	5.22E-08	2.26E-08	23.1	-7.83E-08	-2.05E-08	43.3	3.92E-08	1.98E-08
3	5.89E-08	2.11E-08	23.2	-7.46E-08	-1.79E-08	43.4	4.64E-08	2.31E-08
3.1	6.39E-08	1.86E-08	23.3	-6.43E-08	-1.41E-08	43.5	5.33E-08	2.28E-08
3.2	6.44E-08	1.51E-08	23.4	-5.30E-08	-9.29E-09	43.6	6.00E-08	2.15E-08
3.3	6.23E-08	8.77E-09	23.5	-4.28E-08	-6.71E-09	43.7	6.42E-08	1.92E-08
3.4	5.08E-08	3.89E-09	23.6	-3.26E-08	-1.53E-09	43.8	6.43E-08	1.59E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)	Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)	Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
43.9	6.27E-08	9.61E-09	64.4	-5.67E-08	-2.25E-08	80.7	-7.35E-08	-1.54E-08
44	5.63E-08	4.99E-09	64.5	-6.38E-08	-2.17E-08	80.8	-6.28E-08	-1.92E-08
44.1	4.66E-08	-2.63E-10	64.6	-7.05E-08	-1.98E-08	80.9	-5.24E-08	-2.00E-08
44.2	3.63E-08	-3.97E-09	64.7	-7.69E-08	-1.72E-08	81	-4.22E-08	-2.17E-08
44.3	2.63E-08	-1.05E-08	64.8	-7.92E-08	-1.38E-08	81.1	-3.25E-08	-2.24E-08
44.4	1.66E-08	-1.54E-08	64.9	-7.85E-08	-9.34E-09	81.2	-2.30E-08	-2.19E-08
44.5	4.60E-09	-1.94E-08	65	-7.64E-08	-7.11E-09	81.3	-1.37E-08	-2.03E-08
44.6	-4.65E-09	-2.04E-08	65.1	-6.82E-08	-2.26E-09	81.4	-5.33E-09	-1.80E-08
44.7	-1.30E-08	-2.21E-08	65.2	-5.82E-08	2.44E-09	81.5	1.24E-09	-1.46E-08
44.8	-1.98E-08	-2.29E-08	65.3	-4.85E-08	7.08E-09	81.6	4.07E-09	-1.07E-08
44.9	-2.74E-08	-2.22E-08	65.4	-3.89E-08	1.15E-08	81.7	1.78E-08	-8.55E-09

45	-3.51E-08	-2.05E-08
45.1	-4.28E-08	-1.80E-08
45.2	-5.05E-08	-1.45E-08
45.3	-5.77E-08	-1.02E-08
45.4	-6.52E-08	-7.93E-09
45.5	-7.18E-08	-3.06E-09
45.6	-7.80E-08	1.74E-09
45.7	-7.92E-08	6.47E-09
45.8	-7.82E-08	1.10E-08
62.7	6.18E-08	1.50E-08
62.8	6.42E-08	1.80E-08
62.9	6.38E-08	1.96E-08
63	6.17E-08	2.28E-08
63.1	5.41E-08	2.24E-08
63.2	4.53E-08	2.10E-08
63.3	3.52E-08	1.86E-08
63.4	2.56E-08	1.52E-08
63.5	1.56E-08	9.04E-09
63.6	4.27E-09	4.19E-09
63.7	-4.81E-09	-9.68E-10
63.8	-1.29E-08	-3.97E-09
63.9	-1.98E-08	-1.12E-08
64	-2.69E-08	-1.58E-08
64.1	-3.50E-08	-1.97E-08
64.2	-4.24E-08	-2.03E-08
64.3	-4.98E-08	-2.20E-08

65.5	-2.96E-08	1.51E-08
65.6	-2.07E-08	1.78E-08
65.7	-1.21E-08	1.95E-08
65.8	-3.39E-09	2.26E-08
65.9	2.16E-09	2.22E-08
66	1.02E-08	2.09E-08
66.1	1.79E-08	1.85E-08
66.2	2.04E-08	1.50E-08
66.3	3.52E-08	8.70E-09
66.4	4.22E-08	3.86E-09
66.5	4.92E-08	-1.31E-09
66.6	5.59E-08	-6.54E-09
66.7	6.21E-08	-1.17E-08
66.8	6.45E-08	-1.64E-08
79.5	-1.47E-08	1.80E-08
79.6	-1.98E-08	1.96E-08
79.7	-2.92E-08	2.27E-08
79.8	-3.72E-08	2.23E-08
79.9	-4.54E-08	2.08E-08
80	-5.27E-08	1.86E-08
80.1	-6.07E-08	1.52E-08
80.2	-6.74E-08	9.04E-09
80.3	-7.45E-08	4.40E-09
80.4	-8.06E-08	-6.48E-10
80.5	-7.88E-08	-3.97E-09
80.6	-7.79E-08	-1.06E-08

81.8	2.04E-08	-3.93E-09
81.9	3.55E-08	7.15E-10
82	4.28E-08	4.07E-09
82.1	5.00E-08	9.72E-09
82.2	5.69E-08	1.35E-08
82.3	6.28E-08	1.66E-08
82.4	6.06E-08	1.87E-08
82.5	6.31E-08	2.24E-08
82.6	5.91E-08	2.26E-08
82.7	4.68E-08	2.18E-08
82.8	3.72E-08	2.02E-08
82.9	2.84E-08	1.75E-08
83	1.79E-08	1.41E-08
83.1	8.16E-09	7.84E-09
83.2	-3.81E-09	3.16E-09
83.3	-1.24E-08	-1.77E-09
83.4	-1.98E-08	-6.64E-09
83.5	-2.71E-08	-1.15E-08
83.6	-3.50E-08	-1.60E-08
100.5	-5.61E-08	-1.10E-08
100.6	-4.59E-08	-1.58E-08
100.7	-3.63E-08	-1.97E-08
100.8	-2.66E-08	-2.03E-08
100.9	-1.79E-08	-2.19E-08
101	-8.71E-09	-2.23E-08
101.1	-2.42E-09	-2.14E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
101.2	5.74E-09	-1.95E-08
101.3	1.39E-08	-1.68E-08
101.4	2.04E-08	-1.31E-08
101.5	3.18E-08	-8.41E-09
101.6	3.93E-08	-6.20E-09
101.7	4.65E-08	-1.32E-09
101.8	5.36E-08	3.35E-09
101.9	6.05E-08	8.13E-09
102	6.42E-08	1.24E-08
102.1	6.38E-08	1.58E-08
102.2	6.24E-08	1.83E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
117.5	2.76E-08	-1.99E-08
117.6	1.77E-08	-1.74E-08
117.7	7.82E-09	-1.36E-08
117.8	-3.88E-09	-9.00E-09
117.9	-1.35E-08	-6.59E-09
118	-1.98E-08	-1.58E-09
118.1	-2.82E-08	3.27E-09
118.2	-3.64E-08	8.23E-09
118.3	-4.44E-08	1.25E-08
118.4	-5.24E-08	1.60E-08
118.5	-6.00E-08	1.85E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
121.2	3.14E-08	1.89E-08
121.3	2.14E-08	2.24E-08
121.4	1.13E-08	2.23E-08
142.5	6.29E-08	-1.59E-08
142.6	6.23E-08	-1.21E-08
142.7	5.43E-08	-7.43E-09
142.8	4.26E-08	-5.10E-09
142.9	3.32E-08	-3.07E-10
143	2.22E-08	4.07E-09
143.1	1.21E-08	9.05E-09
143.2	-2.15E-10	1.30E-08

102.3	5.52E-08	1.97E-08
102.4	4.55E-08	2.26E-08
102.5	3.51E-08	2.19E-08
102.6	2.51E-08	2.01E-08
102.7	1.51E-08	1.73E-08
102.8	3.36E-09	1.37E-08
102.9	-6.19E-09	7.05E-09
103	-1.49E-08	2.04E-09
103.1	-1.98E-08	-3.23E-09
103.2	-2.96E-08	-8.30E-09
103.3	-3.73E-08	-1.35E-08
103.4	-4.57E-08	-1.79E-08
103.5	-5.28E-08	-1.90E-08
103.6	-6.04E-08	-2.13E-08
103.7	-6.76E-08	-2.24E-08
103.8	-7.50E-08	-2.21E-08
103.9	-7.89E-08	-2.04E-08
104	-7.87E-08	-1.80E-08
104.1	-7.69E-08	-1.46E-08
104.2	-6.92E-08	-1.02E-08
104.3	-5.86E-08	-7.78E-09
104.4	-4.83E-08	-2.85E-09
104.5	-3.84E-08	2.08E-09
104.6	-2.89E-08	6.86E-09
117.3	4.90E-08	-2.23E-08
117.4	3.84E-08	-2.17E-08

118.6	-6.75E-08	2.22E-08
118.7	-7.45E-08	2.24E-08
118.8	-7.87E-08	2.15E-08
118.9	-8.16E-08	1.96E-08
119	-7.97E-08	1.63E-08
119.1	-7.01E-08	1.00E-08
119.2	-5.48E-08	5.36E-09
119.3	-4.75E-08	6.57E-11
119.4	-3.47E-08	-3.97E-09
119.5	-2.92E-08	-1.05E-08
119.6	-1.99E-08	-1.55E-08
119.7	-9.57E-09	-1.95E-08
119.8	-2.34E-09	-2.03E-08
119.9	1.44E-08	-2.19E-08
120	1.70E-08	-2.23E-08
120.1	2.04E-08	-2.12E-08
120.2	3.20E-08	-1.97E-08
120.3	4.04E-08	-1.60E-08
120.4	4.88E-08	-1.21E-08
120.5	5.55E-08	-7.81E-09
120.6	6.08E-08	-4.95E-09
120.7	6.13E-08	-5.52E-13
120.8	6.09E-08	4.07E-09
120.9	5.99E-08	9.60E-09
121	4.87E-08	1.36E-08
121.1	4.19E-08	1.69E-08

143.3	-3.97E-09	1.63E-08
143.4	-1.88E-08	1.85E-08
143.5	-2.46E-08	2.22E-08
143.6	-3.45E-08	2.24E-08
143.7	-4.21E-08	2.15E-08
143.8	-4.97E-08	1.97E-08
143.9	-5.82E-08	1.68E-08
144	-6.47E-08	1.32E-08
144.1	-7.27E-08	6.52E-09
144.2	-7.93E-08	1.47E-09
144.3	-7.98E-08	-3.86E-09
144.4	-8.01E-08	-8.63E-09
144.5	-7.47E-08	-1.37E-08
144.6	-6.41E-08	-1.79E-08
144.7	-5.35E-08	-1.90E-08
144.8	-4.20E-08	-2.12E-08
144.9	-3.30E-08	-2.22E-08
145	-2.30E-08	-2.18E-08
145.1	-1.34E-08	-2.03E-08
145.2	-5.29E-09	-1.80E-08
145.3	2.43E-09	-1.47E-08
145.4	1.11E-08	-1.05E-08
145.5	1.96E-08	-8.26E-09
145.6	2.96E-08	-3.51E-09
145.7	3.78E-08	1.27E-09
145.8	4.47E-08	4.07E-09

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
145.9	5.19E-08	1.06E-08
146	5.93E-08	1.43E-08
146.1	6.33E-08	1.74E-08
146.2	6.37E-08	1.91E-08
146.3	6.20E-08	2.24E-08
146.4	5.36E-08	2.22E-08
146.5	4.32E-08	2.09E-08
146.6	3.22E-08	1.85E-08
171.9	6.24E-08	2.08E-08
172	5.84E-08	1.87E-08
172.1	4.73E-08	1.56E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
174.8	1.16E-08	2.01E-08
174.9	1.94E-08	1.75E-08
175	3.04E-08	1.40E-08
175.1	3.78E-08	7.75E-09
175.2	4.54E-08	2.93E-09
175.3	5.25E-08	-2.06E-09
175.4	5.96E-08	-6.97E-09
175.5	6.27E-08	-1.20E-08
175.6	6.39E-08	-1.64E-08
175.7	6.19E-08	-1.98E-08
175.8	5.29E-08	-2.04E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
182.7	3.69E-08	1.22E-08
182.8	4.43E-08	1.55E-08
182.9	5.19E-08	1.80E-08
183	5.89E-08	1.94E-08
183.1	6.37E-08	2.24E-08
183.2	6.38E-08	2.19E-08
183.3	6.25E-08	2.05E-08
183.4	5.44E-08	1.81E-08
183.5	4.38E-08	1.48E-08
183.6	3.32E-08	8.68E-09
183.7	2.33E-08	4.10E-09

172.2	3.81E-08	9.47E-09
172.3	2.54E-08	5.18E-09
172.4	1.64E-08	3.05E-10
172.5	4.29E-09	-3.97E-09
172.6	-6.25E-09	-9.34E-09
172.7	-1.39E-08	-1.42E-08
172.8	-1.98E-08	-1.81E-08
172.9	-3.05E-08	-1.90E-08
173	-3.80E-08	-2.11E-08
173.1	-4.62E-08	-2.21E-08
173.2	-5.33E-08	-2.19E-08
173.3	-6.12E-08	-2.05E-08
173.4	-6.90E-08	-1.84E-08
173.5	-7.51E-08	-1.54E-08
173.6	-8.11E-08	-1.16E-08
173.7	-8.33E-08	-7.12E-09
173.8	-8.14E-08	-4.97E-09
173.9	-7.16E-08	-3.58E-10
174	-6.23E-08	3.92E-09
174.1	-5.08E-08	8.73E-09
174.2	-4.06E-08	1.26E-08
174.3	-3.17E-08	1.59E-08
174.4	-2.25E-08	1.82E-08
174.5	-1.23E-08	1.96E-08
174.6	-2.56E-09	2.24E-08
174.7	3.22E-09	2.18E-08

175.9	4.27E-08	-2.18E-08
176	3.15E-08	-2.21E-08
180.3	-1.71E-08	2.23E-08
180.4	-1.98E-08	2.12E-08
180.5	-3.03E-08	1.94E-08
180.6	-3.89E-08	1.64E-08
180.7	-4.78E-08	1.04E-08
180.8	-5.43E-08	6.24E-09
180.9	-6.20E-08	1.32E-09
181	-6.81E-08	-3.86E-09
181.1	-7.52E-08	-8.49E-09
181.2	-8.00E-08	-1.35E-08
181.3	-8.13E-08	-1.76E-08
181.4	-7.96E-08	-1.98E-08
181.5	-7.24E-08	-2.08E-08
181.6	-6.10E-08	-2.20E-08
181.7	-5.11E-08	-2.19E-08
181.8	-4.10E-08	-2.06E-08
181.9	-3.17E-08	-1.85E-08
182	-2.18E-08	-1.56E-08
182.1	-1.32E-08	-1.19E-08
182.2	-4.21E-09	-7.51E-09
182.3	2.21E-09	-5.43E-09
182.4	1.15E-08	-8.12E-10
182.5	1.89E-08	3.42E-09
182.6	2.98E-08	4.07E-09

183.8	1.37E-08	-8.86E-10
183.9	1.60E-09	-3.97E-09
184	-3.97E-09	-1.07E-08
184.1	-1.73E-08	-1.54E-08
184.2	-1.98E-08	-1.92E-08
184.3	-3.19E-08	-1.99E-08
184.4	-3.99E-08	-2.15E-08
197.1	1.47E-08	2.03E-08
197.2	2.04E-08	1.75E-08
197.3	3.43E-08	1.39E-08
197.4	4.18E-08	7.40E-09
197.5	4.90E-08	2.32E-09
197.6	5.68E-08	-2.95E-09
197.7	6.07E-08	-8.02E-09
197.8	6.28E-08	-1.33E-08
197.9	6.17E-08	-1.76E-08
198	5.42E-08	-1.98E-08
198.1	4.37E-08	-2.10E-08
198.2	3.35E-08	-2.21E-08
198.3	2.23E-08	-2.16E-08
198.4	1.03E-08	-2.00E-08
198.5	-4.59E-11	-1.76E-08
198.6	-3.97E-09	-1.40E-08
198.7	-1.73E-08	-9.67E-09
198.8	-1.98E-08	-7.31E-09
198.9	-3.37E-08	-2.40E-09

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
199	-4.17E-08	2.49E-09
199.1	-5.07E-08	7.31E-09
199.2	-5.64E-08	1.17E-08
199.3	-6.39E-08	1.53E-08
199.4	-7.19E-08	1.80E-08
199.5	-7.88E-08	1.95E-08
199.6	-8.08E-08	2.23E-08
199.7	-8.15E-08	2.16E-08
199.8	-7.69E-08	1.99E-08
199.9	-6.68E-08	1.69E-08
200	-5.51E-08	1.32E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
240.5	1.38E-08	2.02E-08
240.6	2.04E-08	1.76E-08
240.7	3.37E-08	1.41E-08
240.8	4.04E-08	7.87E-09
240.9	4.85E-08	3.15E-09
241	5.60E-08	-1.81E-09
241.1	6.10E-08	-6.71E-09
241.2	6.26E-08	-1.17E-08
241.3	6.18E-08	-1.61E-08
241.4	5.37E-08	-1.98E-08
241.5	4.24E-08	-2.02E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
261	-7.17E-08	-1.86E-08
261.1	-5.97E-08	-1.55E-08
261.2	-4.91E-08	-1.16E-08
261.3	-3.83E-08	-6.94E-09
261.4	-2.71E-08	-4.54E-09
261.5	-1.77E-08	2.49E-10
261.6	-8.01E-09	4.07E-09
261.7	-1.04E-09	9.61E-09
261.8	4.07E-09	1.35E-08
261.9	1.62E-08	1.67E-08
262	2.04E-08	1.86E-08

200.1	-4.39E-08	6.48E-09
200.2	-3.40E-08	1.30E-09
200.3	-2.44E-08	-3.97E-09
200.4	-1.51E-08	-9.09E-09
200.5	-5.09E-09	-1.43E-08
200.6	7.18E-10	-1.84E-08
200.7	4.07E-09	-1.95E-08
200.8	1.85E-08	-2.13E-08
200.9	2.91E-08	-2.21E-08
201	3.68E-08	-2.15E-08
201.1	4.48E-08	-1.96E-08
201.2	5.19E-08	-1.71E-08
239.1	-6.58E-08	-1.86E-08
239.2	-7.41E-08	-1.57E-08
239.3	-8.00E-08	-1.19E-08
239.4	-8.21E-08	-7.47E-09
239.5	-8.19E-08	-5.28E-09
239.6	-7.49E-08	-6.44E-10
239.7	-6.32E-08	3.63E-09
239.8	-5.27E-08	4.07E-09
239.9	-4.09E-08	1.25E-08
240	-3.16E-08	1.57E-08
240.1	-2.12E-08	1.81E-08
240.2	-1.10E-08	1.94E-08
240.3	-3.86E-09	2.23E-08
240.4	4.52E-09	2.17E-08

241.6	3.11E-08	-2.16E-08
241.7	2.01E-08	-2.20E-08
241.8	7.91E-09	-2.11E-08
241.9	-4.05E-09	-1.92E-08
242	-1.34E-08	-1.66E-08
242.1	-1.98E-08	-1.31E-08
242.2	-2.99E-08	-8.73E-09
242.3	-3.85E-08	-6.66E-09
242.4	-4.70E-08	-2.01E-09
242.5	-5.45E-08	2.58E-09
242.6	-6.23E-08	7.16E-09
242.7	-7.00E-08	1.14E-08
242.8	-7.70E-08	1.48E-08
242.9	-8.05E-08	1.77E-08
243	-8.15E-08	1.91E-08
243.1	-7.72E-08	2.23E-08
243.2	-6.55E-08	2.19E-08
260.1	-3.63E-08	-1.09E-09
260.2	-4.42E-08	-3.97E-09
260.3	-5.29E-08	-1.15E-08
260.4	-6.08E-08	-1.61E-08
260.5	-6.88E-08	-1.98E-08
260.6	-7.64E-08	-2.03E-08
260.7	-8.23E-08	-2.17E-08
260.8	-8.25E-08	-2.19E-08
260.9	-8.12E-08	-2.07E-08

262.1	3.55E-08	2.21E-08
262.2	4.33E-08	2.21E-08
262.3	5.22E-08	2.10E-08
262.4	5.94E-08	1.89E-08
262.5	6.32E-08	1.57E-08
262.6	6.26E-08	9.60E-09
262.7	6.03E-08	5.11E-09
262.8	5.00E-08	6.26E-11
262.9	4.03E-08	-3.97E-09
263	2.87E-08	-1.01E-08
263.1	1.74E-08	-1.49E-08
263.2	8.34E-09	-1.88E-08
263.3	-4.04E-09	-1.96E-08
263.4	-1.42E-08	-2.13E-08
263.5	-1.98E-08	-2.20E-08
263.6	-3.02E-08	-2.13E-08
263.7	-3.86E-08	-1.96E-08
263.8	-4.66E-08	-1.71E-08
263.9	-5.41E-08	-1.36E-08
264	-6.17E-08	-9.26E-09
264.1	-6.95E-08	-7.14E-09
264.2	-7.66E-08	-2.41E-09
281.1	3.67E-08	1.62E-08
281.2	2.63E-08	1.83E-08
281.3	1.51E-08	1.96E-08
281.4	1.45E-09	2.22E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
284.9	1.90E-09	9.51E-10
285	-7.99E-09	-3.97E-09
285.1	-1.76E-08	-8.79E-09
285.2	-1.98E-08	-1.37E-08
289.5	-8.11E-08	1.29E-08
289.6	-8.16E-08	1.62E-08
289.7	-7.64E-08	1.83E-08
289.8	-6.49E-08	1.96E-08
289.9	-5.27E-08	2.22E-08
290	-4.21E-08	2.13E-08
290.1	-3.28E-08	1.94E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
292.8	-6.80E-08	1.98E-08
292.9	-7.53E-08	1.69E-08
293	-8.17E-08	1.32E-08
293.1	-8.15E-08	6.52E-09
293.2	-7.99E-08	1.34E-09
293.3	-7.00E-08	-3.97E-09
293.4	-5.92E-08	-9.01E-09
293.5	-4.77E-08	-1.42E-08
293.6	-3.69E-08	-1.83E-08
293.7	-2.67E-08	-1.94E-08
293.8	-1.65E-08	-2.13E-08

Elapsed Time (s)	CWZ Current (A)	SAWZ Current (A)
296.5	-7.67E-08	-2.17E-08
296.6	-8.23E-08	-2.19E-08
296.7	-8.21E-08	-2.07E-08
296.8	-8.04E-08	-1.85E-08
296.9	-6.95E-08	-1.53E-08
297	-5.78E-08	-1.12E-08
297.1	-4.63E-08	-8.81E-09
297.2	-3.65E-08	-3.95E-09
297.3	-2.57E-08	9.92E-10
297.4	-1.59E-08	4.07E-09
297.5	-6.18E-09	1.06E-08

290.2	-2.13E-08	1.63E-08	293.9	-6.35E-09	-2.20E-08	297.6	1.26E-09	1.44E-08
290.3	-1.19E-08	1.02E-08	294	-1.45E-10	-2.13E-08	297.7	4.07E-09	1.74E-08
290.4	-2.51E-09	5.94E-09	294.1	4.07E-09	-1.94E-08	297.8	1.77E-08	1.91E-08
290.5	4.02E-09	8.40E-10	294.2	1.73E-08	-1.68E-08	297.9	2.04E-08	2.22E-08
290.6	1.34E-08	-3.97E-09	294.3	2.04E-08	-1.30E-08	298	3.71E-08	2.18E-08
290.7	2.04E-08	-9.34E-09	294.4	3.56E-08	-8.35E-09	298.1	4.52E-08	2.02E-08
290.8	3.30E-08	-1.44E-08	294.5	4.38E-08	-6.03E-09	298.2	5.24E-08	1.75E-08
290.9	4.07E-08	-1.84E-08	294.6	5.19E-08	-1.06E-09	298.3	5.99E-08	1.38E-08
291	4.85E-08	-1.94E-08	294.7	5.85E-08	3.47E-09	298.4	6.32E-08	7.18E-09
291.1	5.51E-08	-2.12E-08	294.8	6.29E-08	4.07E-09	298.5	6.33E-08	2.02E-09
291.2	6.17E-08	-2.20E-08	294.9	6.33E-08	1.27E-08	298.6	6.06E-08	-3.28E-09
291.3	6.43E-08	-2.14E-08	295	6.04E-08	1.62E-08	298.7	4.96E-08	-8.39E-09
291.4	6.29E-08	-1.96E-08	295.1	5.13E-08	1.84E-08	298.8	3.80E-08	-1.37E-08
291.5	5.46E-08	-1.71E-08	295.2	3.99E-08	2.20E-08	298.9	2.72E-08	-1.80E-08
291.6	4.39E-08	-1.35E-08	295.3	2.90E-08	2.22E-08	299	1.73E-08	-1.92E-08
291.7	3.40E-08	-9.08E-09	295.4	1.81E-08	2.11E-08	299.1	5.50E-09	-2.11E-08
291.8	2.25E-08	-6.86E-09	295.5	7.48E-09	1.90E-08	299.2	-6.57E-09	-2.20E-08
291.9	1.17E-08	-1.99E-09	295.6	-3.93E-09	1.57E-08	299.3	-1.59E-08	-2.13E-08
292	-6.81E-10	2.77E-09	295.7	-1.41E-08	9.46E-09	299.4	-1.98E-08	-1.94E-08
292.1	-3.97E-09	7.53E-09	295.8	-1.98E-08	4.83E-09	299.5	-3.33E-08	-1.68E-08
292.2	-1.98E-08	1.19E-08	295.9	-2.94E-08	-4.48E-10	299.6	-4.15E-08	-1.31E-08
292.3	-2.69E-08	1.54E-08	296	-3.84E-08	-3.97E-09	299.7	-5.06E-08	-8.50E-09
292.4	-3.58E-08	1.80E-08	296.1	-4.66E-08	-1.09E-08	299.8	-5.85E-08	-6.08E-09
292.5	-4.48E-08	1.94E-08	296.2	-5.38E-08	-1.59E-08	299.9	-6.65E-08	-1.12E-09
292.6	-5.21E-08	2.22E-08	296.3	-6.15E-08	-1.97E-08	300	-7.01E-08	3.50E-09