Relationship between Bagging Methods and Pre-Weld Holding Times on Porosity Formation in 2219 Aluminum AC-TIG Welds

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by

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Abstract

The purpose of this study was to determine relationships between bagging methods and pre-weld holding times on the formation of porosity when AC-TIG welding 2219 aluminum. Considering the strict guidelines and specifications required within the aerospace industry, maintaining quality welds is of paramount importance to control part integrity for aerospace applications. This project focused on two parameters involved in the preparation of aluminum parts for welding: bagging method and pre-weld holding time. Welding geometry was simplified to bead-on plate instead of the standard joint welds. Radiographic analysis of the samples showed that all levels of both parameters produced “passing welds.” Further investigation using metallography showed that there is no clear relationship between the bagging method and holding time on the formation of porosity. The implications of these results may help simplify the preparation of parts for welding and therefore help minimize costs and increase productivity while maintaining weld quality.

Keywords: Materials Engineering, AC-TIG, Welding, Aluminum, 2219 Al, Porosity, Cleaning, Etching, Aerospace

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Introduction

When welding aluminum (Al) alloys for aerospace applications, great care must be taken to ensure that the welds do not contain a large amount of porosity. However, one of the main sources of porosity in aluminum welds comes from the oxide layer on the aluminum itself. For general welding of aluminum, using a wire brush to mechanically remove the oxide layer is adequate. However, for aerospace welds, greater care must be taken to ensure the surface to be welded is free of any form of debris, sometime involving the use of tweezers and a magnifying glass, which can become time consuming and costly.[1] Therefore, it is common to clean and etch aluminum before welding to remove any possible contaminants.

The main issue with cleaning and etching is that the welding procedure is ideally done immediately after cleaning. The cleaning and etching procedure itself is fairly time consuming, taking anywhere from one to four hours to complete depending on the batch size. The samples must also be handled carefully to ensure that contamination of the surface does not occur. Furthermore, complex manufacturing lines and busy welding departments can make it impossible to weld parts immediately after cleaning. To counter this, the cleaned samples are stored in bags, often purged with inert gases, to prevent the oxide layer from growing in the presence of oxygen (O_2) and moisture in the air.

The purpose of this project was to determine the bagging method that has the longest holding time and still meets aerospace porosity requirement specifications, such as the American Welding Society (AWS) D17.1 standard.[2] Four different bagging methods, each with four different holding times and three samples each will be tested. A standardized cleaning procedure, typical to the aerospace industry, will be used for all samples prior to welding. The welded samples will be sent to a third party vendor for radiographic analysis and interpretation and then sectioned and mounted for metallographic analysis. The goal is to determine if the current standard bagging method, a single nylon bag that has been purged with nitrogen (N_2) and then heat sealed closed, can be held for more than 24 hours without producing excessively porous welds. Another goal is to see how different bagging methods affect the formation of porosity for different holding times. A holding time that is longer than 24 hours will allow greater flexibility

for the cleaning and welding departments. If a bagging method can be used that does not require purging with N_2, it will simplify the bagging procedure and save time and money.

Application

Helium is the most common gas to be used in pressure vessels, or bladders, because of its low molecular weight, high gas density in storage conditions, and minimal residual gas weight after container depletion. Logistically, the helium pressure vessels used in rocket engines cause pressure differences that lead to fluid flow through the pipes. Gaseous helium pressure vessels are used to operate propellant valves and liquid helium tanks. The liquid helium vessels regulate the flow from the O_2 tanks. The vessels are typically formed and welded structures, and often times are over-wrapped with composite to minimize weight while maximizing strength. The vessel material is usually an aluminum alloy because of its low density, corrosion resistance, and weldability. Typical vessel designs, as in Figure 1, will require either a circumferential weld to join two forged and machined hemispherically-shaped "shells" to form the vessel, or two axial welds to join bladder halves formed from sheeting.

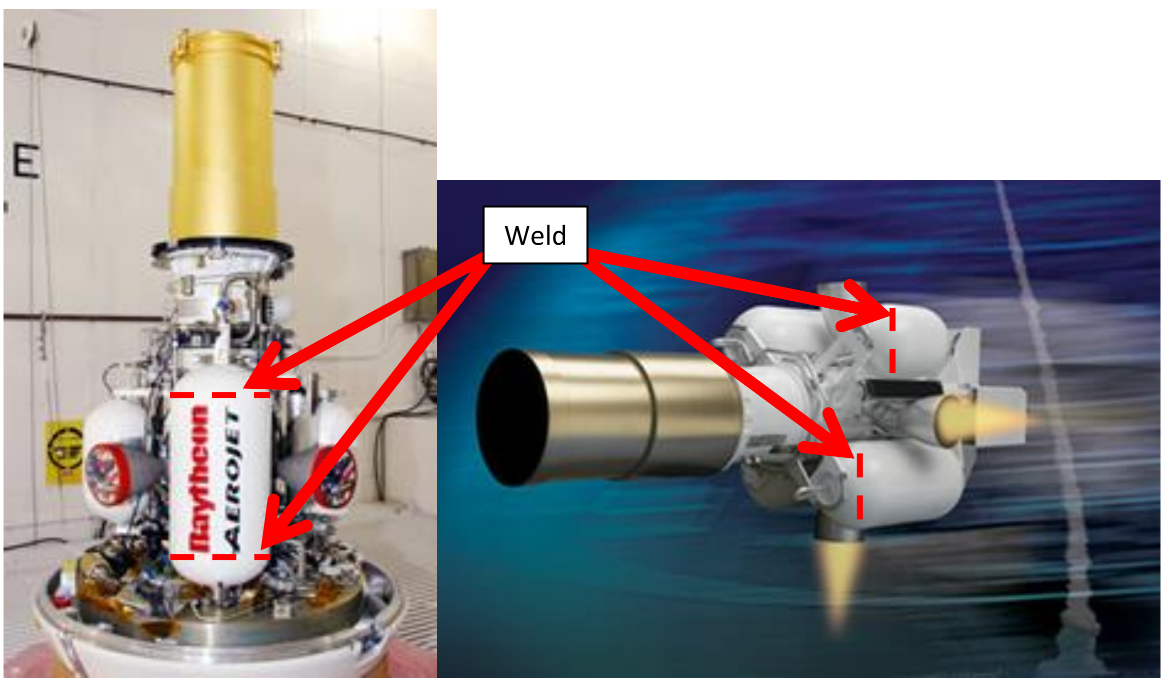


Figure 1 - Sample images of rocket propulsion systems that Aerojet Rocketdyne manufactures. The white hemispherical tanks are where the primary aluminum AC-TIG welds occur.[3]

Each configuration would then require additional welds to attach fittings to either end of the vessel. The welded structures would then undergo rigorous non-destructive evaluation (NDE) to ensure that any weld-related flaws are within structural requirements to ensure performance during service. Typically 2219-T6 or T8 is used in helium bladder design but for this project thin (0.063″) sheets of 2219-T81 aluminum were used.[4]

Materials

2219-T81 Aluminum

2219 Al is part of the 2xxx series aluminum alloys that are age-hardenable and alloyed primarily with copper (Cu). 2219 aluminum is a hypoeutectic alloy that has a simple eutectic structure when equilibrium cooled between the aluminum solid solution (Al) and Θ (Al_2Cu). 2219 aluminum has a high percentage of copper (6.5 wt. % Cu), which is a greater amount than the solubility limit of copper in aluminum (5.7 wt. % Cu, Table I). Other 2xxx alloys have different ranges of copper content (Fig 2).

Table I – Composition of 2219 and 2319 Aluminum[6]

	2219	2319
Element	**% Weight**	**% Weight**
Aluminum (Al)	Bal.	Bal.
Copper (Cu)	6.50	6.30
Magnesium (Mg)	0.01	0.30
Titanium (Ti)	0.04	0.15
Zirconium (Zr)	0.12	0.18
Vanadium (V)	0.07	0.10
Iron (Fe)	0.12	-
Manganese (Mn)	0.31	-
Silicon (Si)	0.06	-
Zinc (Zn)	0.01	-

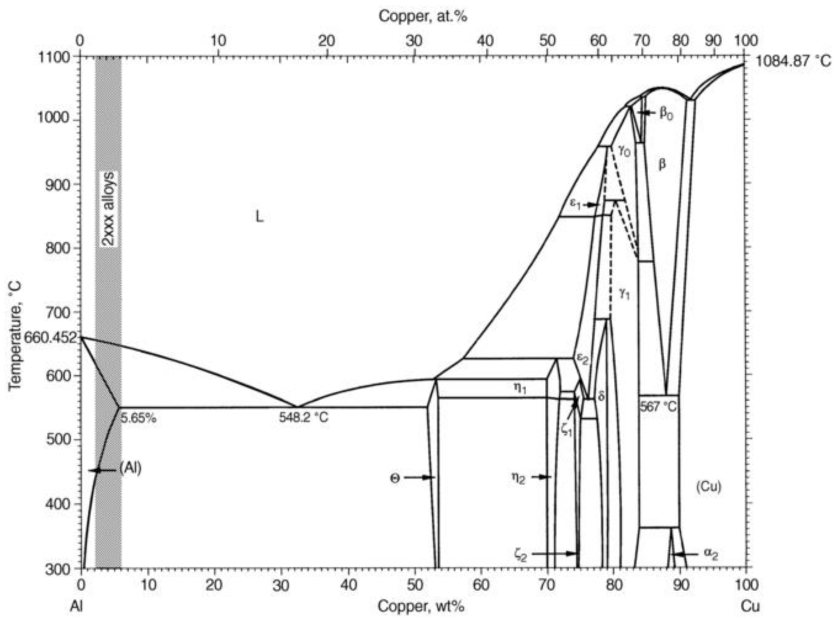


Figure 2 – The Al-Cu phase diagram highlighting the range of copper content for 2xxx series Al alloys.[7]

The high copper content and low magnesium content contribute to the weldability of 2219. Typically, 2xxx series aluminum alloy welds are susceptible to hot cracking and stress corrosion cracking. Hot cracking is caused by the formation of low melting eutectics that shrink and pull away from the base metal during solidification, but 2219 is an exception that can be welded. Low melting eutectics that cause hot cracking in aluminum alloys are related to the relative amounts of copper and magnesium in the aluminum. As (Al) solidifies, Ɵ is still a liquid and will fill the voids left as (Al) shrinks; however, most welding will require filler material to help mitigate hot cracking. The T-81 temper designation means that the alloy has been solution heat-treated, cold worked, and artificially aged. The cold work step improves strength properties after solution heat treating. The mechanical properties are substantially improved after the formation of precipitates from the aging process.[5]

ER2319 Filler Material

2319 is an age hardenable aluminum alloy that was developed for use as a filler rod material for 2219 with the purpose of maintaining resistance to stress corrosion cracking and hot cracking (Fig. 3). The addition of filler wire into the weld pool before it solidifies allows for more molten material to fill hot cracks upon solidification. 2319 filler rod has better mechanical

properties when welding with Al than 4xxx series filler rods. Overall, 2319 has a similar composition to 2219 (Table I).

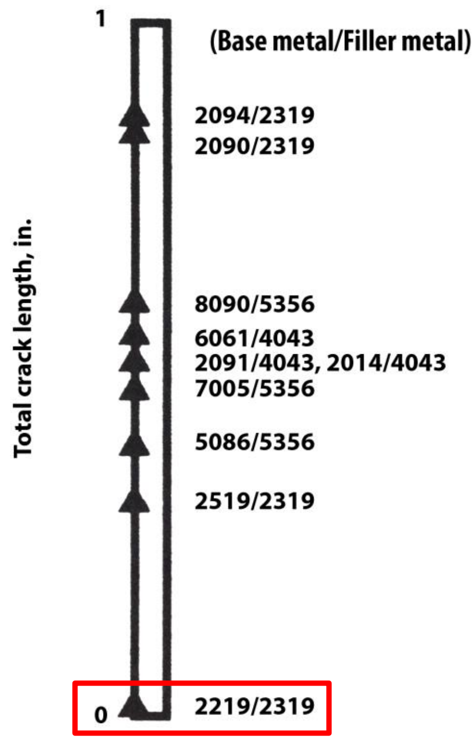


Figure 3 – Chart showing the average crack length for certain base metal/filler metal combinations.[7] Note that 2219 base metal welded with 2319 filler material has a total crack length of essentially 0 inches, which shows that the two materials are highly weldable.

Nylon 6,6

Nylon is used as the primary bagging material for storing cleaned and etched samples prior to welding. A NASA specification (JPG-5322) calls for the use of nylon 6 as the bagging material (Appendix B).[3] However, many grades of nylon exist, each having different properties. It is with this in mind, and because of the availability of supplies, that nylon 6,6 will be used instead. Although both nylon 6 and nylon 6,6 are both commonly used polyamide polymers, their base monomer structures are what differ (Fig. 4). Although the difference in structure is slight, the effect it has on properties is clear (Table II). The longer chain of nylon 6,6 allows for more favorable hydrogen bonding, leading to higher melting temperatures, slightly higher hardness, and lower permeability.[8, 9]

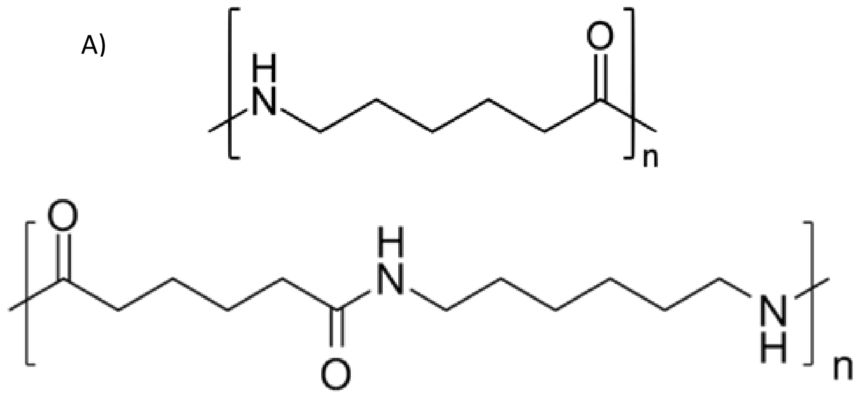


Figure 4 - Comparison of nylon 6 and nylon 6,6 structures.[10, 11] (a) Nylon 6 (caprolactam) has a shorter chain length than nylon 6,6. The branches allow for two ways to align. (b) Nylon 6,6 (Hexamethylene diamine & adipic acid) has a longer chain length than nylon 6 and has more branches which limits hydrogen bonding to one orientation.[8, 9]

Table II - Nominal Property Comparison of Nylon 6 and Nylon 6,6[9, 12]

Property	Nylon 6,6	Nylon 6
Melting Temperature	254°C	224°C
O_2 Permeability	~7.83 Barrer	~12.05 Barrer

The benefits of using nylon 6,6 as the primary bagging material are that the lower permeability will likely decrease the diffusion of O_2, N_2, and water vapor through the sealed bag, thus slowing the rate of oxide layer hydration on the cleaned aluminum surface.[12]

Anti-Static Polyethylene

Anti-static polyethylene (PE) is used as a secondary bagging material because it prevents mechanical and electrostatic damage. PE is a thermoplastic polymer with the main monomer unit being (CH_2-CH_2) that has a semi-crystalline structure. The principle behind static charging is the contact of materials with different surface potentials can cause a discharge of static electricity.[13] Anti-static bags are conductive, which allows static charge to build up on the outside of the bags and protect the samples inside.[14] The anti-static PE bags do not protect against electrostatic discharge (ESD), but ESD should not be a problem for this project. The PE bags are considered waterproof but not water vapor-proof, so the atmospheric conditions the bagged samples are stored in could change the effectiveness of anti-static PE as a second bagging material.

AC-TIG Welding

For direct-current tungsten inert gas (DC-TIG) welding, the tungsten electrode is either negative or positive relative to the workpiece. The polarity controls the direction in which electrons flow within the plasma arc stream. When the electrode is negative, or electrode negative (EN), electrons flow from the tungsten electrode into the workpiece and thus heat the part for joining. For aluminum and its alloys however, EN is not effective because the electrons add thermal energy to the refractory aluminum oxide layer instead of the aluminum itself, taking more time and resulting in "dirty" welds as oxygen atoms are liberated from the oxide. When the polarity of the electrode is positive, or electrode positive (EP), electrons flow from the aluminum surface to the electrode, thus heating the electrode and helping remove the oxide layer (Fig. 5).[15] It is based on this principle that alternating current tungsten inert gas (AC-TIG) welding is used primarily for welding aluminum.[16, 17] The alternating current utilizes both the positive and negative electrode phases to help remove the oxide layer momentarily and then heat the metal for joining. The use of rectangular waveforms for AC-TIG welding seems to provide the most efficient self-cleaning of the aluminum surface, as well as increased weld travel speed.[18]

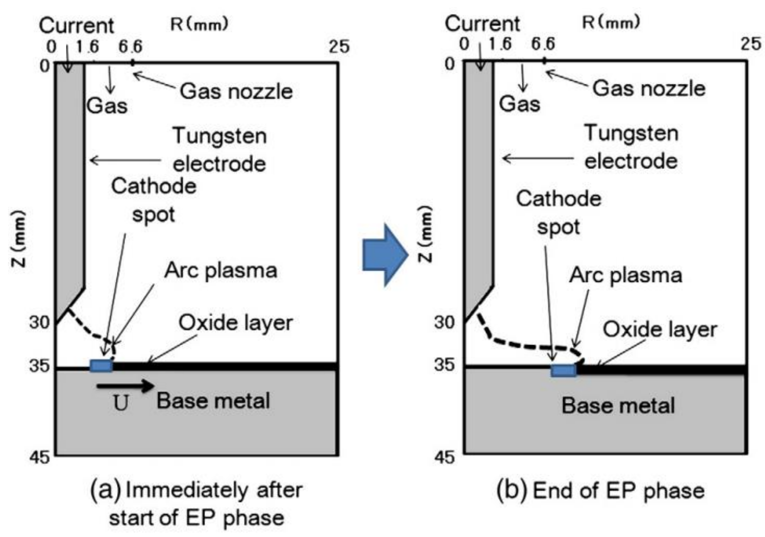


Figure 5 - Schematic of plasma arc distribution at the beginning (a) and end (b) of the electrode positive phase of the waveform. The spread of the plasma is due to increased electron flow from the surface of the metal towards the electrode.[15]

The entrapment of air into the shielding gas, also known as entrainment, can be a major source of porosity. Figure 6 shows a schematic of where the entrained air will flow relative to the

work piece if the shielding gas flow is too high. Even 1% entrained atmospheric air can lead to excess porosity formation within a weld. Unfortunately, there is no standard way to prevent entrainment as the geometry of each TIG torch set-up is different. Guidelines are in place to help welders set-up their equipment more quickly than trial and error.[20]

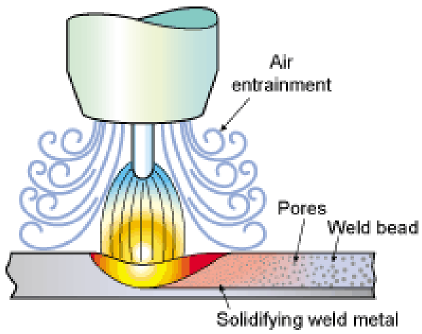


Figure 6 – Diagram showing how entrained air can be introduced into the shielding gas and thus into the weld pool on a work piece.[19]

Porosity and Oxide Kinetics

The oxide layer on aluminum alloys is a primary cause for weld porosity to occur in aluminum welds. The oxide layer can become hydrated from moisture in the air, and when this hydrated oxide is heated by the AC-TIG welding arc, hydrogen and O_2 are liberated from the oxide layer and dissolved into the weld pool. Hydrogen and O_2 have a higher solubility in molten aluminum than they do in solid aluminum and so as the weld pool solidifies, the hydrogen and O_2 get trapped and form pores (Fig. 7).[1, 4] These pores may be expelled from the weld by natural buoyancy or forced convection in the molten weld pool. Therefore, depending on the velocity of the solidification front of the weld, a pore buoyancy velocity may be able to exceed the solidification velocity and allow the pore to expel itself.[4]

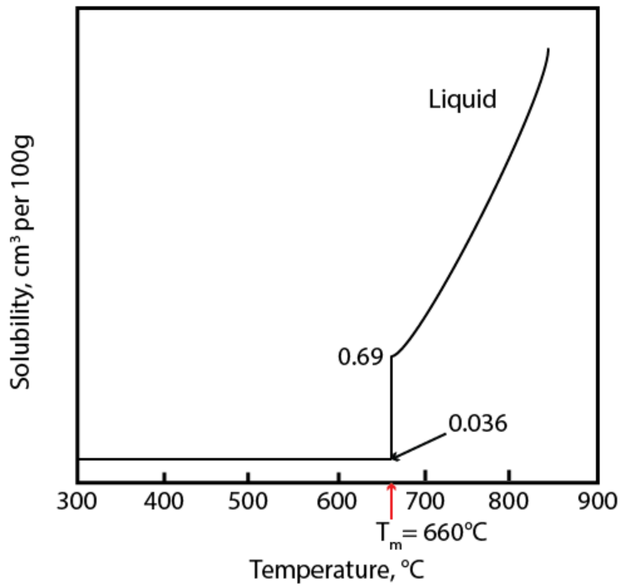


Figure 7 - Hydrogen solubility in pure aluminum increases sharply when T_m is reached.[5]

The oxide layer on the filler wire, hydrated or otherwise, also acts as a source of hydrogen, as well as any gas or water leaks within the water-cooled TIG torch. The shielding gas itself can contain small amounts of moisture, although the amount can be estimated from the purity of the gas or it can be calculated using the dew point of the gas (Fig. 8). The shielding gas flow rate should also be set low enough to prevent turbulent flow that can entrain air and contaminate the weld pool.[19, 20] Unfortunately, a hydrated oxide layer cannot be dehydrated by simply heating it.[5] However, a combination of heating and a vacuum environment may be able to dehydrate a hydrated oxide layer.

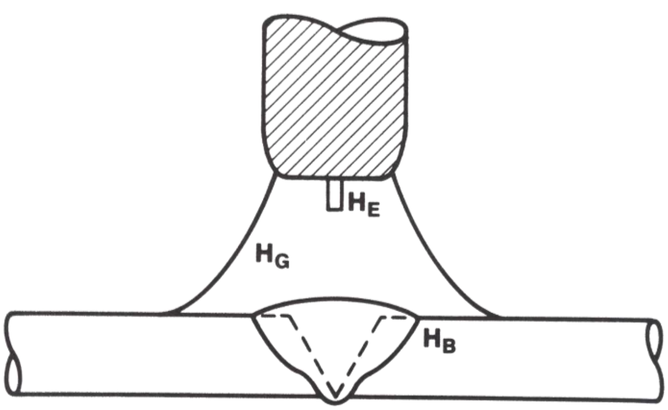


Figure 8 - Sources of hydrogen in gas-metal arc welding. H_G, hydrogen from shielding gas; H_E, hydrogen from electrode; H_B, hydrogen from base metal. This image can be adapted for TIG welding by removing the electrode and adding a filler rod from the side.[6]

The rate and amount of oxide that forms on the surface of aluminum depends on the partial pressure of O_2 and the temperature of the aluminum; as the temperature of the aluminum increases for a given partial pressure of O_2, the oxide layer forms more rapidly until O_2 cannot diffuse through the oxide layer (Fig. 9).[21] Given that the partial pressure of O_2 in an open atmosphere is 21.3 Pa compared to the partial pressure used in the oxide kinetics experiment ($1.33*10^{-4}$ Pa), we expect that the oxide would fully develop much more quickly in an open atmosphere. While the oxide layer has an upper limit to its thickness, moisture can penetrate the oxide's porous structure and allow the layer to grow larger, almost doubling in thickness in high humidity areas.[22]

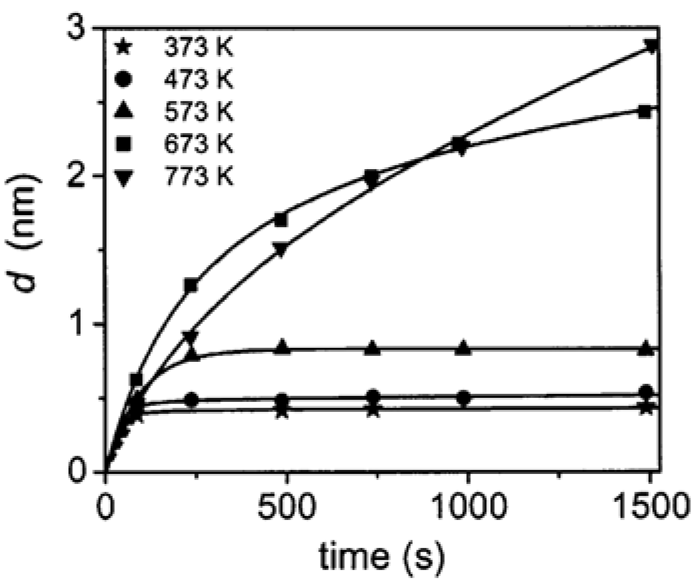


Figure 9 - Oxide layer thickness over time for various temperatures at an overall pressure, $P = 2.5 \cdot 10^{-8}$ Pa, and a partial pressure of O_2, $P_{O2} = 1.33 \cdot 10^{-4}$ Pa. At room temperature (298 K) an oxide layer fully develops within 120 seconds of exposure to O_2, at this given partial pressure.

This temperature dependence also suggests that cooling the samples when they are bagged may be advantageous in slowing oxide kinetics. One main concern of cooling the samples is condensation which would hydrate the surface and readily contribute to porosity. It should be noted that the oxide layer of 2219 aluminum is a more complex form of alumina (Al_2O_3) and will therefore have different kinetics and structure.[22] If the structure of the complex oxide is more porous than Al_2O_3, then it may hydrate more easily and thus contribute more to the formation of porosity within a weld.

Radiography

Radiography is a common form of non-destructive testing used to find sub-surface flaws in welds. Radiography is recommended over ultrasonic techniques in terms of nondestructive testing but is limited by weld thickness and pore size.[23] Weld Radiography is better at detecting flaws that have a large face parallel to the surface being tested, but any pores in the weld will be the same size regardless of orientation. Radiation diffraction angles can detect material interface changes when there is a 1% or more change in radiation absorption, meaning that changes in density such as large pores or contaminants can be detected using radiography with pores showing up darker and most contaminants turning up lighter. Radiography is most capable of detecting flaws that are parallel to the radiation beam; however, defects that approximately the same size in every direction, like pores and inclusions, can also be detected if large enough.

The three main types of radiography are film with x-rays, real-time radiography, and film with gamma-rays. All three radiography methods are good for detecting shrinkage cracks, slag inclusions, incomplete fusion, pores, and incomplete penetration within aluminum alloy welds.[20] Weld Radiography normally requires transmission through the sample onto radiographic film that consists of a layer of radiation sensitive gel-emulsion and a blue tinted base that is flexible and transparent. The gel emulsion usually consists of silver halides such as silver bromide and silver chloride. There can be gel-emulsion layers on both sides of the tinted base to increase the amount of silver halide material exposed to radiation but this method can reduce sharpness. Once the radiographic film is developed, the degree of darkening in the latent image depends on the amount of radiographic exposure on the film with more exposed elements being darker. Image sharpness is determined by the wavelength of the radiation emitted where longer wavelengths have better contrast but can have too much noise to see fine detail while shorter wavelengths have less scatter but can lack necessary contrast to resolve fine details.[24] Within the range of long and short there is an optimal wavelength for the samples that will give both contrast and definition.

Some limitations of radiography include how difficult it is to detect cracks and micro-pores because cracks need to be parallel to the radiation beam in order to be detected, and closed

packed cracks may not be detected even when properly oriented. Micro-pores are difficult to detect at all unless they are clustered together tightly, thus magnifying their effect.[24]

Bagging Methodology

Typical aerospace bagging methods are comprised of placing parts into a nylon bag, purging it with N_2 and then heat sealing it closed (Fig. 10).[1] Another bagging method for critical parts involves placing a purged and sealed nylon bag in an anti-static PE bag, that is also purged and sealed. Nylon was chosen because of contamination arising from other plastics outgassing fluorocarbons that induced weld defects in aluminum welds. 3″x6″ nylon bags that are 2 mils thick were made from nylon sheets using a heat sealer. 4″x6″ preformed PE bags that are 6 mils thick were used. The pink color of the PE bags designates that it is made out of PE and is antistatic but not conductive.[14]

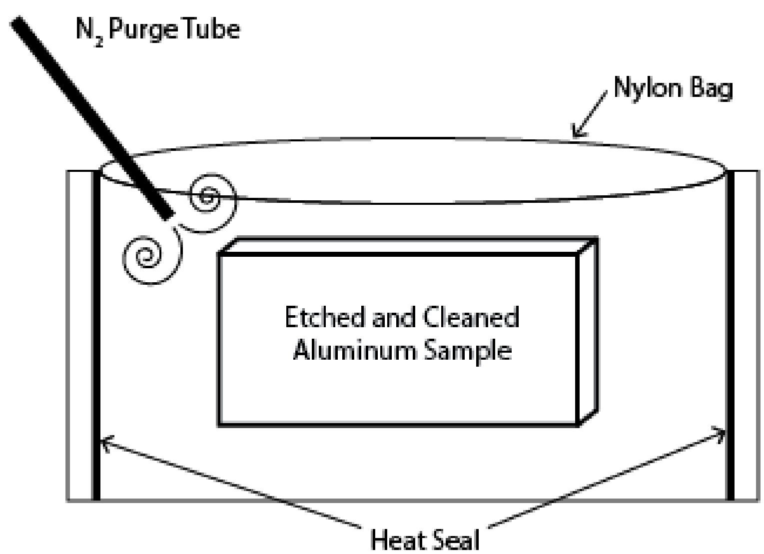


Figure 10 - Schematic bagging configuration used to protect the cleaned sample surface from contamination and excess oxidation.

Procedure

Safety and Materials Handling

Because toxic and corrosive chemicals were handled in this study, proper safety procedures and guidelines had to be established before beginning the cleaning and etching. Our main concerns were how to handle the materials being used and how to dispose of them after use. Our Standard Operating Procedures (SOP) called for proper personal protective equipment

(PPE) and first aid measures were required in order to carry out this experiment, including: Calcium Gluconate gel (to help neutralize hydrofluoric acid (HF) in case of skin contact), splash protective goggles, chemical resistant aprons and gloves, long pants, closed toed shoes, and mandatory use of a fume hood (Appendix A). Possible health and safety risks were considered and a step-by-step procedure was established for such situations.

Cleaning and Etching

The cleaning procedure we followed is based on similar procedures within the aerospace industry and primarily focuses on sample preparation. We prepared each sample with an alkaline emulsion cleaner, etchant, and a final desmutting. The full procedure is described in detail in the Aluminum Cleaning and Etching procedures, including safety protocols and possible dangers (Appendix A). The etchant used is a HF/nitric acid solution meant to remove the oxide layer and the desmut solution is a nitric acid solution meant to remove any non-aluminum metal oxides remaining on the surface. After cleaning, the samples were blow-dried with high purity nitrogen gas and dehydrated in a vacuum oven (-29.5 inHg at 50°C) for about one hour and forty minutes. The samples were handled only by the edges using powder-free nitrile gloves to prevent hand oil contamination. For timing purposes, the cleaning and etching procedures were completed once for each holding time for a total of four separate batches. Each batch processed 12 samples, which were run through the procedure six at a time until just before the dehydration step.

Design of Experiment

For our design of experiment we used a two factorial design, designated with four bagging methods and four holding times, totaling 16 different permutations (Table III). Each permutation contains three samples to increase the sample size to 48 and lead to more reliable results. The labeling scheme used to differentiate between samples was XYZ, where X is the bagging method (1-4), Y is the holding time (A-D), and Z is the sample number (1-3). Bead on plate welding was used instead of typical joint welds to simplify the variables that influence weld porosity. Because of this, the experiment may not be entirely representative of welds that would be performed on aerospace parts.

Table III – Possible Permutations of Design of Experiment

	Double Bag (1)	Single Bag (2)	Sealed Bag (3)	Unsealed Bag (4)
0-Day (A)	1A1, 1A2, 1A3	2A1, 2A2, 2A3	3A1, 3A2, 3A3	4A1, 4A2, 4A3
1-Day (B)	1B1, 1B2, 1B3	2B1, 2B2, 2B3	3B1, 3B2, 3B3	4B1, 4B2. 4B3
2-Day (C)	1C1, 1C2, 1C3	2C1, 2C2, 2C3	3C1, 3C2, 3C3	4C1, 4C2, 4C3
4-Day (D)	1D1, 1D2, 1D3	2D1, 2D2, 2D3	3D1, 3D2, 3D3	4D1, 4D2, 4D3

Bagging

The nylon bags were formed from large sheets that were cut to length, folded over, and heat sealed to leave an opening large enough to fit one of our samples (Fig. 11). The PE bags came pre-made with one side open (Figure 11). Care was taken so that the top and bottom faces of the sample were not touched when removing the Al samples from the vacuum oven. The N_2 purged bagging methods were heat sealed after being purged with N_2 at 10 psi for 10 seconds. The bagging method for each sample and order of bagging were randomized within each holding time.

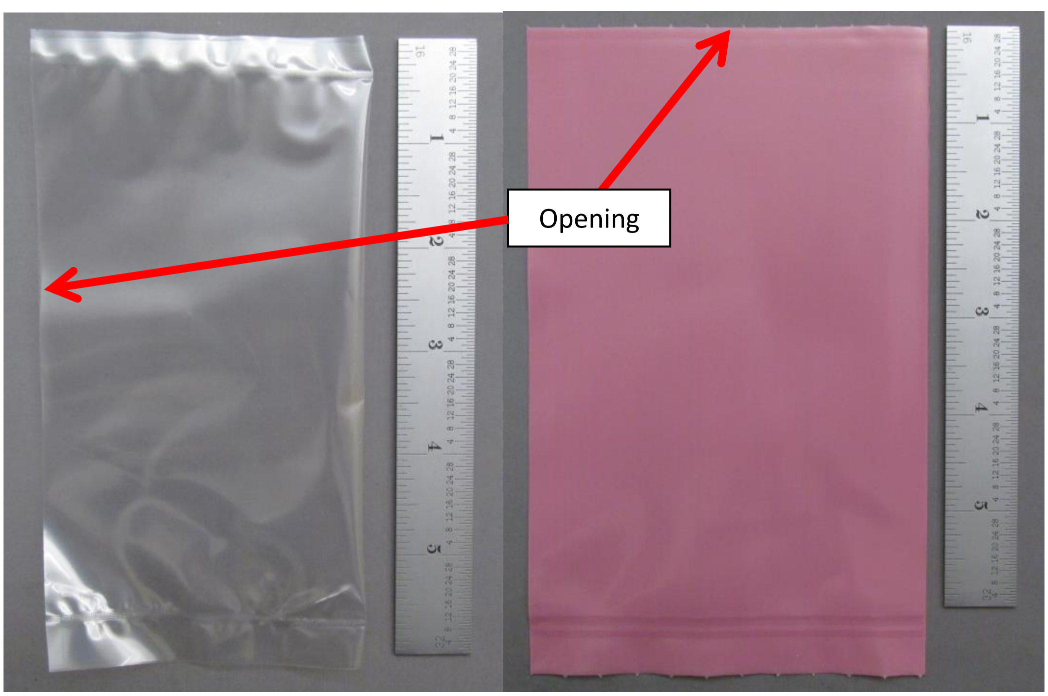


Figure 11 - Photographs of bags used during bagging procedure. Left) nylon bag, Right) anti-static PE bag.

Welding

After the samples were cleaned and bagged, each batch was stored for their respective pre-weld holding times before being welded at Cuesta College. Wendy Jeffries, a student welder at Cuesta College, welded our samples under the supervision of Mike Fontes, her instructor. A Miller Dynasty 200 DX welding machine was used utilizing an offset square-waveform (35% EN, 65% EP), 50 amps, roughly 20 cubic feet per hour (CFH) gas flow of argon, and a 2% thoriated-tungsten electrode (EWTh-2). Prior to welding, the filler rod was cut into 10″ segments, rinsed with acetone, and wiped with a lint free cloth. Before welding, each sample was brushed with stainless steel wire brush to mechanically remove the oxide layer. During welding the time taken for each weld, the length of each weld, and the length of filler wire used was noted. The average travel speed for each weld was 3.7 inches per minute (IPM) and the average weld length was 3″, 1/2″ from either end (Fig. 12).

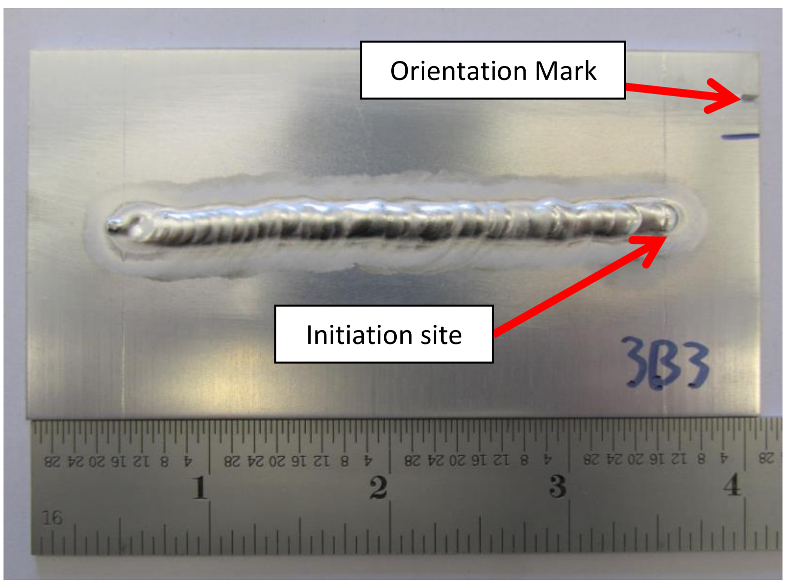


Figure 12 - Representative weld sample with notch cut into up right hand corner for orientation purposes. The arc initiation site is on the right end of the sample. The weld traveled from right to left.

Metallography

For metallographic analysis, all 48 samples had their welded length sectioned transversely into thirds, taking the middle third and sectioning it again transversely about 0.25″ into both ends (Fig. 13). Transverse sections of the weld crown were taken to see how porosity was distributed in the base metal heat affected zone (HAZ) and in the weld crown itself. Because porosity is not likely to form outside of the HAZ, guidelines were established to standardize

porosity measurements (Fig. 14). Because the samples are thinner than typical parts, it is likely that the HAZ is more pronounced than in normal welds and so the scope of the area of interest was extended past the ends of the weld crown.

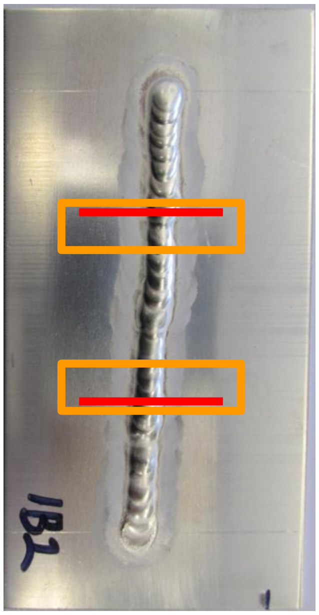


Figure 13 - Sample with lines that section the welded length into thirds. The orange box indicates where the 0.25″ transverse sections were taken to be mounted for analysis.

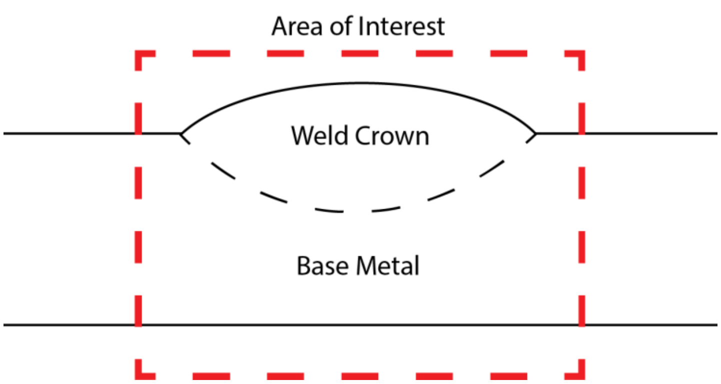


Figure 14 - Schematic of a transverse cross-section of a weld indicating the area of interest for metallographic analysis. The red dashed box extends past the ends of the weld crown to account for a larger HAZ due to the thinness of the sheeting used (0.063″).

Anamet, Hayward, CA, assisted us in the metallographic preparation of 32 of the 48 samples. Their polishing schedule is as follows: Buehler Texmet with 9-micron diamond suspension, Struers Nap with 3-micron diamond suspension, Struers Nap with 1-micron diamond suspension, and Struers Chem with 0.05 micron colloidal silica suspension. The remaining 16 samples were prepared at Cal Poly, San Luis Obispo using the following polishing schedule:

Allied Kempad with 6-micron diamond suspension, Allied Glenco with 1-micron diamond suspension, and Allied Vel-Cloth with 0.05 micron colloidal silica suspension. All samples were mounted in 1.25″ diameter blue diallyl phthalate (mineral filled) mounts for increased edge retention from grinding and polishing (Fig. 15). Optical microscopy was used to photograph, measure, and count pores in the welded region of two transverse-cross sections of each sample using QCapture Pro to photograph, and ImageJ to measure. Pores were identified from inclusion pull outs by smooth inner surfaces and rounded edges that are typically formed when gases come out solution in welds (Fig. 16). Inclusion pull outs typically have a dendritic shape and are jagged along the edges and occur during the polishing steps; polishing pads that have high nap, or "fuzzy" texture, cause the harder intermetallic phases in 2219 Al (Al_2Cu) get caught on the pad and pulled out (Fig. 17).[26] Welding 2219 makes inclusion pull out more prevalent due to refinement of the intermetallic phases due to rapid melting and solidification.

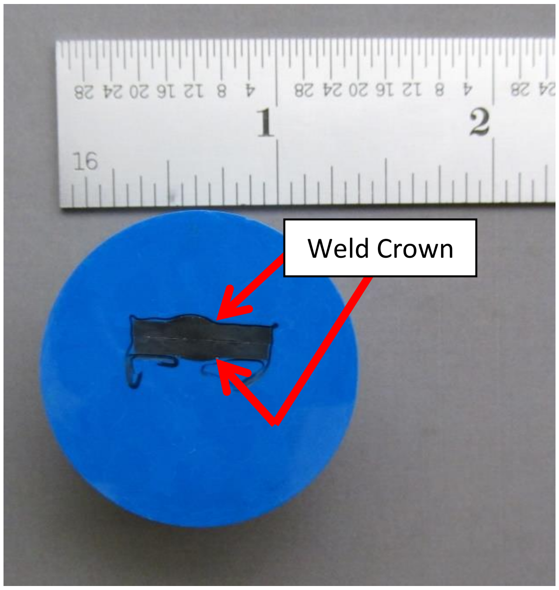


Figure 15 - Metallographic mount of two transverse cross sections of a weld. Mounted in 1.25″ diameter blue diallyl phthalate (mineral filled).

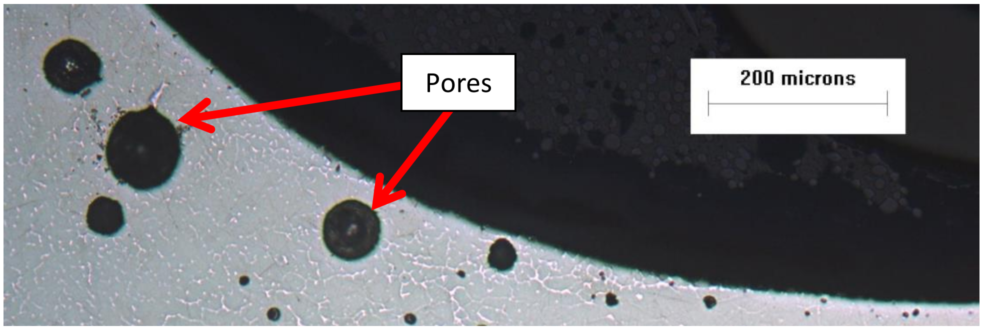


Figure 16 – Micrograph of weld porosity at the edge of a weld crown (100x magnification). Note the round edges and smooth texture that is slightly visible within the pores.

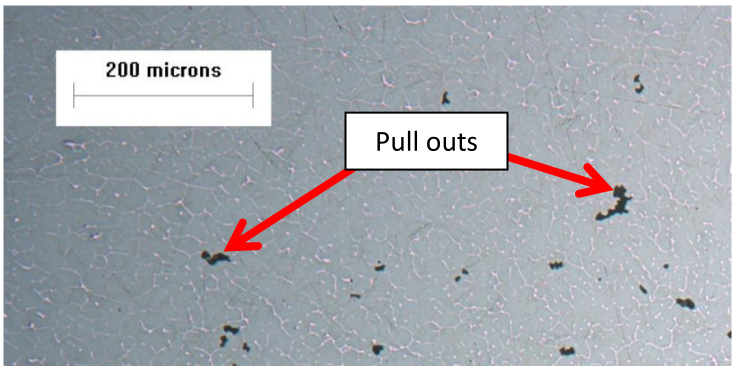


Figure 17 - Micrograph of inclusion pull outs in a weld crown (100x magnification). Note the jagged edges of the voids and also how skinny they are compared to pores (Fig. 16).

Pores that were 10 microns or larger in diameter were measured while pores that were smaller than 10 microns were considered features inherent of the base material and ignored. All the pores observed in the samples are considered micro-pores as they are smaller than 300 microns in diameter.[27]

Results

Welding

After the first batch of samples (0-day holding time sample group) had been welded, it was discovered that an error had been made when setting the flow rate of the shielding gas. Instead of 20 CFH, which is typical for almost all welding, it was set at 30 CFH. The issue this posed is that it introduced the possibility of entrained air entering the weld pool and contaminating it. After considering the options available, it was decided to not consider this sample group for in-depth analysis and continue welding the remainder of the samples with the correct gas flow rate of 20 CFH.[26, 20]

Radiography

Radiographic analysis showed that all 48 samples were “passing” welds according to QC Services, Hayward, CA., which means that there were no large pores or defects that should be of structural concern. Photographs were unable to be taken of the radiographs themselves as the film is inherently reflective and the nature of radiography requires that the film be dark, essentially preventing any imaging of them. Visual inspection of the radiographs with backlighting did not reveal any obvious porosity or defects. To determine a difference between the parameters for this project, however, metallographic analysis was used to observe porosity that was smaller than what radiography could resolve.

Metallography

Metallography did reveal porosity within the welds and in the HAZ. The base metal itself did contain some porosity (<10 microns) and sometimes inclusion pull outs from polishing. All micrographs were taken at 100x magnification and were examined un-etched. ImageJ was used to measure pore sizes which were then transfered to excel for statistical comparison. A table containing an excerpt of the raw pore measurements can be found in Appendix B. Majority of the observed porosity was uniformly distributed, although the larger pores seemed to be transitional at the interface between the deposited bead and the base metal.[28]

Some micrographs show both uniform and transitional porosity can be seen (Fig. 18). Other micrographs showed excess inclusion pull out and/or odd geometries of pores at the top of a weld crown (Fig. 19). More representative micrographs can be seen in Appendix C.

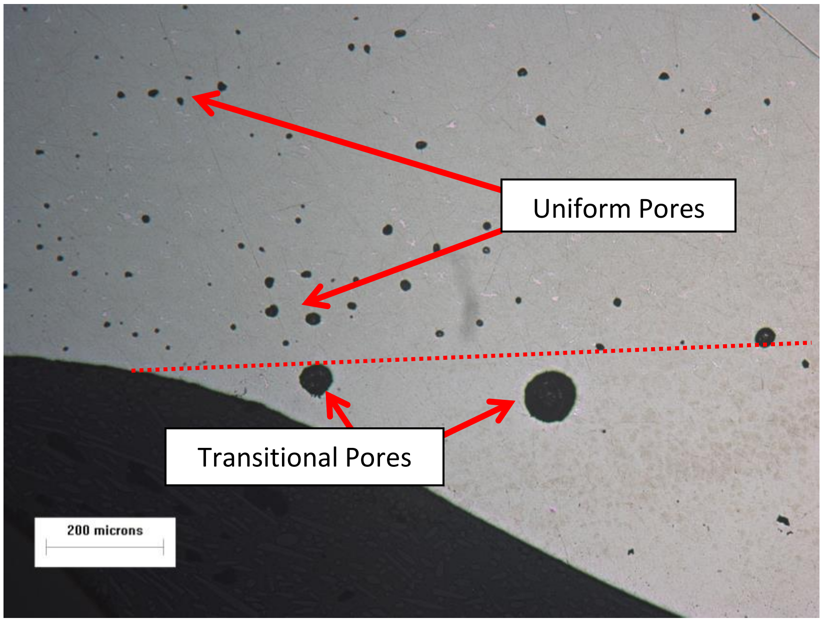


Figure 18 - Micrograph displaying the difference between transitional and uniform porosity, particularly the difference in size.

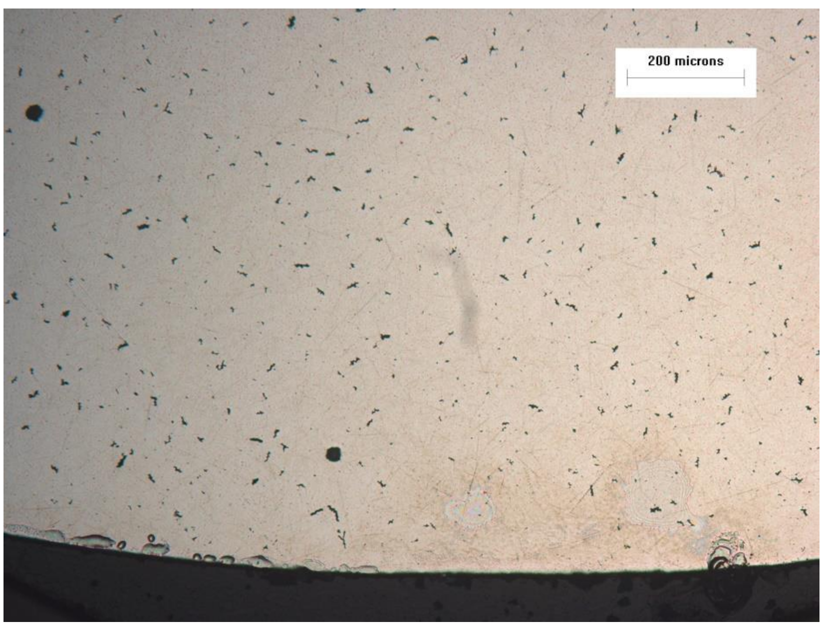


Figure 19 - Micrograph of a sample with excess inclusion pull out and/or an odd formation of porosity.

Because the A group samples were welded under different welding parameters, only 36 out of the original 48 were analyzed using ImageJ to measure the diameters of pores. This data was compiled together to compare pores sizes between different bagging methods and holding times to try and observe any sort of relationship between them.

Analysis

The pore measurements were compiled to compare total pore count, mean pore sizes, median pore sizes, and standard deviations (Table IV). Each bagging method was compared to each other for a given holding time, and likewise, each holding time was compared to each other for a given bagging method (Fig. 20 & 21). The variance between the mean and median pore sizes for all bagging methods and holding times is too low for there to be any significant relationship between either parameter and the formation of porosity.

Table IV - Compiled Porosity Data for 1-Day, 2-Day, and 4-Day Sample Groups

	1BX	2BX	3BX	4BX	1CX	2CX	3CX	4CX	1DX	2DX	3DX	4DX
Count	879	696	874	962	1429	1676	1293	999	1366	1157	944	1018
Mean	18.60	19.75	20.79	20.02	17.76	20.25	19.51	19.44	22.64	21.57	19.26	22.04
Median	17.22	18.20	18.74	18.52	15.63	17.61	16.96	17.72	19.27	17.54	16.89	17.97
Std. Dev	6.61	7.29	8.33	7.37	8.09	9.57	9.09	7.81	13.22	12.55	9.82	12.62

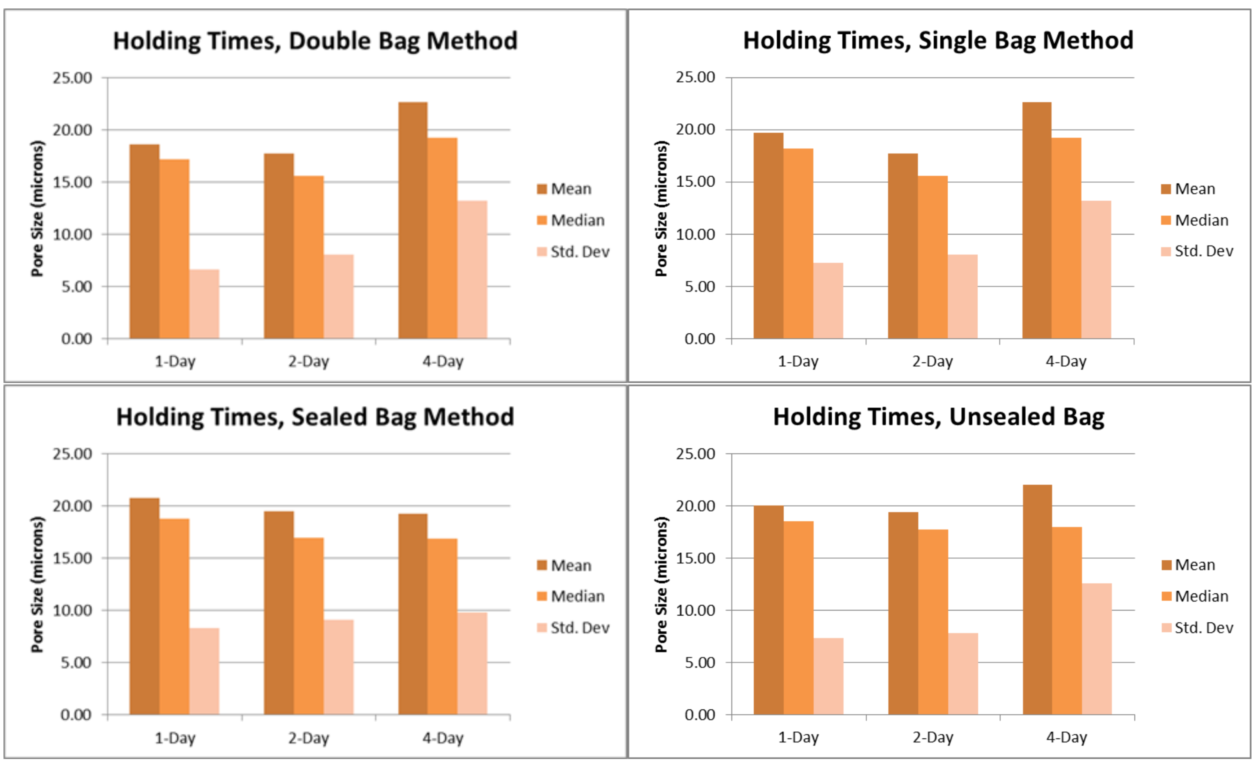


Figure 20 - Four charts detailing the effect of holding time on porosity formation for a given bagging method. All of these charts indicate that holding parts past a 1-Day holding time has little to no effect on the formation of porosity.

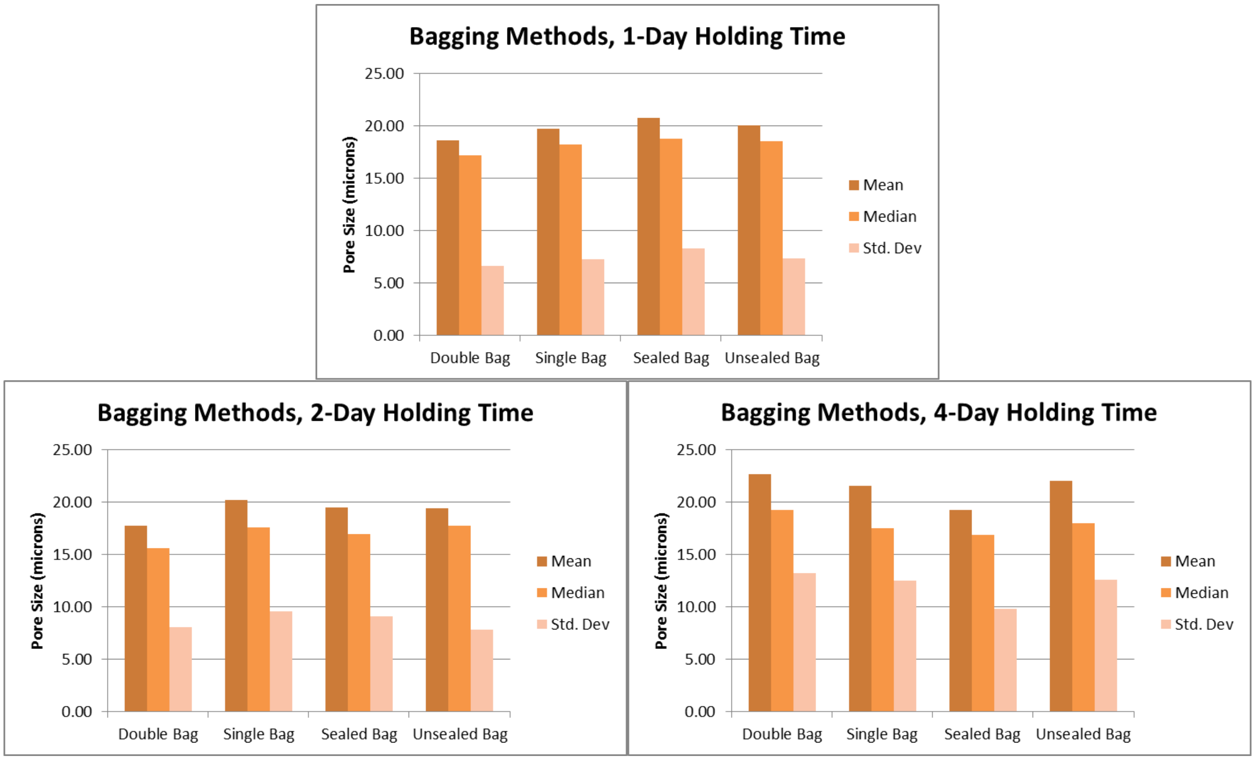


Figure 21 - Three charts detailing the variance in pore sizes between bagging methods for a given holding time. Overall, the variance between bagging methods is less than 5 microns. There seems to be little to no correlation between bagging method and porosity formation.

From Appendix B, the largest pore size observed from all the samples was 162 microns, which is still considered a micro-pore for most welds.[27] The total number of pores counted for each group seems to be more related to when the batch was welded than it does to the parameters they are looking at, namely group B compared to group C and group D. Group C also has a higher count of pores than group D which goes against the logic established by the common aerospace industry standard.

Discussion

Because no apparent relationship exists between either bagging method or holding time on the formation of porosity, it would seem that the aerospace industry's "limit" on how long parts can stored before welding should be reexamined more closely. A simplification of bagging methodology may be possible based off of these results, such as sealing bag without purging them with N_2. Further investigation using hemispherical joint weld geometry could yield more reliable data about the formation of porosity due to bagging method or holding time. Bead on plate welding may over simplify the variables that influence weld porosity to an extent that it is not realistic enough for practical applications. The average pore sizes were around 20 microns,

which are considered micro-pores (<300 microns) and therefore are most likely not comparable to the majority of aerospace joint welds.[27]

The lack of a correlation between the parameters and porosity formation is most likely due to the oxide kinetics of aluminum (Fig. 9). Aluminum oxide fully develops onto bare aluminum surfaces quickly (120 seconds in a high vacuum environment and exposure to a low partial pressure of O_2).[21] No matter what etching procedure is used to remove the oxide layer, as soon as it is exposed to atmospheric air, it will be completely oxidized within seconds. However, bagging the samples may still be a crucial part of the process to prevent moisture from hydrating the oxide layer.

It should be noted that many other factors could have contributed or influenced the results of this project, including but not limited to: subjectivity of pore definition during measurements, difference in polishing quality between Cal Poly and Anamet Inc., shielding gas flow quality and rate, and countless other factors.

Conclusions

1. The evidence from this study suggests that neither bagging method nor holding time has any correlation to the formation of porosity in 2219 AC-TIG welds.

2. Bagging methods used to store samples prior to welding can be simplified.

3. Pre-weld holding times can be extended to at least four days.

4. Further investigation is needed to verify if the common aerospace standard has any legitimacy.

Acknowledgements

We would like to acknowledge some people that assisted us throughout this project. Our advisor, Professor Blair London, gave us guidance on how to organize our experiment and rectify mishaps that occurred. Our industry contact, Christopher Shipley, answered any questions we had regarding the project and explaining the issues that the aerospace industry faces with porosity. Dr. Daniel Walsh and Professor David Gibbs gave us dependable welding and metallography advice for setting up our welding parameters and analyzing our samples. QC Services, Hayward, CA., performed radiographic analysis on our samples and Anamet Inc., Hayward, CA., assisted us in grinding and polishing our samples. Lastly, we would like to thank Mike Fontes, a welding instructor at Cuesta College, for letting us use their facilities for our project, and Wendy Jeffries, a student welder at Cuesta College, who performed the experimental welds for us.

References

1. Cole, Spencer P. "A Comparison Between Weld Precleaning Methods for Electron Beam Welded 2219 Aluminum." Thesis. California Polytechnic State University San Luis Obispo, 1998. Print.

2. "Acceptable Criteria for Weld Defects."D17.1: Specification for Fusion Welding for Aerospace Applications. Miami: American Welding Society, 2001. 28-30. Print.

3. Shipley, Christopher. "Introduction and Progress Report #18: Welding Progress and Analysis Timeline & Last Round of Questions and Conference Call." Message to the author. 15 May 2014. E-mail.

4. Arbit, Harry. *Modern Engineering for Design of Liquid-Propellant Rocket Engines Vol. 147*. American Institute of Aeronautics and Astronautics, Inc. 1992.

5. R. B. C. Cayless. "Alloy and Temper Designation Systems for Aluminum and Aluminum Alloys ." *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials*, Vol 2, *ASM Handbook*, ASM International, 1990, pp. 15–28.

6. Davis, J. R. *ASM Specialty Handbook: Aluminum and Aluminum Alloys*. Material Park: ASM International, 1993. Print.

7. "Alloy Phase Diagrams and Microstructure." *Metals Handbook Desk Edition.* ASM Handbooks Online. 1998. pp. 95-114.

8. Antron. "The Difference between Type 6,6 and Type 6 Nylon." (18 June 2013): 3. Antron. Web. <http://antron.net/na/pdfs/literature/K02510_N66vsN6_Tech_Bulletin_06_18_13.pdf>

9. Ultron. "Ultron Nylon 6,6." (21 May 2007): 2. Ultron. Web. <http://www.mannington.com/commercial/assets/pdfs/Literature/Ultron_Nylon66PRESS.pdf>

10. Wikipedia contributors. "Nylon 6." *Wikipedia, The Free Encyclopedia*. Wikipedia, The Free Encyclopedia, 24 Dec. 2013. Web. 20 Jan. 2014.

11. Wikipedia contributors. "Nylon 6-6." *Wikipedia, The Free Encyclopedia*. Wikipedia, The Free Encyclopedia, 31 Jan. 2014. Web. 20 Jan. 2014.

12. Massey, Liesl K. *Permeability Properties of Plastics and Elastomers, 2nd Ed.: A Guide to Packaging and Barrier Materials (Plastics Design Library)*. 2nd ed. N.p.: William Andrew, 2003. N. pag. Web. 25 Apr. 2014. < http://books.google.com/books?id=MBFwBw2woJIC&printsec=frontcover#v=onepage&q&f=false >.

13. Groth, David. *PC Chop Shop: Tricked out Guide to PC Modeling.* John Wiley & Sons. 26 Dec. 2006.

14. "Antistatic Bags and Conductive Bags." *PackingKnowledge.* Web. 29 Jan. 2014. <http://www.packagingknowledge.com/Anti_Static_Bags.asp>

15. Tashiro, Shinichi, Minoru Miyata, and Manabu Tanaka. "Numerical analysis of AC tungsten inert gas welding of aluminum plate in consideration of oxide layer cleaning." Thin Solid Films 519 (2011): 7025-7029. Print.

16. Reynolds Metals Co. "Inert-Gas-Shielded Tungsten-Arc AC Welding." *Welding Aluminum*. Louisville, KY: Reynolds Metals, 1953. 43-51. Print.

17. The Aluminum Association. *Welding Aluminum: Theory and Practice*. 2nd ed. N.p.: n.p., n.d. Print.

18. Scotti, Americo. "The influence of parameter settings on cathodic self-etching during aluminum welding." *Journal of Materials Processing Technology* 100.1-3 (2000) 179-187. ScienceDirect. Web. 20 Oct. 2013.

19. "Defects/Imperfections in Welds." *Porosity* (n.d.): n. pag. *Job Knowledge*. The Welding Institute. Web. <http://www.twi-global.com/technical-knowledge/job-knowledge/defects-imperfections-in-welds-porosity-042/>.

20. *Guidelines for Gas Tungsten Arc Welding (GTAW)*. N.p.: Miller, n.d. *Miller*. Miller. Web. <http://www.millerwelds.com/pdf/gtawbook.pdf>.

21. Jeurgens, L. P. H., W. G. Sloof, F. D. Tichelaar, and E. J. Mittemeijer. "Growth Kinetics and Mechanisms of Aluminum-oxide Films Formed by Thermal Oxidation of Aluminum." *Journal of Applied Physics* 92.3 (2002): 1649. Print.

22. Hatch, John E. "Properties of Pure Aluminum." *Aluminum Properties and Physical Metallurgy*. Materials Park: ASM International, 1984. 17. Print.

23. "How can weld porosity be detected and how can it be remedied." *TWI*. The Welding Institute. n. d. Web. 29 Oct 2013. http://www.twi.co.uk

24. "Radiographic Inspection." *ASMInternational.org.* ASM International. Web. 8, Jan. 2014.

25. "Liquid Penetrant Testing (PT)." *RNDT*. Nondestructive Testing Services. n. d. Web. 29 Oct 2013. http://www.rndt.net

26. Walsh, Daniel, Dr., and David Gibbs, Prof. "Welding and Metallography." Personal interview.

27. LEGAIT, Pierre-Alexandre. *Formation and Distribution of Porosity in Al-Si Welds*. Worchester: WORCESTER POLYTECHNIC INSTITUTE, May 2005. PDF.

28. Norris, Jerome T., and Matthew J. Perricone. *Evaluation of Weld Porosity in Laser Beam Seam Welds: Optimizing Continuous Wave and Square Wave Modulated Processes.* Albuquerque: Sandia National Labs, Feb. 2007. PDF.

Appendix A – 2219 Aluminum Cleaning & Etching Procedure

Relationship between Bagging Methods and Pre-Weld Holding Times on Porosity Formation in 2219 Aluminum AC-TIG Welds

Aerojet Rocketdyne Welding Senior Project

Principal Investigators: Mariah Head & Tyson Mobley (Materials Engineering)
Faculty Advisor: Prof. Blair London (Materials Engineering)

2219 Aluminum Cleaning & Etching Procedure
April 30, 2014

Safety Callouts

1. HAZMAT

- Hydrofluoric Acid (HF) – Caution: HF is extremely corrosive and toxic and should be handled with great care. HF is a colorless, fuming liquid or gas with a strong, irritating odor. It readily dissolves in water (details below). It will not always cause a burning sensation when in contact with skin so diligence is required to quickly rinse affected area and contact emergency personnel for medical attention.
- Nitric Acid (HNO_3) – Caution: strongly corrosive, toxic, and oxidizing. Nitric acid is a colorless to slightly yellow liquid that is a strong oxidizing acid. Is capable of spontaneous combustion in contact with ignitable materials.

2. Personal Protection Equipment (PPE)

- Splash goggles
- Aprons
- Long pants
- Closed toe shoes
- Chemical resistant gloves
- All work done in fume hood

3. First Aid

- A safely shower / eye wash station must be on site to wash exposed areas with water for at least 15 minutes while medical personnel are contacted.
- Call 911 for any HF exposure and for any non-trivial Nitric Acid exposure
- Calcium Gluconate must be on hand when handling HF acid. After washing 15 minutes, apply to the exposed areas of skin to help reduce the amount of damage done if exposed to HF while medical personnel arrive.

Materials Handling Details

- Turco: Avoid contact with eyes and skin as it can irritate and cause burns in severe cases, and you should rinse thoroughly after any contact. Stable at normal conditions and should be used in a well-ventilated confined or enclosed space. Wear PPE when handling.
- Hydrofluoric Acid (HF): Is toxic and can cause severe burns to the skin, irritation and blindness, and is toxic by inhalation, ingestion, or contact with skin. If any contact occurs, wash effected areas with water for at least 15 minutes and seek medical attention. Splash protection goggles, chemical resistance gloves, and aprons should be worn to prevent any contact. Store in a dry, well-ventilated place in an upright position. Dumping into sewers or waterways is prohibited.

- Nitric Acid (HNO_3): Causes burns to the skin, irritation to the eyes, and injury if inhaled or ingested. Slightly explosive in presence of reducing materials, organic materials, metals, and alkalis. Non-explosive in presence of open flames and sparks, or shocks. In presence of traces of oxides, it attacks all base metals except aluminum and special chromium steels. It will attack some forms of plastics, rubber, and coatings. No corrosive effect on bronze. Keep container tightly closed. Keep container in a cool, well-ventilated area. Avoid contact with ignitable materials.

Procedures

- Prepare etchant and desmut solutions by first measuring out required amount of DI water and then adding the remaining components.
    - Etchant: 50 mL HF acid, 150 mL HNO_3, and 800 mL DI H_2O
    - Desmut agent: 240 mL HNO_3 and 760 mL H_2O
    - Turco solution: pre-diluted to 15%
- Place Turco solution and desmut agent containers on hot plates and heat to required temperatures.
- Arrange beakers and containers into a near assembly line manner to easily proceed through the remaining steps of the procedure.
- Place samples in Turco 3878 LFNC (15% dilute solution, alkaline) for soaking @ 115°F for 20-30 minutes.
- With tongs, remove the sample from the Turco solution and spray rinse into the basic rinse collector with room temperature DI H_2O for no less than 1 minute.
- After rinse, etch the sample surface by immerse in 15% Nitric/5 % HF etching solution at room temperature for 25 seconds .
- Remove the sample from the etch and spray rinse into acid rinse collector, then place in rinse tank (DI H_2O) for 5 minutes minimum at room temperature.
- Desmut the sample surface by immersing in 24% Nitric acid solution at 120°F for 25 seconds to remove any residual metal contaminants from the aluminum sample. This step mostly removes other metal oxides present such as copper oxides but should not contribute to major material removal.
- After desmutting, spray rinse the sample into the acid rinse collector, then place in the rinse tank (DI H_2O) for 5 minutes minimum at room temperature.
- Blow dry the sample with N_2 gas.
- Place sample(s) in vacuum oven for dehydration at 120°F for 60 minutes, minimum.
- Upon removal from the oven, place samples in nylon bags to be purged and heat sealed with N_2 gas.
- Package again in PE bag purged with N_2 gas.
- Once all the samples have been cleaned and etched, dispose of the etchant and desmut agent into the acid waste container and rinse the beakers with water, dumping contents into acid waste a few times to ensure through removal of chemicals.
- Pour the Turco solution back into its container (unless cleaning is completed, then pour into basic waste).

Waste Streams

a. Rinsate from Basic Rinse Collector
b. Rinsate from Acid Rinse Collector and Dilute Acid Rinsate from Rinse Tank

We plan to use a spray rinse method to rinse the samples before placing them within rinse tank. A basic rinse tank will not be used as the Turco solution will be reused until the end of testing and then disposed of into the basic waste container. The etching and desmut steps do require a rinse tank that we will just use spray rinsing before placing into a stagnant DI water container.

Possible Safety Risks

- **Should any chemicals splash onto any exposed skin or clothing**

The emergency shower/eye rinse station will be utilized for at least 15 minutes while emergency personnel (911) are contacted and debriefed about the situation. The Chemical Hygiene Officer will be contacted as well. Once the personnel arrive, they will assess the situation and act accordingly.

- **Should any chemicals get ingested**

Keep calm, seek medical attention, this is listed on MSDS. Sometimes induce vomiting, sometimes not depending on the ingested substance as per the MSDS. Emergency Medical Services and the Chemical Hygiene Officer will be contacted in this situation. Wash hands after handling chemicals and do not handle personal items, such as cell phones, until hands have been washed.

- **Should any chemicals spill**

The number one concern during a spill situation with these materials is personal safety. Only attempt to mitigate spill (keep spill from reaching drain, etc.) and call for help. If safe, absorb a small spill with inert material and contact the Chemical Hygiene Officer. For large spills vacate the area and call 911 and the Environmental Health and Safety office to alert them of the spill during business hours or call 911 after hours. Remain nearby to report an estimate of the amount spilled and what the solution was.

- **Should a chemical fire occur**

The number one concern is personal safety. Vacate the area and call 911. A fire extinguisher may be employed if safe. However, personal safety and notifying emergency personnel are the most important here.

Appendix B – Data Table Excerpt of Porosity Measurements

1AX	2AX	3AX	4AX	1BX	2BX	3BX	4BX	1CX	2CX	3CX	4CX	1DX	2DX	3DX	4DX
97.93	56.87	83.99	61.26	55.10	64.64	92.29	65.37	125.43	85.77	93.75	102.42	162.02	137.67	117.58	114.54
58.74	47.19	67.43	47.35	53.39	64.16	74.36	60.50	94.43	82.08	89.04	83.55	158.35	120.14	110.80	95.26
36.02	43.53	55.36	46.21	53.24	62.33	71.07	55.82	75.99	79.20	73.17	61.53	135.45	106.00	75.51	92.10
35.89	38.17	55.19	42.77	51.13	57.02	66.11	55.67	74.58	74.34	72.23	55.48	134.17	105.82	75.10	91.67
31.14	33.18	51.37	42.27	47.78	54.62	57.91	49.90	60.86	73.18	71.61	53.55	123.59	101.23	66.65	84.97
23.84	29.68	50.24	40.93	47.03	45.14	53.15	49.79	59.14	71.37	68.22	52.92	122.56	79.92	60.97	80.09
23.06	28.69	49.57	38.96	42.54	44.99	50.82	47.58	58.86	66.05	65.38	47.02	99.36	79.84	59.95	79.41
18.98	23.23	49.21	38.43	42.54	42.93	50.30	47.13	53.95	64.33	60.24	46.56	99.13	78.10	59.45	76.18
15.10	23.23	48.91	35.35	42.30	42.09	49.50	45.31	53.38	63.58	58.47	45.85	97.01	75.83	59.37	75.11
13.09	22.82	48.67	34.52	40.83	42.05	48.24	43.20	52.45	61.55	58.30	45.50	92.05	75.22	56.70	70.42
	16.97	48.47	31.82	40.74	41.60	47.86	42.05	52.40	59.93	57.76	45.22	86.28	75.09	55.80	69.43
	15.56	48.43	29.00	39.47	40.74	46.85	41.75	50.67	58.43	57.74	44.34	81.88	74.75	55.12	68.59
	15.37	46.75	28.78	39.29	40.31	46.74	41.69	50.65	58.28	56.48	42.57	79.30	74.27	54.82	67.77
	14.13	45.87	28.26	38.84	40.00	46.43	41.45	48.50	56.19	50.12	42.48	79.28	73.32	54.08	66.80
	13.62	45.85	28.05	38.50	39.47	46.21	41.24	46.27	55.34	49.16	41.71	78.53	72.58	53.05	65.33
	13.13	45.21	27.17	38.38	38.68	45.80	40.93	44.97	54.26	47.64	41.66	71.64	70.46	51.75	65.10
	13.08	45.04	26.17	37.23	37.75	45.14	40.31	43.98	54.17	46.93	41.45	70.70	70.12	51.21	64.71
	13.04	44.81	25.38	37.18	37.61	44.36	39.95	43.30	53.84	46.23	41.29	70.45	69.94	50.81	63.90
	12.15	43.74	23.93	36.53	36.75	43.65	39.95	43.25	51.93	46.22	41.18	69.87	67.25	50.56	63.15
	11.70	43.00	23.91	36.21	36.75	42.71	39.61	43.07	51.47	45.87	40.95	69.69	65.55	50.18	61.48
	11.35	42.45	23.91	36.08	36.01	42.09	39.59	42.32	50.95	45.83	40.32	67.54	63.75	47.45	60.27
	10.70	40.91	22.93	36.08	35.68	41.75	39.49	41.70	50.70	45.82	39.49	61.01	63.24	46.75	60.16
		39.56	22.69	36.08	35.47	41.52	38.61	41.62	50.43	45.55	39.25	60.40	63.20	45.96	60.03
		39.40	22.40	35.35	35.20	41.41	38.27	40.98	50.42	45.42	39.13	60.28	58.93	45.49	59.93
		39.37	22.40	34.80	35.13	41.18	38.27	40.34	50.35	45.21	38.86	57.61	57.39	44.84	59.44
		38.96	21.87	34.60	34.76	41.11	38.19	40.29	49.85	45.05	38.68	57.61	57.29	44.52	58.92
		38.46	21.84	34.60	34.45	39.37	38.14	40.22	49.67	44.96	38.67	56.65	55.65	44.35	56.51
		38.10	21.84	34.40	34.21	39.35	38.14	40.14	49.46	44.89	38.37	56.35	54.99	43.87	56.23
		37.17	20.68	34.21	34.12	38.68	37.94	40.05	49.41	44.44	37.74	56.08	54.83	43.56	56.19
		36.78	19.83	34.19	33.82	38.54	37.56	39.76	48.54	44.15	37.64	55.77	54.49	43.14	55.56
		36.33	19.59	33.65	33.79	38.19	37.04	39.28	48.53	43.90	36.90	53.90	54.32	42.80	54.53
		35.38	19.01	33.06	33.65	37.97	36.97	38.95	48.33	43.79	36.83	53.78	54.01	42.61	54.15
		35.05	18.76	32.60	33.63	37.77	36.75	38.28	48.09	43.20	36.83	53.42	52.43	41.56	53.48
		34.79	17.82	32.60	33.33	37.61	36.54	37.21	47.64	41.70	36.79	52.18	51.51	40.29	53.42
		34.11	17.82	32.50	33.08	37.52	36.41	36.50	47.50	41.66	36.44	51.76	51.21	40.29	51.76
		33.81	17.69	32.39	32.84	37.23	36.26	36.33	47.03	41.29	36.41	51.67	50.95	40.27	51.67
		33.48	17.42	32.04	32.70	36.75	36.21	36.10	47.03	41.29	36.07	51.21	50.76	39.95	50.89
		33.05	16.55	31.76	32.63	36.21	36.01	36.07	46.38	41.09	35.84	51.21	50.67	39.45	50.66
		33.00	16.44	31.16	32.33	35.93	35.16	35.68	45.72	40.94	35.61	50.37	50.47	39.35	50.45
		32.70	16.34	30.68	32.26	35.85	35.08	35.57	45.65	40.39	35.51	49.99	50.18	38.69	50.36
		31.52	16.04	30.63	31.89	35.85	35.08	35.32	45.01	40.32	35.30	49.78	50.16	38.04	50.16
		31.35	15.56	30.60	31.69	35.73	34.88	35.32	44.72	39.95	34.80	49.15	49.95	37.61	49.53
		31.08	15.56	30.58	31.67	35.73	34.88	35.21	44.33	39.73	34.76	48.23	49.32	37.48	49.45
		30.22	15.37	30.51	31.61	35.62	34.74	35.10	44.29	39.45	34.74	47.35	49.32	37.35	49.32
		30.20	15.37	30.45	31.30	35.28	34.45	35.05	43.96	39.40	34.40	47.14	48.62	37.21	49.13
		29.38	15.37	30.35	30.98	35.13	34.21	34.93	43.80	39.28	34.33	47.04	48.08	37.02	49.07
		28.77	15.10	30.06	30.81	35.01	34.19	34.86	43.60	39.25	34.05	46.54	48.06	36.55	48.88
		28.53	14.29	29.97	30.81	34.88	34.19	34.62	43.38	38.95	33.87	46.28	47.96	36.18	48.50
		28.28	14.17	29.84	30.76	34.85	33.89	34.39	43.31	38.90	33.58	46.08	47.21	36.08	47.97
		28.05	13.62	29.75	30.70	34.81	33.84	34.20	43.17	38.76	33.48	45.96	46.73	35.95	47.89
		27.71	13.13	29.66	30.68	34.78	33.82	33.96	43.15	38.67	33.48	45.68	46.38	35.51	47.83
		27.52	13.04	29.53	30.58	34.62	33.79	33.82	43.07	37.93	33.44	45.31	46.33	35.13	47.64
		27.43	12.72	29.49	30.35	34.60	33.42	33.82	43.03	37.93	33.44	45.14	46.31	35.07	47.56
		27.17	12.72	29.49	30.27	34.45	33.26	33.58	42.97	37.87	33.28	44.72	46.30	35.01	47.26
		26.99	12.67	29.43	30.27	34.45	32.97	33.53	42.80	37.86	33.26	44.33	45.87	34.93	45.96

26.53	12.39	29.34	30.27	33.84	32.75	33.51	42.71	37.77	33.26	43.91	45.76	34.88	45.77
26.28	12.39	29.33	30.21	33.79	32.70	33.50	42.64	37.68	33.24	43.79	45.33	34.79	45.62
26.17	12.39	29.33	30.13	33.65	32.64	33.44	42.28	37.63	33.24	43.31	44.75	34.60	45.49
26.17	12.15	29.27	30.05	33.33	32.50	33.22	42.19	37.41	33.22	43.16	44.68	34.59	45.44
26.10	12.15	29.26	29.91	33.26	32.39	33.20	42.03	37.28	32.79	42.93	43.70	34.13	45.32
25.37	11.95	29.24	29.91	33.08	32.39	33.18	41.98	37.17	32.79	42.87	43.03	33.86	45.14
25.28	11.75	29.16	29.75	32.97	32.33	32.97	41.94	37.09	32.68	42.72	42.90	33.69	45.13
25.09	11.70	29.00	29.75	32.93	32.19	32.72	41.77	36.96	32.68	42.54	42.83	33.48	44.91
25.09	11.55	28.94	29.63	32.70	32.19	32.50	41.77	36.90	32.63	42.54	42.64	33.30	44.63
25.02	11.34	28.94	29.33	32.61	32.17	32.28	41.77	36.86	32.25	42.43	42.62	33.27	44.58
25.00	11.08	28.84	29.33	32.50	32.04	32.04	41.75	36.59	32.19	42.17	42.49	33.12	44.41
24.78	10.02	28.84	29.23	32.50	32.04	31.82	41.73	36.54	32.14	42.08	42.43	32.62	44.34
24.13		28.76	29.23	32.39	31.89	31.73	41.60	36.36	31.82	41.41	42.19	32.47	43.84
24.13		28.70	29.01	32.32	31.89	31.70	41.46	36.33	31.76	41.39	41.75	32.42	43.64
23.86		28.44	28.94	32.26	31.76	31.12	41.29	36.15	31.71	41.31	41.56	32.33	43.57
22.85		28.34	28.78	32.26	31.76	30.98	41.29	35.95	31.48	41.01	41.02	32.19	43.57
22.30		28.11	28.76	32.19	31.76	30.82	41.21	35.87	31.42	41.01	40.86	31.99	43.53
22.17		27.95	28.66	31.89	31.42	30.75	41.18	35.61	31.42	40.83	40.29	31.97	43.37
21.57		27.94	28.41	31.76	31.16	30.62	41.10	35.55	30.97	40.70	40.07	31.67	43.06
21.10		27.86	28.41	31.72	31.00	30.50	41.08	35.51	30.75	40.42	39.85	31.52	42.75
20.99		27.84	28.34	31.52	30.96	30.45	41.08	35.34	30.53	40.42	39.73	31.35	42.73
20.90		27.84	28.32	31.44	30.96	30.45	40.85	35.22	30.39	40.36	39.73	31.05	42.21
20.90		27.84	28.26	31.36	30.85	30.43	40.79	35.08	30.37	40.08	39.65	30.66	42.16
20.68		27.84	28.11	31.19	30.85	30.27	40.68	35.05	30.21	39.97	39.45	30.51	41.94
20.65		27.77	28.11	31.16	30.83	30.22	40.66	35.02	30.20	39.97	39.42	30.45	41.86
20.65		27.77	27.77	30.83	30.83	30.21	40.65	34.88	30.04	39.89	39.25	30.20	41.69
20.62		27.71	27.77	30.83	30.83	30.21	40.48	34.86	29.91	39.85	39.13	29.98	41.40
20.21		27.43	27.77	30.81	30.70	30.10	40.26	34.74	29.60	39.65	39.10	29.97	41.35
19.95		27.26	27.43	30.75	30.68	30.09	40.06	34.47	29.48	39.47	38.74	29.91	41.30
19.83		27.23	27.32	30.75	30.68	30.02	39.98	34.45	29.43	39.35	38.67	29.88	41.21
19.68		27.17	27.32	30.70	30.52	29.91	39.89	34.35	29.35	38.88	38.27	29.84	41.21
19.59		27.06	27.26	30.52	30.52	29.66	39.85	34.35	29.26	38.79	38.22	29.73	40.86
19.56		26.97	27.26	30.50	30.50	29.49	39.78	34.33	28.89	38.64	37.40	29.66	40.45
18.76		26.90	27.23	30.50	30.50	29.49	39.78	34.28	28.87	38.38	37.38	29.63	40.44
18.70		26.84	27.06	30.38	30.50	29.48	39.47	34.21	28.83	38.29	36.93	29.48	40.21
18.57		26.47	26.97	30.27	30.50	29.46	39.42	34.05	28.70	38.25	36.86	29.46	40.13
18.48		26.37	26.97	30.13	30.50	29.28	39.40	33.84	28.67	38.13	36.72	29.43	40.03
18.09		26.19	26.95	30.13	30.29	29.13	39.34	33.82	28.67	38.04	36.62	29.01	40.00
17.99		26.18	26.95	30.05	30.27	29.12	39.31	33.79	28.66	37.89	36.50	28.95	39.97
17.39		26.18	26.53	29.91	30.27	29.12	39.28	33.77	28.59	37.89	36.36	28.94	39.76
17.39		26.18	26.50	29.91	30.27	29.09	39.25	33.54	28.58	37.81	36.35	28.78	39.76
17.18		26.17	26.50	29.63	30.13	28.95	39.22	33.51	28.42	37.77	36.28	28.71	39.65
16.97		26.14	26.50	29.43	30.13	28.94	38.99	33.44	28.34	37.56	36.17	28.50	39.35
16.55		25.98	26.37	29.43	29.97	28.91	38.86	33.38	28.33	37.44	35.97	28.44	39.35
16.34		25.84	26.35	29.33	29.73	28.88	38.79	33.18	28.24	37.26	35.80	28.28	39.10
16.30		25.83	26.35	29.33	29.73	28.87	38.77	32.91	28.21	37.26	35.80	28.28	38.97
15.82		25.83	26.23	29.33	29.43	28.87	38.69	32.79	28.14	37.26	35.68	28.28	38.86
15.37		25.83	26.23	29.33	29.43	28.83	38.58	32.79	28.11	37.14	35.60	28.12	38.86
15.37		25.52	26.19	29.31	29.33	28.67	38.27	32.70	28.04	37.04	35.44	27.86	38.51
15.22		25.44	26.17	29.31	29.33	28.54	38.15	32.69	27.74	37.01	35.22	27.77	38.38
15.22		25.43	25.98	29.27	29.33	28.52	37.64	32.65	27.74	37.01	35.05	27.77	38.29
15.14		25.41	25.89	29.11	29.07	28.51	37.60	32.65	27.71	36.97	34.90	27.77	38.13
14.78		25.41	25.89	29.07	29.01	28.43	37.52	32.40	27.67	36.64	34.78	27.71	38.05
14.62		25.41	25.89	29.01	28.84	28.41	37.46	32.39	27.58	36.54	34.74	27.61	37.89
14.29		25.41	25.89	28.94	28.78	28.34	37.40	32.28	27.56	36.54	34.74	27.56	37.89
14.13		25.34	25.82	28.76	28.78	28.04	37.38	32.15	27.39	36.52	34.66	27.54	37.77
13.83		25.27	25.71	28.76	28.76	27.97	37.04	31.89	27.35	36.51	34.59	27.50	37.27

13.26	25.15	25.71	28.72	28.66	27.89	36.98	31.88	27.35	36.50	34.47	27.48	36.92
12.72	25.15	25.71	28.66	28.59	27.82	36.90	31.76	27.28	36.49	34.35	27.43	36.53
11.95	25.15	25.71	28.59	28.51	27.80	36.82	31.63	27.25	36.36	34.28	27.43	36.52
11.76	25.15	25.71	28.41	28.51	27.50	36.69	31.62	27.09	36.28	34.14	27.41	36.41
10.92	25.09	25.71	28.34	28.51	27.48	36.64	31.60	27.06	36.28	33.98	27.41	36.26
10.70	25.09	25.52	28.34	28.51	27.48	36.53	31.58	26.96	36.28	33.97	27.32	36.10
10.26	25.09	25.52	28.32	28.41	27.43	36.53	31.58	26.91	36.10	33.97	27.26	35.84
	25.08	25.41	28.26	28.41	27.41	36.53	31.35	26.89	36.10	33.88	27.26	35.52
	25.02	25.34	28.26	28.34	27.37	36.53	31.26	26.89	35.96	33.88	27.23	35.51
	25.00	25.15	28.01	28.34	27.32	36.21	31.26	26.87	35.96	33.82	27.06	35.28
	24.86	25.15	28.01	28.34	27.25	35.96	31.21	26.83	35.82	33.81	26.90	35.27
	24.84	25.15	27.84	28.34	27.25	35.93	31.20	26.79	35.68	33.79	26.90	35.20
	24.84	25.15	27.77	28.32	27.24	35.83	31.20	26.71	35.28	33.77	26.80	34.83
	24.84	25.15	27.77	28.32	27.22	35.74	31.18	26.71	35.08	33.77	26.79	34.67
	24.58	25.08	27.71	28.32	27.20	35.68	30.85	26.69	34.88	33.72	26.71	34.12
	24.52	24.84	27.32	28.26	27.13	35.57	30.85	26.56	34.81	33.61	26.71	33.93
	24.52	24.84	27.32	28.11	27.04	35.57	30.52	26.53	34.60	33.56	26.69	33.93
	24.48	24.84	27.30	28.11	26.72	35.51	30.45	26.40	34.49	33.44	26.64	33.89
	24.48	24.70	27.30	28.11	26.64	35.40	30.43	26.37	34.45	33.40	26.62	33.79
	24.48	24.70	27.30	27.92	26.60	35.08	30.35	26.37	34.45	33.38	26.59	33.65
	24.42	24.48	27.26	27.90	26.59	35.05	30.20	26.29	34.21	32.92	26.37	33.53
	24.36	24.36	27.23	27.77	26.56	35.04	30.04	26.20	34.12	32.91	26.35	33.44
	24.30	24.36	27.23	27.77	26.43	34.93	29.84	26.20	34.05	32.91	26.29	33.38
	24.19	24.36	27.23	27.56	26.40	34.88	29.84	26.19	33.84	32.79	26.29	33.24
	24.19	24.19	27.17	27.43	26.36	34.81	29.76	26.19	33.84	32.56	26.28	32.93
	24.19	24.19	27.17	27.43	26.35	34.74	29.75	26.14	33.84	32.40	26.19	32.65
	24.19	24.11	27.17	27.32	26.35	34.62	29.72	26.08	33.79	32.25	26.14	32.50
	24.13	24.11	26.97	27.32	26.32	34.59	29.59	26.04	33.79	32.25	26.10	32.50
	24.06	23.99	26.97	27.26	26.31	34.59	29.57	25.97	33.77	32.15	25.81	32.43
	24.06	23.99	26.97	27.26	26.20	34.59	29.52	25.88	33.65	32.10	25.58	32.39
	23.99	23.99	26.90	27.26	26.19	34.59	29.42	25.82	33.58	32.06	25.52	32.36
	23.93	23.99	26.79	27.26	26.19	34.47	29.42	25.81	33.56	31.91	25.50	32.33
	23.92	23.99	26.59	27.23	26.17	34.45	29.33	25.74	33.44	31.84	25.41	32.18
	23.91	23.99	26.59	27.23	26.17	34.21	29.19	25.74	33.20	31.76	25.32	32.04
	23.89	23.99	26.50	27.23	26.13	34.12	29.19	25.71	33.13	31.73	25.28	32.04
	23.89	23.99	26.50	27.23	26.04	33.90	29.12	25.65	33.08	31.69	25.08	31.76
	23.89	23.92	26.35	27.06	25.90	33.85	29.11	25.65	32.93	31.67	25.08	31.67
	23.84	23.89	26.35	26.95	25.89	33.76	29.09	25.64	32.90	31.61	25.04	31.67
	23.79	23.89	26.35	26.95	25.83	33.69	29.01	25.60	32.85	31.59	25.00	31.67
	23.52	23.89	26.33	26.53	25.83	33.69	29.00	25.60	32.84	31.59	24.85	31.61
	23.52	23.79	26.33	26.53	25.81	33.67	28.95	25.53	32.77	31.59	24.84	31.59
	23.41	23.79	26.33	26.53	25.81	33.42	28.87	25.53	32.72	31.35	24.80	31.58
	23.39	23.57	26.29	26.53	25.79	33.38	28.76	25.52	32.70	31.28	24.65	31.48
	23.31	23.57	26.23	26.53	25.76	33.34	28.76	25.51	32.68	31.18	24.61	31.39
	23.16	23.47	26.23	26.50	25.69	33.30	28.74	25.50	32.68	31.18	24.58	31.36
	23.16	23.39	26.23	26.37	25.62	33.16	28.72	25.43	32.68	31.18	24.53	31.19
	23.11	23.31	26.23	26.35	25.60	33.12	28.70	25.34	32.68	31.05	24.48	31.19
	23.11	23.29	26.19	26.35	25.60	33.01	28.66	25.34	32.64	31.05	24.47	31.19
	23.11	23.29	26.19	26.33	25.53	32.92	28.58	25.32	32.50	31.05	24.36	30.96
	23.11	23.16	26.17	26.23	25.53	32.90	28.54	25.23	32.42	30.91	24.36	30.74
	23.08	23.16	26.17	26.19	25.51	32.90	28.54	25.20	32.39	30.69	24.27	30.68
	23.08	23.11	26.14	26.19	25.44	32.90	28.51	25.11	32.39	30.68	24.17	30.68
	23.06	23.11	26.13	26.17	25.41	32.79	28.43	25.08	32.33	30.55	24.08	30.68
	23.03	23.11	26.10	25.98	25.37	32.75	28.42	25.08	32.26	30.54	24.06	30.58
	23.03	23.11	25.98	25.98	25.37	32.74	28.41	25.06	32.15	30.53	24.02	30.54
	23.03	23.08	25.98	25.98	25.35	32.72	28.33	25.06	32.06	30.52	24.01	30.52
	23.03	23.08	25.98	25.98	25.34	32.68	28.32	25.06	32.04	30.52	23.97	30.29

	22.98	23.08	25.98	25.98	25.34	32.64	28.32	25.00	32.04	30.49	23.95	30.21
	22.98	22.98	25.89	25.89	25.34	32.48	28.26	25.00	31.82	30.45	23.93	30.13
	22.93	22.98	25.89	25.89	25.27	32.33	28.14	24.99	31.76	30.35	23.92	29.84
	22.93	22.98	25.89	25.89	25.23	32.18	28.12	24.99	31.72	30.35	23.89	29.73
	22.90	22.90	25.89	25.71	25.21	32.15	28.01	24.95	31.72	30.35	23.89	29.59
	22.90	22.90	25.82	25.64	25.15	32.15	27.95	24.94	31.67	30.21	23.89	29.52
	22.90	22.90	25.82	25.52	25.11	32.06	27.86	24.84	31.59	30.13	23.82	29.46
	22.88	22.90	25.82	25.50	25.08	32.04	27.83	24.80	31.44	30.08	23.79	29.43
	22.85	22.90	25.71	25.50	25.05	32.04	27.67	24.76	31.42	29.91	23.75	29.43
	22.85	22.85	25.64	25.50	25.02	31.97	27.67	24.76	31.36	29.66	23.73	29.33
	22.85	22.67	25.64	25.43	25.00	31.97	27.65	24.70	31.28	29.54	23.73	29.33
	22.82	22.46	25.64	25.43	24.85	31.76	27.56	24.66	31.26	29.52	23.73	29.33
	22.82	22.46	25.63	25.41	24.81	31.63	27.52	24.64	31.20	29.52	23.57	29.33
	22.80	22.46	25.52	25.34	24.80	31.48	27.50	24.58	31.19	29.48	23.57	29.28
	22.75	22.46	25.50	25.34	24.64	31.47	27.37	24.56	31.19	29.41	23.57	29.27
	22.46	22.46	25.43	25.27	24.63	31.43	27.32	24.52	31.16	29.28	23.57	29.20
	22.46	22.43	25.43	25.15	24.63	31.29	27.28	24.52	31.16	29.28	23.45	29.12
	22.46	22.43	25.41	25.15	24.61	31.28	27.28	24.52	30.98	29.28	23.45	29.09
	22.46	22.43	25.41	25.15	24.56	31.22	27.25	24.52	30.98	29.26	23.40	29.01
	22.46	22.35	25.41	25.15	24.52	31.22	27.25	24.48	30.96	29.26	23.39	29.00
	22.46	22.35	25.38	25.08	24.39	31.19	27.17	24.46	30.96	29.23	23.39	28.95
	22.43	22.22	25.38	25.05	24.36	31.06	27.04	24.41	30.96	29.19	23.31	28.94
	22.38	22.22	25.38	25.05	24.32	31.05	27.00	24.36	30.83	29.05	23.31	28.87
	22.35	22.06	25.34	24.89	24.30	31.01	26.95	24.32	30.83	29.01	23.29	28.84
	22.30	22.06	25.34	24.89	24.27	30.97	26.90	24.32	30.81	29.00	23.22	28.78
	22.17	22.06	25.27	24.86	24.19	30.85	26.71	24.29	30.81	28.95	23.19	28.76
	22.17	22.06	25.15	24.84	24.19	30.85	26.71	24.29	30.70	28.89	23.14	28.56
	22.06	22.06	25.15	24.70	24.19	30.83	26.69	24.29	30.70	28.87	23.11	28.54
	22.06	22.03	25.08	24.70	24.17	30.74	26.69	24.19	30.68	28.76	23.05	28.54
	22.03	21.90	25.05	24.65	24.05	30.74	26.64	24.19	30.68	28.76	23.05	28.41
	22.03	21.81	24.89	24.48	24.02	30.72	26.64	24.19	30.68	28.43	22.99	27.91
	21.98	21.81	24.89	24.48	24.01	30.68	26.62	24.12	30.68	28.42	22.99	27.88
	21.98	21.81	24.84	24.48	23.99	30.62	26.59	24.06	30.52	28.39	22.98	27.84
	21.98	21.81	24.84	24.48	23.97	30.53	26.56	24.06	30.51	28.33	22.98	27.77
	21.92	21.74	24.84	24.36	23.95	30.52	26.56	24.05	30.29	28.26	22.92	27.77
	21.87	21.71	24.84	24.36	23.93	30.47	26.54	24.02	30.27	28.26	22.92	27.58
	21.85	21.62	24.83	24.36	23.93	30.43	26.47	24.02	30.21	28.25	22.90	27.50
	21.84	21.62	24.70	24.36	23.90	30.38	26.40	24.02	30.05	28.14	22.90	27.39
	21.84	21.62	24.70	24.19	23.89	30.20	26.35	24.02	30.05	28.12	22.90	27.37
	21.84	21.57	24.65	24.19	23.89	30.15	26.35	23.97	29.97	28.11	22.76	27.32
	21.81	21.57	24.58	24.19	23.87	30.04	26.29	23.93	29.97	28.04	22.60	27.32
	21.81	21.49	24.52	24.19	23.87	30.02	26.17	23.93	29.96	28.00	22.57	27.32
	21.81	21.49	24.48	24.11	23.79	30.00	26.16	23.92	29.91	27.96	22.56	27.26
	21.79	21.49	24.48	24.11	23.71	29.91	26.15	23.67	29.91	27.90	22.50	27.23
	21.79	21.49	24.42	24.11	23.65	29.86	26.15	23.67	29.73	27.86	22.50	27.09
	21.79	21.49	24.42	24.11	23.65	29.84	26.09	23.50	29.68	27.84	22.46	27.04
	21.76	21.46	24.36	24.06	23.65	29.82	25.94	23.50	29.63	27.77	22.46	26.97
	21.74	21.46	24.36	23.99	23.52	29.72	25.88	23.48	29.54	27.77	22.46	26.82
	21.74	21.40	24.36	23.97	23.50	29.72	25.84	23.46	29.49	27.76	22.43	26.71
	21.74	21.40	24.19	23.97	23.48	29.63	25.84	23.43	29.49	27.71	22.39	26.60
	21.74	21.15	24.19	23.97	23.45	29.48	25.83	23.43	29.46	27.67	22.33	26.60
	21.74	21.15	24.19	23.97	23.39	29.46	25.69	23.27	29.43	27.39	22.22	26.53
	21.74	21.15	24.19	23.89	23.27	29.46	25.60	23.22	29.43	27.35	22.07	26.44
	21.66	21.15	24.13	23.89	23.27	29.41	25.60	23.11	29.43	27.25	21.96	26.40
	21.57	21.04	24.11	23.79	23.27	29.26	25.60	22.98	29.33	27.24	21.90	26.37
	21.46	21.04	24.06	23.57	23.22	29.23	25.60	22.91	29.33	27.24	21.90	26.35
	21.46	21.04	23.99	23.57	23.22	29.19	25.52	22.91	29.31	27.24	21.90	26.35

21.46	20.95	23.97	23.57	23.17	29.19	25.52	22.91	29.28	27.11	21.87	26.33
21.40	20.95	23.97	23.52	23.12	29.19	25.47	22.90	29.26	27.11	21.81	26.23
21.40	20.95	23.94	23.52	23.12	29.13	25.45	22.86	29.19	27.09	21.81	26.20
21.40	20.93	23.92	23.52	23.12	29.12	25.43	22.80	29.19	27.06	21.79	26.19
21.35	20.93	23.92	23.52	23.08	29.09	25.39	22.76	29.07	27.00	21.79	26.15
21.35	20.93	23.92	23.47	23.08	29.07	25.39	22.76	29.05	26.97	21.57	26.14
21.15	20.93	23.91	23.47	23.06	29.05	25.34	22.76	29.00	26.96	21.57	26.06
21.15	20.81	23.89	23.39	23.05	29.01	25.32	22.67	28.95	26.87	21.55	25.98
21.15	20.81	23.89	23.39	23.04	29.00	25.15	22.65	28.94	26.87	21.49	25.89
21.15	20.81	23.79	23.39	23.03	28.99	25.15	22.65	28.94	26.83	21.49	25.89
21.10	20.81	23.57	23.39	22.99	28.95	25.11	22.57	28.84	26.83	21.46	25.81
21.10	20.81	23.57	23.31	22.98	28.94	25.11	22.46	28.84	26.82	21.40	25.69
21.10	20.81	23.57	23.31	22.93	28.91	25.11	22.46	28.84	26.82	21.35	25.60
21.10	20.81	23.52	23.31	22.93	28.91	25.11	22.46	28.76	26.79	21.27	25.53
21.04	20.73	23.52	23.31	22.93	28.91	25.06	22.46	28.76	26.78	21.25	25.53
21.04	20.73	23.52	23.29	22.93	28.81	25.04	22.46	28.76	26.74	21.19	25.52
20.99	20.73	23.52	23.29	22.90	28.76	25.00	22.41	28.76	26.71	21.19	25.50
20.95	20.70	23.52	23.16	22.88	28.76	25.00	22.39	28.74	26.71	21.19	25.41
20.95	20.67	23.51	23.16	22.88	28.76	24.95	22.39	28.67	26.69	21.19	25.34
20.95	20.67	23.47	23.11	22.88	28.66	24.89	22.39	28.59	26.64	21.15	25.34
20.95	20.67	23.47	23.11	22.85	28.62	24.89	22.39	28.59	26.60	21.15	25.21
20.81	20.67	23.41	23.11	22.85	28.62	24.80	22.35	28.51	26.53	21.15	25.15
20.81	20.67	23.31	23.11	22.80	28.59	24.80	22.34	28.45	26.40	21.15	25.15
20.81	20.55	23.31	23.11	22.69	28.59	24.77	22.33	28.41	26.37	21.10	25.15
20.77	20.47	23.29	23.11	22.66	28.58	24.76	22.22	28.34	26.35	21.10	25.08
20.76	20.47	23.29	22.98	22.65	28.58	24.73	22.22	28.32	26.35	21.05	25.08
20.76	20.35	23.23	22.98	22.61	28.58	24.68	22.17	28.32	26.31	21.04	25.08
20.76	20.35	23.16	22.98	22.57	28.56	24.66	22.12	28.32	26.29	21.02	25.05
20.73	20.35	23.16	22.98	22.50	28.52	24.61	22.12	28.28	26.20	21.02	24.99
20.73	20.09	23.11	22.90	22.46	28.50	24.61	22.06	28.26	26.19	21.02	24.94
20.70	20.09	23.08	22.90	22.46	28.45	24.61	22.06	28.21	26.17	20.96	24.89
20.70	20.09	23.08	22.90	22.42	28.25	24.61	22.04	28.21	26.16	20.95	24.89
20.70	20.09	23.06	22.90	22.41	28.18	24.53	22.03	28.14	26.15	20.95	24.86
20.70	20.09	22.98	22.90	22.40	28.14	24.52	22.03	28.01	26.15	20.95	24.86
20.68	20.03	22.98	22.90	22.39	28.14	24.51	22.03	27.92	26.14	20.90	24.84
20.68	20.03	22.98	22.90	22.39	28.14	24.51	22.03	27.90	26.08	20.88	24.84
20.68	20.03	22.98	22.90	22.36	28.12	24.51	21.98	27.90	26.06	20.81	24.80
20.67	20.03	22.90	22.90	22.34	28.12	24.48	21.98	27.86	26.01	20.80	24.70
20.67	20.03	22.88	22.75	22.34	28.04	24.48	21.96	27.84	25.97	20.73	24.61
20.67	20.03	22.85	22.67	22.34	28.04	24.46	21.96	27.84	25.84	20.70	24.58
20.65	20.00	22.82	22.67	22.34	28.01	24.39	21.96	27.84	25.76	20.70	24.52
20.65	20.00	22.75	22.46	22.33	27.91	24.34	21.93	27.84	25.71	20.70	24.48
20.65	20.00	22.75	22.46	22.23	27.91	24.29	21.93	27.77	25.69	20.67	24.48
20.65	20.00	22.75	22.46	22.22	27.88	24.19	21.93	27.77	25.67	20.65	24.48
20.65	19.88	22.67	22.46	22.22	27.84	24.19	21.90	27.77	25.65	20.62	24.36
20.62	19.88	22.67	22.46	22.12	27.83	24.12	21.87	27.58	25.53	20.50	24.36
20.55	19.88	22.61	22.46	22.12	27.82	24.06	21.85	27.58	25.51	20.50	24.36
20.55	19.73	22.46	22.46	22.06	27.80	24.06	21.81	27.56	25.50	20.47	24.32
20.50	19.64	22.46	22.43	22.06	27.78	24.02	21.81	27.56	25.47	20.47	24.11
20.47	19.64	22.46	22.43	22.04	27.77	23.97	21.80	27.56	25.43	20.47	24.11
20.47	19.64	22.46	22.43	22.01	27.77	23.93	21.79	27.53	25.43	20.47	24.08
20.47	19.64	22.46	22.35	21.98	27.74	23.89	21.77	27.49	25.37	20.42	24.06
20.47	19.64	22.46	22.35	21.96	27.65	23.87	21.75	27.48	25.37	20.42	24.02
20.47	19.64	22.46	22.22	21.96	27.52	23.82	21.74	27.23	25.34	20.42	23.92
20.42	19.64	22.46	22.22	21.96	27.43	23.78	21.69	27.23	25.32	20.39	23.89
20.42	19.64	22.43	22.22	21.96	27.43	23.65	21.68	27.23	25.23	20.35	23.89
20.42	19.64	22.43	22.22	21.96	27.41	23.65	21.68	27.06	25.11	20.35	23.87

20.35	19.64	22.43	22.06	21.93	27.39	23.65	21.62	27.04	25.08	20.34	23.79
20.09	19.64	22.43	22.06	21.92	27.37	23.65	21.62	27.04	24.89	20.27	23.79
20.09	19.64	22.41	22.06	21.80	27.35	23.58	21.58	27.04	24.89	20.26	23.79
20.09	19.61	22.35	22.06	21.79	27.30	23.58	21.57	26.97	24.86	20.24	23.79
20.09	19.61	22.35	21.92	21.79	27.30	23.57	21.46	26.97	24.84	20.22	23.73
20.09	19.61	22.35	21.92	21.77	27.30	23.52	21.46	26.95	24.77	20.21	23.52
20.09	19.57	22.35	21.92	21.75	27.25	23.52	21.46	26.95	24.77	20.21	23.52
20.03	19.49	22.32	21.92	21.75	27.24	23.50	21.44	26.90	24.66	20.15	23.52
20.03	19.49	22.06	21.92	21.75	27.24	23.48	21.40	26.90	24.66	20.09	23.52
20.03	19.49	22.06	21.92	21.70	27.23	23.46	21.36	26.90	24.61	20.09	23.50
20.00	19.49	22.06	21.90	21.69	27.20	23.45	21.35	26.90	24.58	20.09	23.48
20.00	19.40	22.06	21.90	21.69	27.13	23.43	21.30	26.90	24.46	20.09	23.47
19.98	19.40	22.06	21.90	21.69	27.11	23.43	21.27	26.79	24.46	20.09	23.43
19.98	19.40	22.06	21.90	21.68	27.06	23.31	21.27	26.79	24.46	20.09	23.33
19.98	19.30	22.06	21.81	21.67	27.04	23.29	21.27	26.71	24.39	20.09	23.31
19.98	19.27	22.00	21.81	21.61	26.95	23.27	21.27	26.59	24.39	20.04	23.29
19.95	19.27	21.98	21.81	21.61	26.90	23.27	21.27	26.59	24.36	20.04	23.29
19.88	19.27	21.92	21.81	21.60	26.90	23.27	21.24	26.58	24.29	20.03	23.29
19.88	19.27	21.92	21.79	21.59	26.90	23.27	21.24	26.55	24.27	20.00	23.29
19.88	19.27	21.92	21.79	21.59	26.88	23.19	21.21	26.53	24.19	20.00	23.29
19.88	19.27	21.90	21.79	21.57	26.83	23.19	21.21	26.53	24.17	20.00	23.16
19.88	19.27	21.90	21.79	21.57	26.80	23.17	21.19	26.53	24.17	19.98	23.14
19.88	19.06	21.90	21.79	21.55	26.78	23.16	21.19	26.50	23.97	19.88	23.14
19.83	19.06	21.81	21.79	21.44	26.74	23.11	21.19	26.50	23.93	19.88	23.11
19.83	19.06	21.81	21.79	21.44	26.74	23.11	21.10	26.50	23.87	19.83	23.04
19.83	19.06	21.81	21.71	21.41	26.69	23.10	21.04	26.37	23.82	19.80	23.04
19.73	19.02	21.74	21.71	21.37	26.60	23.04	21.02	26.35	23.73	19.74	22.98
19.73	19.02	21.74	21.71	21.36	26.56	22.99	21.02	26.35	23.73	19.74	22.98
19.73	19.02	21.71	21.71	21.36	26.56	22.98	21.02	26.35	23.73	19.73	22.98
19.64	19.02	21.71	21.57	21.35	26.53	22.98	21.02	26.35	23.63	19.68	22.98
19.64	18.81	21.71	21.49	21.30	26.53	22.98	20.93	26.35	23.63	19.64	22.90
19.64	18.81	21.49	21.49	21.27	26.50	22.93	20.93	26.33	23.58	19.64	22.90
19.64	18.81	21.49	21.49	21.27	26.42	22.93	20.93	26.32	23.51	19.64	22.75
19.64	18.81	21.46	21.46	21.20	26.42	22.91	20.88	26.31	23.45	19.62	22.75
19.64	18.81	21.46	21.46	21.19	26.42	22.91	20.85	26.29	23.45	19.62	22.67
19.64	18.81	21.46	21.40	21.05	26.35	22.90	20.81	26.23	23.40	19.61	22.57
19.61	18.76	21.46	21.40	21.04	26.29	22.90	20.81	26.23	23.29	19.49	22.55
19.61	18.74	21.46	21.15	21.02	26.29	22.88	20.74	26.23	23.29	19.49	22.55
19.61	18.74	21.46	21.15	21.02	26.19	22.88	20.70	26.23	23.29	19.44	22.46
19.60	18.65	21.46	21.15	21.02	26.19	22.85	20.70	26.23	23.29	19.44	22.46
19.59	18.65	21.40	21.15	21.00	26.17	22.81	20.70	26.23	23.27	19.40	22.46
19.59	18.61	21.40	21.15	20.96	26.15	22.73	20.70	26.19	23.27	19.35	22.43
19.59	18.61	21.15	21.15	20.95	26.14	22.73	20.70	26.19	23.16	19.34	22.43
19.56	18.61	21.15	21.15	20.90	26.10	22.73	20.67	26.19	23.12	19.34	22.34
19.49	18.61	21.15	21.04	20.90	26.06	22.67	20.67	26.19	23.11	19.32	22.23
19.49	18.61	21.15	21.04	20.88	26.04	22.67	20.55	26.19	23.11	19.27	22.22
19.49	18.61	21.15	21.04	20.88	25.97	22.57	20.53	26.19	23.11	19.27	22.22
19.49	18.61	21.15	21.04	20.88	25.89	22.57	20.53	26.17	23.01	19.27	22.12
19.44	18.55	21.15	21.04	20.88	25.88	22.57	20.53	26.17	22.99	19.26	22.07
19.40	18.55	21.10	21.04	20.88	25.83	22.46	20.53	26.15	22.96	19.26	22.06
19.40	18.55	21.04	21.04	20.87	25.74	22.43	20.51	26.14	22.93	19.26	22.06
19.40	18.55	20.95	21.04	20.85	25.71	22.41	20.51	26.14	22.93	19.19	22.06
19.30	18.55	20.95	21.04	20.81	25.62	22.39	20.50	26.14	22.91	19.19	22.06
19.30	18.55	20.95	20.95	20.80	25.60	22.39	20.50	26.14	22.90	19.13	22.06
19.26	18.52	20.95	20.95	20.78	25.60	22.36	20.47	26.14	22.88	19.09	22.03
19.02	18.52	20.95	20.95	20.76	25.60	22.34	20.44	26.14	22.85	19.06	21.98
19.02	18.52	20.93	20.95	20.75	25.52	22.33	20.42	26.06	22.80	19.06	21.96

	19.02	18.52	20.93	20.95	20.74	25.51	22.22	20.35	25.98	22.75	19.02	21.92
	19.02	18.52	20.91	20.95	20.73	25.51	22.22	20.34	25.98	22.75	19.02	21.92
	19.02	18.52	20.81	20.95	20.71	25.50	22.22	20.34	25.94	22.75	19.02	21.92
	19.02	18.52	20.81	20.93	20.70	25.39	22.18	20.24	25.89	22.75	19.02	21.92
	19.01	18.52	20.81	20.93	20.67	25.39	22.18	20.24	25.89	22.70	19.02	21.92
	18.98	18.49	20.81	20.93	20.67	25.37	22.12	20.24	25.89	22.57	18.95	21.90
	18.98	18.26	20.81	20.93	20.62	25.23	22.12	20.22	25.89	22.57	18.95	21.87
	18.98	18.26	20.81	20.93	20.55	25.20	22.12	20.22	25.89	22.55	18.95	21.85
	18.81	18.13	20.81	20.93	20.51	25.18	22.07	20.21	25.89	22.46	18.91	21.79
	18.81	18.13	20.81	20.81	20.51	25.18	22.07	20.18	25.83	22.40	18.81	21.79
	18.81	18.13	20.81	20.81	20.51	25.18	22.04	20.09	25.82	22.39	18.81	21.79
	18.76	18.13	20.81	20.81	20.50	25.18	22.03	20.09	25.82	22.39	18.81	21.73
	18.74	18.03	20.81	20.81	20.47	25.11	21.98	20.09	25.82	22.34	18.81	21.70
	18.65	18.03	20.77	20.73	20.47	25.08	21.96	20.04	25.71	22.34	18.81	21.70
	18.65	17.97	20.77	20.73	20.39	25.04	21.96	20.00	25.71	22.25	18.80	21.70
	18.65	17.97	20.73	20.73	20.39	25.04	21.85	20.00	25.71	22.25	18.78	21.60
	18.65	17.97	20.73	20.70	20.35	25.00	21.85	20.00	25.69	22.23	18.78	21.57
	18.65	17.87	20.73	20.70	20.34	25.00	21.85	19.98	25.62	22.12	18.78	21.55
	18.60	17.87	20.73	20.70	20.34	24.99	21.85	19.98	25.60	22.07	18.78	21.49
	18.60	17.73	20.70	20.70	20.30	24.95	21.85	19.98	25.60	22.07	18.76	21.49
	18.60	17.73	20.70	20.70	20.27	24.86	21.85	19.95	25.53	22.06	18.76	21.49
	18.57	17.73	20.67	20.67	20.27	24.85	21.81	19.88	25.52	22.04	18.74	21.46
	18.57	17.73	20.67	20.67	20.26	24.84	21.79	19.83	25.52	22.03	18.74	21.46
	18.55	17.73	20.67	20.67	20.26	24.80	21.77	19.83	25.52	21.96	18.70	21.46
	18.55	17.73	20.55	20.55	20.24	24.77	21.75	19.83	25.50	21.96	18.65	21.40
	18.55	17.73	20.55	20.55	20.23	24.76	21.70	19.83	25.50	21.96	18.65	21.40
	18.55	17.60	20.55	20.55	20.22	24.66	21.69	19.80	25.43	21.93	18.65	21.30
	18.52	17.60	20.55	20.55	20.22	24.66	21.66	19.80	25.43	21.92	18.65	21.27
	18.52	17.60	20.47	20.55	20.21	24.66	21.62	19.80	25.41	21.91	18.61	21.24
	18.52	17.60	20.47	20.47	20.21	24.63	21.58	19.74	25.34	21.91	18.61	21.15
	18.51	17.60	20.47	20.47	20.18	24.61	21.55	19.74	25.34	21.90	18.59	21.15
	18.51	17.57	20.35	20.47	20.16	24.51	21.55	19.74	25.34	21.87	18.57	21.15
	18.49	17.57	20.35	20.47	20.16	24.51	21.49	19.68	25.34	21.85	18.55	21.15
	18.48	17.57	20.30	20.47	20.16	24.48	21.44	19.68	25.32	21.81	18.55	21.04
	18.47	17.57	20.09	20.35	20.16	24.46	21.44	19.68	25.32	21.75	18.55	21.02
	18.47	17.57	20.09	20.35	20.16	24.46	21.42	19.68	25.27	21.75	18.55	21.02
	18.45	17.57	20.09	20.35	20.09	24.46	21.42	19.68	25.27	21.69	18.55	20.95
	18.26	17.57	20.09	20.26	20.09	24.39	21.40	19.65	25.27	21.69	18.53	20.95
	18.26	17.57	20.09	20.26	20.09	24.39	21.35	19.64	25.27	21.69	18.53	20.95
	18.26	17.57	20.09	20.09	20.03	24.39	21.35	19.64	25.27	21.68	18.52	20.93
	18.26	17.57	20.03	20.09	20.00	24.36	21.27	19.64	25.27	21.68	18.52	20.93
	18.22	17.57	20.03	20.09	20.00	24.34	21.27	19.62	25.27	21.62	18.52	20.93
	18.03	17.46	20.03	20.09	19.98	24.32	21.27	19.52	25.15	21.57	18.52	20.88
	18.03	17.46	20.03	20.09	19.98	24.29	21.27	19.50	25.15	21.55	18.52	20.88
	18.03	17.46	20.03	20.09	19.98	24.19	21.27	19.39	25.15	21.49	18.52	20.85
	17.99	17.46	20.03	20.09	19.95	24.19	21.24	19.39	25.13	21.48	18.52	20.85
	17.97	17.43	20.03	20.09	19.95	24.19	21.19	19.39	25.11	21.46	18.52	20.81
	17.97	17.43	20.03	20.09	19.83	24.19	21.15	19.34	25.08	21.46	18.52	20.81
	17.97	17.43	20.03	20.09	19.83	24.17	21.04	19.34	25.08	21.44	18.44	20.81
	17.97	17.43	20.00	20.03	19.83	24.12	21.02	19.34	25.08	21.42	18.26	20.76
	17.93	17.43	20.00	20.03	19.83	24.05	21.02	19.32	25.08	21.42	18.26	20.74
	17.93	17.22	20.00	20.03	19.80	24.05	21.02	19.32	25.05	21.42	18.18	20.70
	17.93	17.22	20.00	20.03	19.80	23.97	21.02	19.26	24.99	21.42	18.13	20.70
	17.93	17.22	19.88	20.03	19.80	23.97	21.02	19.26	24.89	21.42	18.13	20.67
	17.92	17.22	19.73	20.03	19.74	23.97	20.93	19.26	24.89	21.36	18.13	20.67
	17.92	17.22	19.73	20.03	19.74	23.97	20.88	19.26	24.86	21.35	18.11	20.55
	17.87	17.05	19.73	20.00	19.74	23.94	20.88	19.25	24.86	21.27	18.11	20.42

17.87	17.02	19.73	19.88	19.73	23.93	20.85	19.19	24.86	21.24	18.11	20.35
17.73	17.02	19.64	19.88	19.68	23.92	20.85	19.16	24.84	21.24	18.11	20.35
17.73	17.02	19.64	19.88	19.68	23.89	20.85	19.13	24.77	21.19	18.11	20.35
17.73	17.02	19.64	19.73	19.64	23.89	20.85	19.13	24.76	21.19	18.04	20.27
17.73	17.02	19.64	19.73	19.64	23.87	20.85	19.13	24.70	21.15	18.01	20.27
17.70	17.02	19.64	19.64	19.64	23.87	20.81	19.13	24.65	21.10	18.01	20.26
17.70	16.95	19.64	19.64	19.64	23.82	20.81	19.09	24.65	21.05	17.98	20.26
17.70	16.91	19.61	19.64	19.59	23.79	20.80	19.07	24.61	21.05	17.98	20.22
17.60	16.91	19.61	19.64	19.59	23.78	20.76	19.07	24.61	21.02	17.97	20.22
17.60	16.66	19.61	19.64	19.57	23.78	20.76	19.07	24.58	21.02	17.97	20.09
17.60	16.63	19.59	19.64	19.56	23.73	20.74	19.06	24.58	21.02	17.97	20.09
17.60	16.63	19.49	19.64	19.56	23.65	20.73	19.06	24.48	20.96	17.97	20.09
17.60	16.63	19.49	19.64	19.55	23.65	20.73	19.06	24.48	20.96	17.97	20.09
17.57	16.63	19.49	19.64	19.52	23.65	20.73	19.02	24.48	20.88	17.97	20.09
17.57	16.63	19.40	19.64	19.52	23.65	20.70	19.02	24.48	20.88	17.97	20.03
17.57	16.63	19.40	19.64	19.50	23.65	20.70	19.00	24.39	20.85	17.97	20.03
17.57	16.59	19.40	19.64	19.49	23.65	20.70	18.91	24.36	20.81	17.97	20.03
17.57	16.48	19.35	19.64	19.46	23.65	20.62	18.81	24.36	20.81	17.92	20.03
17.56	16.48	19.30	19.64	19.46	23.58	20.62	18.80	24.36	20.80	17.92	20.03
17.56	16.48	19.30	19.61	19.40	23.57	20.62	18.78	24.36	20.73	17.92	20.03
17.56	16.38	19.30	19.61	19.35	23.52	20.59	18.76	24.36	20.70	17.87	20.00
17.53	16.38	19.30	19.61	19.35	23.52	20.59	18.76	24.29	20.70	17.87	20.00
17.53	16.38	19.30	19.61	19.34	23.50	20.59	18.65	24.29	20.67	17.87	19.98
17.53	16.38	19.30	19.49	19.33	23.48	20.55	18.65	24.19	20.62	17.78	19.88
17.53	16.38	19.27	19.49	19.32	23.48	20.55	18.65	24.19	20.59	17.74	19.88
17.52	16.38	19.27	19.49	19.32	23.48	20.55	18.63	24.19	20.55	17.73	19.83
17.46	16.38	19.27	19.49	19.32	23.46	20.55	18.63	24.17	20.53	17.73	19.74
17.46	16.34	19.23	19.49	19.30	23.46	20.53	18.61	24.11	20.50	17.67	19.74
17.46	16.34	19.06	19.49	19.28	23.45	20.53	18.59	24.11	20.47	17.60	19.73
17.46	16.34	19.06	19.40	19.28	23.43	20.50	18.55	24.11	20.44	17.60	19.64
17.46	16.34	19.02	19.30	19.26	23.43	20.50	18.55	24.06	20.42	17.60	19.64
17.46	16.34	19.02	19.30	19.25	23.43	20.50	18.53	24.02	20.42	17.58	19.64
17.46	16.34	19.02	19.30	19.19	23.43	20.39	18.53	23.99	20.35	17.57	19.64
17.46	16.34	19.02	19.27	19.19	23.43	20.39	18.53	23.99	20.35	17.57	19.64
17.43	16.34	19.02	19.27	19.19	23.43	20.35	18.53	23.99	20.34	17.57	19.64
17.43	16.34	19.02	19.27	19.16	23.42	20.35	18.53	23.99	20.34	17.57	19.64
17.43	16.34	18.81	19.06	19.16	23.40	20.34	18.53	23.99	20.34	17.56	19.64
17.43	16.34	18.81	19.06	19.16	23.40	20.27	18.52	23.99	20.34	17.56	19.61
17.42	16.34	18.81	19.06	19.13	23.34	20.27	18.52	23.99	20.34	17.56	19.61
17.40	16.19	18.74	19.06	19.10	23.29	20.27	18.52	23.97	20.27	17.54	19.55
17.39	16.19	18.74	19.02	19.09	23.27	20.22	18.50	23.93	20.26	17.54	19.55
17.39	16.19	18.74	19.02	19.08	23.22	20.22	18.50	23.92	20.24	17.54	19.40
17.22	16.19	18.74	19.02	19.08	23.22	20.16	18.49	23.89	20.22	17.52	19.40
17.22	16.19	18.74	19.02	19.07	23.17	20.16	18.48	23.89	20.22	17.51	19.40
17.22	16.19	18.74	19.02	19.02	23.16	20.09	18.43	23.89	20.21	17.51	19.34
17.22	16.19	18.65	19.02	19.01	23.14	20.09	18.43	23.89	20.15	17.50	19.30
17.22	16.19	18.65	18.81	18.98	23.11	20.09	18.37	23.89	20.15	17.46	19.30
17.22	16.19	18.61	18.81	18.95	22.99	20.09	18.37	23.89	20.09	17.46	19.30
17.22	16.08	18.61	18.81	18.91	22.98	20.09	18.31	23.63	20.09	17.46	19.27
17.22	16.08	18.61	18.81	18.91	22.91	20.04	18.30	23.58	20.04	17.46	19.27
17.19	16.08	18.55	18.81	18.88	22.91	20.04	18.30	23.52	20.04	17.44	19.27
17.19	16.08	18.55	18.81	18.88	22.91	20.04	18.27	23.52	20.03	17.44	19.13
17.18	15.86	18.55	18.81	18.88	22.90	20.00	18.27	23.52	20.03	17.43	19.13
17.18	15.86	18.55	18.74	18.82	22.88	19.98	18.27	23.47	20.00	17.43	19.07
17.05	15.86	18.55	18.74	18.81	22.86	19.98	18.18	23.47	19.98	17.34	19.07
17.05	15.86	18.55	18.74	18.81	22.86	19.98	18.18	23.45	19.88	17.31	19.06
17.05	15.86	18.55	18.74	18.76	22.85	19.98	18.18	23.43	19.88	17.30	19.06

	17.02	15.86	18.55	18.74	18.76	22.81	19.98	18.18	23.40	19.88	17.22	19.06
	17.01	15.71	18.55	18.65	18.76	22.75	19.95	18.18	23.39	19.83	17.22	19.06
	17.01	15.71	18.55	18.65	18.76	22.75	19.95	18.14	23.31	19.80	17.22	19.06
	16.98	15.71	18.52	18.65	18.74	22.75	19.88	18.14	23.31	19.80	17.20	19.06
	16.97	15.60	18.52	18.65	18.72	22.75	19.88	18.13	23.31	19.74	17.10	19.02
	16.97	15.60	18.52	18.65	18.65	22.75	19.83	18.11	23.29	19.74	17.10	19.02
	16.91	15.60	18.52	18.65	18.65	22.75	19.83	18.11	23.29	19.74	17.06	19.02
	16.91	15.60	18.52	18.61	18.63	22.75	19.74	18.11	23.29	19.74	17.05	19.02
	16.91	15.60	18.52	18.61	18.61	22.73	19.74	18.11	23.27	19.74	17.05	19.00
	16.87	15.60	18.52	18.61	18.56	22.70	19.74	18.11	23.27	19.73	17.05	18.97
	16.87	15.60	18.48	18.61	18.56	22.70	19.74	18.05	23.27	19.68	17.02	18.88
	16.87	15.60	18.26	18.61	18.55	22.65	19.74	18.05	23.19	19.65	17.02	18.88
	16.87	15.60	18.26	18.61	18.55	22.65	19.74	18.05	23.16	19.64	17.01	18.81
	16.87	15.60	18.26	18.61	18.55	22.60	19.68	18.04	23.16	19.64	17.01	18.81
	16.87	15.60	18.26	18.55	18.53	22.60	19.64	18.04	23.16	19.62	16.96	18.81
	16.66	15.60	18.26	18.55	18.53	22.60	19.64	18.01	23.11	19.61	16.96	18.80
	16.63	15.60	18.26	18.55	18.53	22.57	19.64	18.01	23.11	19.61	16.92	18.78
	16.63	15.48	18.26	18.55	18.50	22.57	19.64	17.99	23.11	19.52	16.91	18.74
	16.63	15.48	18.26	18.55	18.48	22.52	19.61	17.98	23.11	19.50	16.87	18.74
	16.63	15.48	18.26	18.55	18.47	22.46	19.61	17.98	23.11	19.49	16.78	18.74
	16.63	15.48	18.13	18.55	18.43	22.46	19.55	17.97	23.08	19.46	16.66	18.65
	16.63	15.48	18.13	18.55	18.43	22.44	19.52	17.97	23.08	19.44	16.66	18.65
	16.63	15.48	18.09	18.55	18.31	22.43	19.52	17.97	23.08	19.39	16.66	18.65
	16.63	15.48	18.09	18.55	18.31	22.43	19.50	17.97	23.04	19.39	16.60	18.61
	16.60	15.41	18.03	18.55	18.31	22.43	19.49	17.92	22.99	19.34	16.59	18.55
	16.59	15.41	18.03	18.55	18.31	22.41	19.49	17.87	22.98	19.34	16.59	18.55
	16.59	15.41	18.03	18.52	18.30	22.41	19.49	17.87	22.98	19.34	16.59	18.55
	16.59	15.41	18.03	18.52	18.27	22.39	19.46	17.87	22.98	19.32	16.59	18.55
	16.59	15.41	17.99	18.52	18.27	22.39	19.34	17.87	22.98	19.30	16.57	18.55
	16.59	15.41	17.97	18.52	18.26	22.39	19.34	17.84	22.98	19.30	16.57	18.52
	16.59	15.41	17.97	18.52	18.26	22.39	19.32	17.84	22.98	19.27	16.57	18.52
	16.59	15.41	17.87	18.52	18.22	22.36	19.32	17.84	22.98	19.27	16.57	18.52
	16.55	15.41	17.87	18.52	18.22	22.36	19.30	17.84	22.91	19.26	16.48	18.52
	16.48	15.41	17.87	18.52	18.19	22.35	19.27	17.84	22.90	19.26	16.47	18.52
	16.48	15.41	17.87	18.52	18.19	22.33	19.26	17.84	22.90	19.26	16.44	18.52
	16.48	15.41	17.73	18.52	18.18	22.25	19.26	17.84	22.90	19.19	16.44	18.49
	16.48	15.29	17.73	18.52	18.18	22.23	19.25	17.81	22.90	19.19	16.42	18.49
	16.45	15.29	17.73	18.49	18.14	22.23	19.25	17.78	22.90	19.16	16.39	18.31
	16.44	15.29	17.73	18.26	18.13	22.23	19.19	17.78	22.90	19.13	16.39	18.30
	16.38	15.29	17.73	18.26	18.13	22.22	19.19	17.78	22.90	19.13	16.38	18.27
	16.38	15.29	17.73	18.26	18.13	22.22	19.19	17.78	22.90	19.07	16.38	18.27
	16.38	15.26	17.60	18.26	18.11	22.22	19.16	17.73	22.88	19.07	16.38	18.26
	16.34	15.25	17.60	18.13	18.11	22.22	19.13	17.73	22.86	19.02	16.38	18.26
	16.34	15.25	17.60	18.13	18.11	22.12	19.09	17.73	22.75	19.02	16.35	18.13
	16.34	15.25	17.60	18.13	18.11	22.12	19.09	17.73	22.75	19.00	16.35	18.13
	16.34	15.25	17.60	18.13	18.11	22.12	19.09	17.72	22.75	19.00	16.34	18.11
	16.34	15.25	17.60	18.13	18.09	22.07	19.09	17.72	22.67	19.00	16.34	18.11
	16.34	15.25	17.57	18.13	18.07	22.04	19.09	17.72	22.67	19.00	16.34	18.11
	16.34	15.17	17.57	18.13	18.05	22.03	19.07	17.72	22.67	18.97	16.32	18.11
	16.34	15.17	17.57	18.03	18.04	21.96	19.07	17.60	22.67	18.95	16.30	18.03
	16.34	15.17	17.57	18.03	18.04	21.96	19.06	17.58	22.65	18.95	16.30	18.03
	16.34	15.17	17.57	18.03	18.03	21.96	19.06	17.58	22.57	18.91	16.19	18.01
	16.34	15.17	17.57	17.97	17.99	21.96	19.06	17.56	22.57	18.91	16.19	18.01
	16.30	15.13	17.57	17.97	17.98	21.96	19.06	17.54	22.46	18.88	16.19	17.97
	16.30	15.13	17.53	17.97	17.98	21.92	19.06	17.54	22.46	18.88	16.18	17.97
	16.30	15.13	17.53	17.97	17.98	21.90	18.97	17.54	22.46	18.78	16.18	17.97
	16.30	15.13	17.46	17.97	17.98	21.90	18.97	17.51	22.46	18.72	16.15	17.97

	16.30	15.13	17.46	17.97	17.98	21.88	18.95	17.44	22.44	18.72	16.13	17.97
	16.19	14.82	17.46	17.87	17.97	21.87	18.91	17.44	22.44	18.63	16.13	17.97
	16.16	14.82	17.46	17.87	17.93	21.87	18.88	17.44	22.43	18.61	16.08	17.87
	16.16	14.82	17.46	17.87	17.92	21.87	18.81	17.43	22.43	18.59	16.08	17.87
	16.16	14.82	17.43	17.87	17.85	21.85	18.81	17.43	22.39	18.59	16.08	17.87
	16.16	14.82	17.43	17.87	17.84	21.79	18.80	17.40	22.39	18.55	16.08	17.84
	16.16	14.82	17.22	17.73	17.84	21.69	18.80	17.40	22.35	18.53	16.05	17.84
	16.16	14.82	17.22	17.73	17.81	21.69	18.78	17.40	22.35	18.53	16.03	17.84
	16.08	14.82	17.22	17.73	17.78	21.68	18.76	17.40	22.35	18.50	16.02	17.81
	16.08	14.82	17.22	17.73	17.78	21.62	18.74	17.37	22.35	18.49	16.02	17.73
	16.08	14.82	17.22	17.73	17.78	21.60	18.74	17.34	22.22	18.49	16.02	17.73
	16.08	14.82	17.22	17.73	17.78	21.58	18.74	17.31	22.22	18.43	15.94	17.73
	16.05	14.82	17.22	17.73	17.78	21.58	18.72	17.31	22.22	18.43	15.88	17.73
	16.04	14.82	17.22	17.73	17.74	21.57	18.72	17.31	22.06	18.43	15.88	17.73
	15.86	14.82	17.22	17.73	17.73	21.55	18.72	17.31	22.06	18.43	15.88	17.73
	15.86	14.66	17.22	17.73	17.73	21.55	18.65	17.30	22.06	18.31	15.86	17.67
	15.83	14.66	17.22	17.73	17.73	21.49	18.65	17.22	22.06	18.31	15.86	17.67
	15.82	14.62	17.22	17.73	17.71	21.49	18.63	17.22	22.06	18.31	15.86	17.64
	15.71	14.62	17.22	17.73	17.70	21.44	18.63	17.22	22.06	18.31	15.86	17.60
	15.71	14.62	17.05	17.73	17.69	21.44	18.61	17.10	22.06	18.27	15.86	17.60
	15.71	14.62	17.05	17.73	17.69	21.44	18.61	17.10	22.06	18.27	15.86	17.60
	15.71	14.62	17.05	17.60	17.68	21.42	18.61	17.09	22.03	18.27	15.83	17.60
	15.71	14.53	17.05	17.60	17.67	21.40	18.61	17.06	22.03	18.27	15.83	17.60
	15.67	14.53	17.05	17.60	17.67	21.36	18.59	17.05	22.03	18.26	15.83	17.60
	15.60	14.53	17.02	17.60	17.67	21.36	18.59	17.02	21.96	18.20	15.82	17.60
	15.60	14.53	17.02	17.60	17.64	21.30	18.59	17.02	21.96	18.20	15.80	17.60
	15.60	14.53	17.02	17.57	17.61	21.30	18.55	16.98	21.96	18.18	15.71	17.57
	15.60	14.33	17.02	17.57	17.60	21.25	18.55	16.96	21.92	18.14	15.71	17.57
	15.60	14.33	16.98	17.57	17.59	21.24	18.55	16.96	21.92	18.13	15.71	17.57
	15.60	14.33	16.95	17.57	17.58	21.24	18.55	16.96	21.92	18.11	15.68	17.57
	15.60	14.20	16.95	17.57	17.58	21.21	18.55	16.96	21.92	18.11	15.60	17.57
	15.60	14.20	16.95	17.57	17.56	21.19	18.55	16.95	21.90	18.11	15.60	17.57
	15.60	14.20	16.91	17.57	17.56	21.15	18.55	16.95	21.90	18.11	15.60	17.56
	15.60	14.20	16.91	17.57	17.55	21.15	18.53	16.92	21.87	18.11	15.60	17.46
	15.56	14.20	16.91	17.57	17.54	21.15	18.53	16.92	21.81	18.11	15.60	17.46
	15.56	14.20	16.66	17.46	17.53	21.10	18.53	16.92	21.81	18.11	15.60	17.46
	15.56	14.20	16.66	17.46	17.52	21.05	18.52	16.92	21.81	18.05	15.60	17.46
	15.56	14.20	16.66	17.46	17.51	21.04	18.52	16.89	21.81	18.05	15.60	17.44
	15.56	14.20	16.66	17.46	17.51	21.02	18.52	16.89	21.79	18.04	15.58	17.43
	15.56	14.20	16.66	17.43	17.51	21.02	18.52	16.87	21.79	18.01	15.56	17.37
	15.56	14.20	16.66	17.43	17.51	21.02	18.52	16.81	21.79	17.98	15.48	17.34
	15.50	14.16	16.66	17.43	17.51	21.02	18.50	16.81	21.79	17.98	15.48	17.31
	15.48	14.16	16.66	17.22	17.51	21.02	18.48	16.78	21.79	17.98	15.48	17.22
	15.48	14.16	16.63	17.22	17.49	21.02	18.43	16.78	21.79	17.97	15.48	17.22
	15.48	14.16	16.63	17.22	17.44	21.02	18.37	16.78	21.79	17.92	15.48	17.20
	15.48	14.16	16.63	17.22	17.44	20.96	18.31	16.78	21.73	17.92	15.48	17.10
	15.48	14.16	16.63	17.22	17.44	20.95	18.27	16.78	21.71	17.92	15.42	17.10
	15.48	14.16	16.63	17.22	17.44	20.95	18.26	16.71	21.71	17.87	15.42	17.09
	15.44	14.16	16.63	17.22	17.44	20.95	18.13	16.71	21.70	17.84	15.42	17.05
	15.44	14.16	16.63	17.22	17.44	20.95	18.13	16.71	21.70	17.84	15.42	17.05
	15.41	14.16	16.59	17.05	17.43	20.93	18.13	16.71	21.69	17.84	15.41	17.02
	15.41	14.16	16.59	17.05	17.42	20.88	18.11	16.66	21.68	17.84	15.41	17.02
	15.41	14.16	16.59	17.05	17.40	20.88	18.11	16.63	21.62	17.84	15.41	17.02
	15.41	14.16	16.59	17.05	17.40	20.88	18.11	16.63	21.62	17.82	15.37	17.02
	15.37	13.95	16.59	17.05	17.40	20.88	18.11	16.59	21.62	17.81	15.37	16.96
	15.37	13.95	16.59	17.05	17.37	20.88	18.11	16.59	21.62	17.78	15.35	16.95
	15.37	13.95	16.59	17.05	17.36	20.85	18.11	16.59	21.58	17.78	15.34	16.95

15.37	13.95	16.59	17.05	17.34	20.85	18.09	16.57	21.58	17.74	15.34	16.91
15.29	13.95	16.56	17.05	17.34	20.85	18.05	16.57	21.57	17.74	15.29	16.91
15.29	13.95	16.48	17.05	17.31	20.85	18.05	16.57	21.57	17.73	15.29	16.91
15.29	13.95	16.48	17.02	17.31	20.85	18.05	16.57	21.55	17.64	15.29	16.91
15.29	13.95	16.48	17.02	17.31	20.85	18.04	16.57	21.49	17.64	15.25	16.91
15.29	13.95	16.48	17.02	17.30	20.85	18.01	16.57	21.49	17.60	15.25	16.88
15.25	13.95	16.48	16.95	17.30	20.85	18.01	16.57	21.49	17.58	15.25	16.71
15.25	13.87	16.45	16.95	17.26	20.81	18.01	16.57	21.46	17.58	15.25	16.67
15.25	13.87	16.38	16.95	17.23	20.81	18.01	16.54	21.46	17.56	15.25	16.67
15.25	13.87	16.38	16.95	17.22	20.81	17.98	16.48	21.46	17.54	15.17	16.66
15.25	13.78	16.38	16.91	17.22	20.76	17.98	16.48	21.42	17.54	15.17	16.66
15.25	13.78	16.38	16.91	17.20	20.76	17.98	16.48	21.36	17.52	15.17	16.66
15.25	13.78	16.34	16.91	17.20	20.74	17.98	16.48	21.35	17.51	15.17	16.63
15.25	13.78	16.34	16.91	17.10	20.74	17.98	16.47	21.30	17.51	15.17	16.63
15.25	13.78	16.34	16.66	17.10	20.74	17.98	16.42	21.21	17.46	15.14	16.63
15.22	13.78	16.34	16.66	17.10	20.73	17.98	16.42	21.19	17.44	15.14	16.63
15.22	13.65	16.34	16.66	17.09	20.73	17.97	16.42	21.19	17.44	15.13	16.63
15.17	13.65	16.34	16.66	17.05	20.70	17.92	16.39	21.15	17.44	15.10	16.60
15.17	13.65	16.34	16.63	17.05	20.70	17.92	16.39	21.05	17.44	15.03	16.59
15.17	13.65	16.34	16.63	17.03	20.59	17.92	16.38	21.04	17.43	15.03	16.59
15.17	13.65	16.34	16.59	17.02	20.59	17.92	16.38	21.04	17.43	14.99	16.59
15.17	13.47	16.34	16.59	17.02	20.55	17.84	16.38	21.04	17.43	14.99	16.59
15.17	13.47	16.34	16.59	17.02	20.53	17.84	16.35	21.02	17.40	14.96	16.59
15.17	13.47	16.34	16.59	17.02	20.53	17.84	16.34	20.96	17.40	14.88	16.59
15.14	13.30	16.30	16.59	17.01	20.51	17.84	16.34	20.95	17.37	14.82	16.57
15.14	13.30	16.19	16.59	17.00	20.51	17.84	16.32	20.95	17.37	14.82	16.54
15.14	13.30	16.19	16.48	16.97	20.51	17.74	16.32	20.95	17.37	14.82	16.48
15.13	13.30	16.19	16.48	16.96	20.50	17.73	16.32	20.93	17.34	14.82	16.47
15.10	13.30	16.19	16.48	16.95	20.50	17.73	16.25	20.93	17.31	14.82	16.39
15.10	13.27	16.19	16.48	16.92	20.50	17.73	16.25	20.93	17.31	14.80	16.39
14.82	13.25	16.19	16.48	16.92	20.47	17.72	16.25	20.90	17.31	14.75	16.38
14.82	13.25	16.19	16.38	16.92	20.47	17.67	16.19	20.88	17.31	14.72	16.38
14.82	13.25	16.08	16.38	16.92	20.47	17.67	16.19	20.85	17.31	14.72	16.38
14.82	13.16	16.08	16.38	16.92	20.44	17.64	16.19	20.85	17.30	14.67	16.38
14.78	13.16	16.08	16.38	16.92	20.44	17.60	16.19	20.85	17.30	14.66	16.38
14.78	13.16	16.08	16.38	16.92	20.39	17.60	16.19	20.81	17.30	14.66	16.38
14.78	13.16	16.08	16.38	16.91	20.35	17.56	16.19	20.81	17.22	14.66	16.38
14.66	13.16	16.08	16.38	16.91	20.35	17.56	16.18	20.81	17.22	14.64	16.38
14.66	13.16	16.08	16.34	16.91	20.34	17.56	16.17	20.81	17.22	14.62	16.38
14.66	13.12	15.86	16.34	16.91	20.34	17.56	16.17	20.81	17.22	14.62	16.35
14.66	13.12	15.86	16.34	16.89	20.34	17.54	16.16	20.81	17.20	14.62	16.35
14.66	13.12	15.86	16.34	16.89	20.34	17.54	16.09	20.76	17.20	14.62	16.34
14.66	13.12	15.86	16.34	16.89	20.34	17.54	16.08	20.74	17.20	14.62	16.34
14.66	13.12	15.86	16.34	16.88	20.34	17.54	16.08	20.74	17.10	14.62	16.34
14.66	13.12	15.86	16.34	16.83	20.34	17.51	16.04	20.73	17.10	14.61	16.34
14.62	13.12	15.86	16.34	16.82	20.26	17.51	16.03	20.73	17.10	14.58	16.34
14.62	13.12	15.86	16.34	16.82	20.24	17.51	16.03	20.70	17.10	14.53	16.34
14.62	13.12	15.86	16.34	16.81	20.24	17.46	16.03	20.70	17.09	14.53	16.25
14.62	13.07	15.86	16.34	16.81	20.22	17.46	16.02	20.70	17.09	14.53	16.19
14.62	12.75	15.71	16.34	16.78	20.22	17.44	15.94	20.70	17.06	14.50	16.19
14.58	12.75	15.71	16.34	16.78	20.18	17.43	15.94	20.70	17.05	14.47	16.19
14.53	12.75	15.71	16.19	16.71	20.18	17.43	15.91	20.70	17.02	14.39	16.19
14.53	12.75	15.71	16.19	16.71	20.15	17.40	15.88	20.67	16.96	14.39	16.19
14.53	12.70	15.71	16.19	16.68	20.15	17.37	15.88	20.67	16.96	14.38	16.19
14.50	12.70	15.71	16.19	16.67	20.15	17.34	15.88	20.55	16.96	14.38	16.18
14.50	12.70	15.71	16.19	16.66	20.09	17.34	15.88	20.55	16.96	14.38	16.13
14.33	12.70	15.68	16.19	16.66	20.09	17.31	15.88	20.50	16.96	14.38	16.09

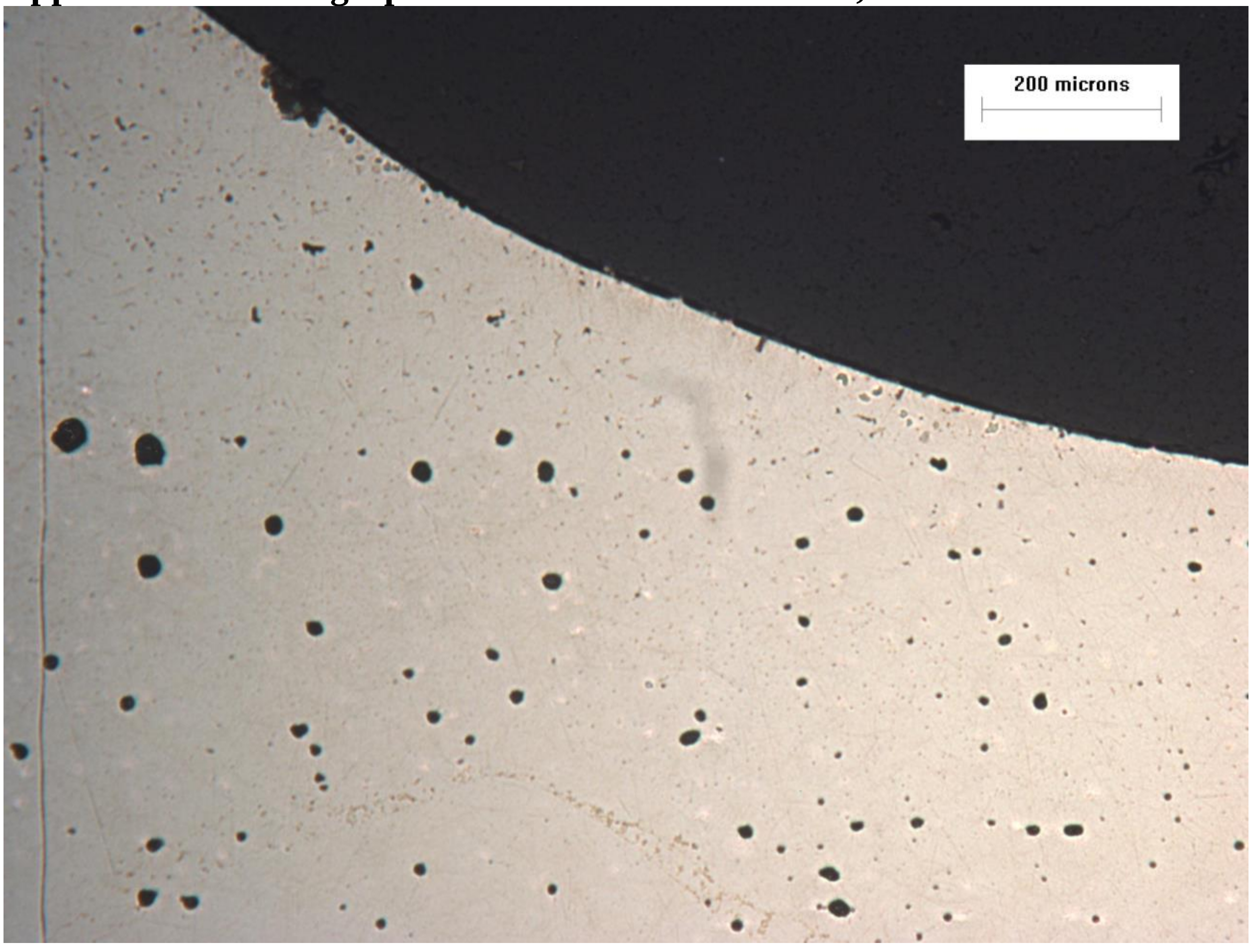
14.33	12.70	15.67	16.19	16.66	20.09	17.31	15.88	20.47	16.96	14.38	16.08
14.33	12.70	15.60	16.19	16.66	20.09	17.31	15.88	20.47	16.96	14.33	16.08
14.33	12.42	15.60	16.19	16.66	20.04	17.31	15.83	20.47	16.95	14.33	16.03
14.33	12.42	15.60	16.19	16.63	20.03	17.22	15.83	20.47	16.95	14.30	16.03
14.30	12.42	15.60	16.19	16.60	20.03	17.22	15.83	20.47	16.92	14.29	16.02
14.30	12.42	15.60	16.19	16.60	20.03	17.22	15.83	20.39	16.92	14.20	16.02
14.30	12.42	15.60	16.19	16.60	20.03	17.22	15.80	20.39	16.92	14.20	15.91
14.29	12.42	15.60	16.19	16.59	20.00	17.22	15.80	20.35	16.91	14.20	15.91
14.29	12.42	15.60	16.19	16.57	19.98	17.10	15.80	20.35	16.91	14.20	15.88
14.20	12.42	15.60	16.19	16.57	19.98	17.10	15.72	20.35	16.89	14.20	15.88
14.20	12.42	15.60	16.08	16.57	19.98	17.10	15.72	20.26	16.88	14.20	15.86
14.20	12.32	15.48	16.08	16.57	19.95	17.10	15.72	20.26	16.87	14.20	15.86
14.20	12.32	15.48	16.08	16.57	19.95	17.10	15.72	20.26	16.82	14.20	15.86
14.20	12.18	15.48	16.08	16.57	19.95	17.09	15.68	20.24	16.82	14.20	15.83
14.20	12.18	15.48	16.08	16.57	19.95	17.06	15.68	20.22	16.81	14.20	15.80
14.20	12.18	15.48	16.08	16.57	19.95	17.06	15.61	20.15	16.81	14.20	15.80
14.17	12.18	15.48	16.08	16.54	19.95	17.05	15.60	20.09	16.78	14.17	15.80
14.17	12.18	15.41	16.08	16.54	19.88	17.02	15.60	20.03	16.78	14.17	15.72
14.16	12.18	15.41	16.08	16.54	19.88	17.02	15.60	20.03	16.78	14.16	15.71
14.16	12.18	15.41	16.08	16.47	19.83	17.02	15.60	20.00	16.78	14.16	15.71
14.16	12.18	15.41	16.08	16.47	19.83	17.01	15.58	20.00	16.71	14.16	15.71
14.16	12.18	15.41	15.86	16.44	19.83	16.96	15.58	20.00	16.71	14.16	15.71
14.16	12.18	15.37	15.86	16.42	19.83	16.96	15.58	20.00	16.71	14.16	15.61
14.13	12.18	15.29	15.86	16.42	19.83	16.96	15.50	20.00	16.67	14.14	15.60
14.10	12.03	15.29	15.86	16.39	19.83	16.92	15.50	20.00	16.67	14.14	15.60
13.95	12.03	15.29	15.86	16.39	19.80	16.91	15.50	19.88	16.67	14.13	15.60
13.95	12.03	15.29	15.86	16.39	19.80	16.91	15.49	19.88	16.67	14.10	15.60
13.95	11.98	15.25	15.86	16.38	19.74	16.91	15.49	19.83	16.63	14.06	15.60
13.92	11.98	15.25	15.86	16.38	19.74	16.89	15.48	19.83	16.63	14.06	15.60
13.91	11.78	15.25	15.86	16.38	19.74	16.82	15.48	19.83	16.63	14.06	15.60
13.87	11.78	15.25	15.71	16.38	19.74	16.82	15.42	19.74	16.60	14.01	15.60
13.87	11.78	15.22	15.71	16.35	19.68	16.82	15.42	19.73	16.60	13.95	15.60
13.87	11.78	15.17	15.71	16.35	19.68	16.82	15.42	19.73	16.57	13.95	15.58
13.87	11.78	15.17	15.71	16.35	19.68	16.78	15.41	19.65	16.57	13.92	15.48
13.78	11.78	15.17	15.71	16.35	19.68	16.78	15.41	19.64	16.57	13.92	15.48
13.78	11.73	15.17	15.71	16.34	19.65	16.78	15.41	19.64	16.57	13.91	15.48
13.78	11.73	15.17	15.71	16.34	19.64	16.78	15.41	19.64	16.57	13.89	15.42
13.78	11.73	15.14	15.60	16.34	19.64	16.78	15.38	19.64	16.57	13.89	15.41
13.78	11.73	15.13	15.60	16.30	19.64	16.78	15.38	19.64	16.57	13.89	15.41
13.75	11.73	15.13	15.60	16.25	19.64	16.71	15.35	19.64	16.57	13.89	15.41
13.75	11.73	15.13	15.60	16.25	19.62	16.67	15.34	19.62	16.57	13.79	15.41
13.70	11.73	15.13	15.60	16.20	19.62	16.67	15.34	19.61	16.54	13.79	15.38
13.65	11.58	15.13	15.60	16.19	19.61	16.66	15.34	19.61	16.48	13.79	15.35
13.65	11.58	15.13	15.60	16.19	19.61	16.66	15.34	19.61	16.48	13.78	15.34
13.65	11.58	15.10	15.60	16.19	19.55	16.63	15.29	19.50	16.44	13.78	15.34
13.47	11.58	15.10	15.60	16.19	19.55	16.60	15.29	19.49	16.42	13.78	15.34
13.47	11.37	14.82	15.48	16.19	19.55	16.60	15.26	19.49	16.42	13.75	15.29
13.47	11.37	14.82	15.48	16.19	19.55	16.60	15.26	19.40	16.39	13.71	15.29
13.47	11.37	14.82	15.48	16.18	19.52	16.59	15.26	19.40	16.39	13.71	15.29
13.44	11.22	14.82	15.48	16.17	19.52	16.57	15.26	19.40	16.38	13.71	15.26
13.44	11.22	14.82	15.48	16.17	19.52	16.57	15.26	19.40	16.38	13.66	15.25
13.40	11.11	14.82	15.41	16.13	19.52	16.57	15.26	19.40	16.35	13.66	15.25
13.30	11.11	14.82	15.41	16.13	19.46	16.57	15.26	19.40	16.35	13.65	15.25
13.30	11.11	14.82	15.41	16.09	19.46	16.57	15.26	19.39	16.35	13.65	15.17
13.30	10.95	14.82	15.41	16.09	19.39	16.57	15.25	19.32	16.35	13.65	15.17
13.30	10.89	14.82	15.41	16.08	19.34	16.57	15.25	19.30	16.34	13.65	15.17
13.27	10.89	14.82	15.41	16.08	19.34	16.57	15.17	19.30	16.34	13.65	15.17

	13.27	10.78	14.82	15.41	16.02	19.32	16.48	15.17	19.27	16.34	13.62	15.17
	13.27	10.78	14.78	15.41	16.02	19.32	16.48	15.17	19.27	16.34	13.62	15.17
	13.25	10.33	14.66	15.41	16.02	19.32	16.48	15.17	19.27	16.32	13.53	15.14
	13.25	10.33	14.66	15.41	16.02	19.30	16.42	15.13	19.27	16.32	13.53	15.13
	13.25	10.28	14.66	15.41	15.98	19.30	16.42	15.13	19.27	16.32	13.47	15.13
	13.25	10.28	14.66	15.41	15.94	19.30	16.42	15.10	19.27	16.25	13.47	15.13
	13.25	10.04	14.66	15.41	15.94	19.27	16.39	15.10	19.26	16.25	13.47	15.13
	13.22	10.04	14.66	15.41	15.93	19.27	16.39	15.10	19.26	16.19	13.47	15.13
	13.22	10.04	14.62	15.41	15.91	19.27	16.39	15.06	19.26	16.19	13.47	15.13
	13.16	10.04	14.62	15.41	15.91	19.26	16.35	15.03	19.19	16.19	13.47	15.13
	13.16	10.04	14.53	15.29	15.88	19.26	16.35	15.03	19.19	16.19	13.45	15.03
	13.16	10.04	14.53	15.29	15.88	19.19	16.35	15.03	19.13	16.17	13.45	14.96
	13.16	10.04	14.53	15.29	15.88	19.19	16.35	15.03	19.13	16.13	13.45	14.96
	13.16	10.04	14.53	15.29	15.88	19.19	16.35	14.99	19.13	16.09	13.45	14.88
	13.16		14.53	15.29	15.86	19.13	16.35	14.99	19.09	16.09	13.44	14.88
	13.16		14.53	15.25	15.83	19.13	16.35	14.96	19.06	16.09	13.40	14.88
	13.16		14.53	15.25	15.83	19.13	16.35	14.96	19.06	16.08	13.40	14.87
	13.13		14.53	15.17	15.83	19.09	16.34	14.88	19.06	16.08	13.36	14.82
	13.13		14.53	15.17	15.83	19.07	16.34	14.87	19.06	16.08	13.35	14.82
	13.12		14.50	15.17	15.80	19.06	16.34	14.87	19.02	16.08	13.30	14.82
	13.12		14.33	15.17	15.79	19.06	16.34	14.87	19.02	16.03	13.30	14.82
	13.12		14.33	15.17	15.78	19.06	16.34	14.82	19.02	16.03	13.30	14.82
	13.12		14.33	15.17	15.77	19.06	16.32	14.82	19.02	16.03	13.30	14.82
	13.12		14.33	15.17	15.76	19.06	16.32	14.82	19.02	16.02	13.30	14.82
	13.12		14.33	15.17	15.72	19.06	16.32	14.82	19.02	16.02	13.30	14.82
	13.12		14.33	15.17	15.71	19.02	16.32	14.82	19.02	16.02	13.30	14.82
	13.12		14.33	15.13	15.71	19.02	16.32	14.82	19.00	15.94	13.26	14.82
	13.10		14.33	15.13	15.68	19.02	16.25	14.75	18.97	15.91	13.26	14.82
	13.09		14.33	15.13	15.68	19.00	16.25	14.75	18.91	15.91	13.26	14.80
	13.09		14.33	15.13	15.68	19.00	16.25	14.75	18.81	15.91	13.25	14.72
	13.09		14.33	15.13	15.64	18.98	16.19	14.72	18.81	15.91	13.25	14.66
	13.08		14.20	15.13	15.63	18.97	16.19	14.72	18.80	15.91	13.25	14.66
	13.08		14.20	15.13	15.63	18.95	16.19	14.72	18.78	15.88	13.17	14.66
	13.08		14.20	15.13	15.61	18.95	16.19	14.72	18.78	15.88	13.17	14.62
	13.08		14.20	14.82	15.61	18.95	16.18	14.72	18.78	15.88	13.17	14.62
	13.08		14.20	14.82	15.61	18.91	16.18	14.71	18.78	15.88	13.17	14.62
	13.08		14.20	14.82	15.61	18.91	16.13	14.71	18.74	15.88	13.17	14.62
	13.07		14.20	14.82	15.60	18.91	16.09	14.71	18.74	15.88	13.16	14.62
	13.07		14.20	14.82	15.60	18.91	16.08	14.67	18.74	15.83	13.16	14.62
	13.07		14.20	14.82	15.58	18.91	16.08	14.67	18.74	15.83	13.16	14.62
	13.04		14.20	14.82	15.58	18.88	16.05	14.67	18.72	15.83	13.16	14.62
	13.04		14.20	14.82	15.58	18.88	16.03	14.67	18.72	15.83	13.12	14.61
	13.04		14.20	14.82	15.58	18.88	16.03	14.67	18.65	15.83	13.12	14.53
	12.75		14.16	14.82	15.58	18.81	16.03	14.67	18.65	15.83	13.12	14.53
	12.75		14.16	14.82	15.58	18.81	16.03	14.64	18.65	15.80	13.08	14.53
	12.75		14.16	14.66	15.55	18.81	16.03	14.64	18.65	15.80	13.08	14.53
	12.75		14.16	14.66	15.55	18.80	16.02	14.64	18.65	15.80	13.07	14.42
	12.75		14.16	14.66	15.53	18.78	15.94	14.53	18.63	15.80	13.07	14.42
	12.75		14.16	14.66	15.52	18.78	15.94	14.53	18.61	15.80	13.07	14.33
	12.75		14.16	14.66	15.50	18.78	15.94	14.53	18.61	15.72	13.07	14.33
	12.75		14.16	14.66	15.50	18.78	15.94	14.53	18.61	15.71	12.99	14.33
	12.75		14.16	14.66	15.50	18.78	15.94	14.53	18.61	15.71	12.95	14.33
	12.72		14.16	14.66	15.49	18.76	15.94	14.50	18.61	15.67	12.95	14.33
	12.70		14.16	14.66	15.49	18.76	15.94	14.50	18.61	15.67	12.95	14.30
	12.70		14.16	14.62	15.45	18.74	15.91	14.50	18.61	15.61	12.91	14.26
	12.70		13.95	14.62	15.44	18.74	15.91	14.47	18.59	15.60	12.91	14.26
	12.70		13.95	14.62	15.43	18.72	15.91	14.42	18.59	15.60	12.82	14.20

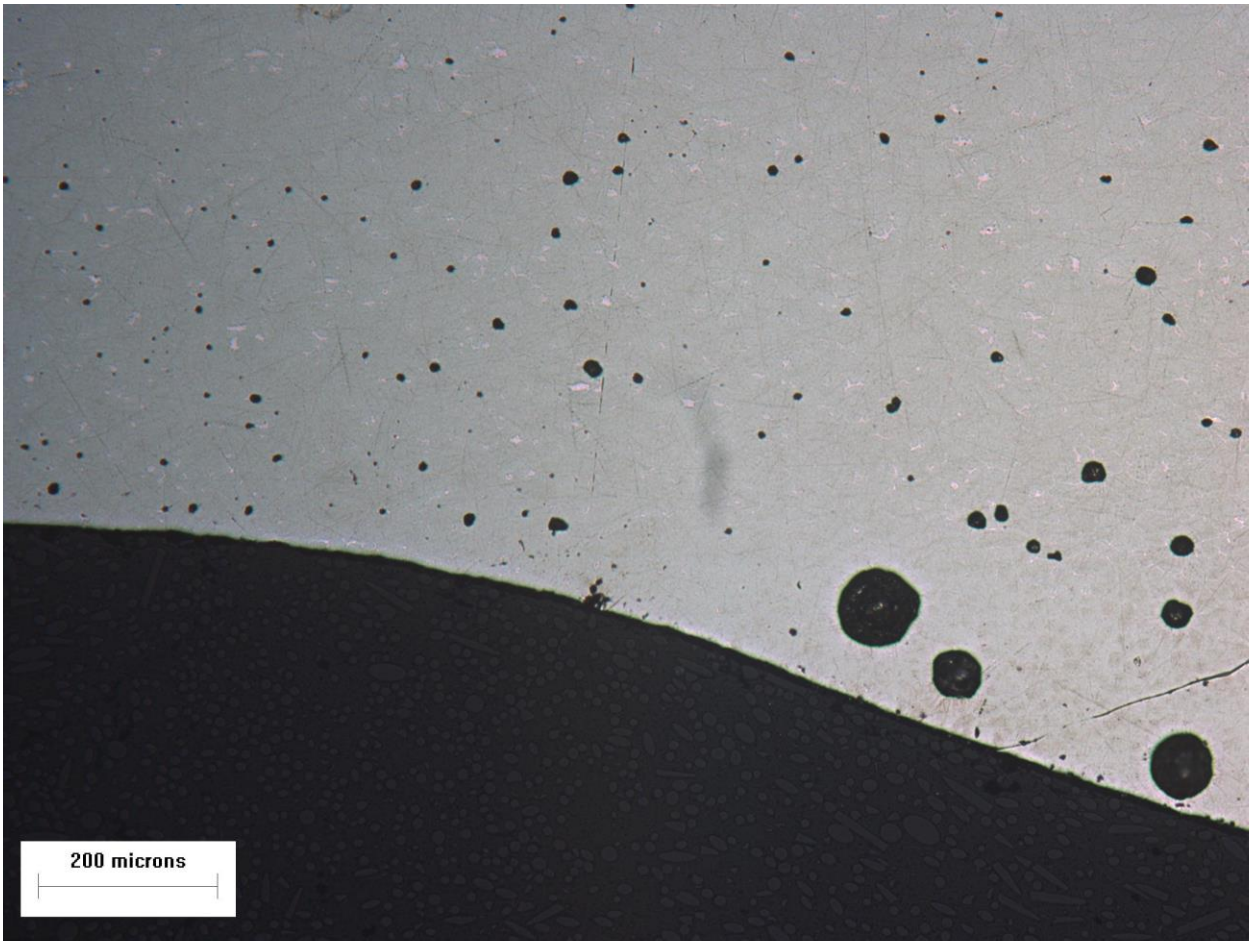
	12.70		13.95	14.62	15.42	18.72	15.91	14.42	18.55	15.60	12.82	14.20
	12.70		13.95	14.62	15.42	18.72	15.88	14.38	18.55	15.58	12.76	14.20
	12.70		13.95	14.62	15.41	18.63	15.88	14.38	18.55	15.49	12.75	14.20
	12.70		13.95	14.62	15.41	18.63	15.88	14.38	18.55	15.48	12.75	14.20
	12.68		13.95	14.62	15.41	18.63	15.88	14.33	18.53	15.48	12.75	14.20
	12.42		13.87	14.53	15.38	18.61	15.88	14.33	18.53	15.48	12.75	14.20
	12.42		13.87	14.53	15.38	18.61	15.88	14.33	18.52	15.42	12.75	14.20
	12.42		13.83	14.53	15.35	18.61	15.86	14.30	18.52	15.42	12.72	14.20
	12.42		13.78	14.53	15.35	18.61	15.86	14.30	18.52	15.42	12.72	14.20
	12.42		13.78	14.53	15.35	18.59	15.86	14.30	18.52	15.42	12.70	14.20
	12.42		13.78	14.53	15.34	18.59	15.86	14.30	18.52	15.42	12.70	14.20
	12.42		13.75	14.53	15.34	18.59	15.86	14.30	18.52	15.42	12.70	14.20
	12.42		13.65	14.33	15.34	18.59	15.86	14.30	18.52	15.41	12.70	14.16
	12.42		13.62	14.33	15.33	18.55	15.83	14.30	18.50	15.41	12.67	14.16
	12.42		13.47	14.33	15.32	18.55	15.80	14.26	18.49	15.41	12.67	14.16
	12.40		13.47	14.33	15.32	18.55	15.80	14.26	18.49	15.41	12.67	14.16
	12.39		13.47	14.33	15.29	18.53	15.72	14.20	18.49	15.41	12.67	14.16
	12.39		13.30	14.33	15.29	18.53	15.68	14.20	18.49	15.41	12.67	14.16
	12.39		13.30	14.20	15.29	18.52	15.68	14.20	18.47	15.41	12.63	14.16
	12.18		13.30	14.20	15.27	18.52	15.68	14.20	18.37	15.38	12.57	14.16
	12.18		13.30	14.20	15.26	18.52	15.61	14.20	18.31	15.35	12.57	14.16
	12.18		13.25	14.20	15.26	18.50	15.61	14.20	18.30	15.34	12.57	14.16
	12.18		13.25	14.20	15.26	18.50	15.61	14.20	18.27	15.34	12.57	14.16
	12.18		13.25	14.20	15.26	18.49	15.61	14.20	18.27	15.29	12.54	14.16
	12.18		13.25	14.20	15.26	18.49	15.60	14.20	18.26	15.29	12.53	14.16
	12.15		13.25	14.20	15.26	18.48	15.60	14.20	18.26	15.27	12.44	14.16
	12.15		13.16	14.20	15.26	18.43	15.60	14.17	18.26	15.26	12.43	14.06
	12.03		13.16	14.20	15.26	18.43	15.60	14.17	18.26	15.26	12.42	13.95
	12.03		13.16	14.20	15.25	18.43	15.58	14.16	18.26	15.26	12.42	13.95
	12.03		13.16	14.20	15.21	18.43	15.50	14.16	18.26	15.26	12.42	13.95
	12.03		13.16	14.20	15.19	18.43	15.49	14.16	18.26	15.25	12.42	13.95
	12.03		13.16	14.16	15.19	18.37	15.49	14.16	18.26	15.25	12.42	13.89
	12.03		13.16	14.16	15.17	18.37	15.49	14.16	18.26	15.25	12.42	13.89
	12.00		13.16	14.16	15.17	18.37	15.49	14.13	18.26	15.19	12.42	13.89
	12.00		13.16	14.16	15.17	18.31	15.49	14.13	18.13	15.17	12.42	13.89
	12.00		13.16	14.16	15.14	18.31	15.49	14.13	18.13	15.17	12.42	13.86
	11.98		13.12	14.16	15.14	18.31	15.48	14.00	18.13	15.17	12.42	13.78
	11.98		13.12	14.16	15.13	18.31	15.48	13.96	18.13	15.14	12.42	13.78
	11.95		13.12	14.16	15.12	18.30	15.42	13.95	18.11	15.14	12.42	13.78
	11.95		13.12	13.95	15.10	18.30	15.42	13.92	18.11	15.14	12.42	13.78
	11.95		13.12	13.95	15.06	18.30	15.42	13.92	18.11	15.13	12.42	13.78
	11.95		13.12	13.95	15.06	18.27	15.41	13.92	18.11	15.13	12.39	13.75
	11.95		13.12	13.95	15.06	18.27	15.41	13.92	18.11	15.13	12.35	13.75
	11.78		13.12	13.95	15.06	18.26	15.41	13.89	18.05	15.13	12.35	13.75
	11.78		13.12	13.87	15.03	18.20	15.41	13.89	18.04	15.13	12.32	13.75
	11.78		13.12	13.87	15.03	18.18	15.38	13.89	18.03	15.13	12.29	13.65
	11.78		13.07	13.87	15.03	18.14	15.35	13.89	18.03	15.10	12.29	13.65
	11.78		13.07	13.87	14.99	18.13	15.35	13.89	18.03	15.06	12.24	13.65
	11.75		12.75	13.78	14.99	18.13	15.34	13.89	18.03	15.06	12.24	13.65
	11.75		12.75	13.78	14.97	18.11	15.34	13.89	18.03	15.06	12.18	13.65
	11.75		12.75	13.78	14.96	18.11	15.34	13.86	17.99	15.03	12.18	13.65
	11.73		12.75	13.78	14.96	18.11	15.34	13.79	17.98	14.99	12.18	13.65
	11.73		12.75	13.65	14.96	18.11	15.34	13.79	17.97	14.99	12.18	13.65
	11.73		12.75	13.65	14.96	18.05	15.34	13.79	17.97	14.99	12.18	13.62
	11.73		12.75	13.65	14.96	18.04	15.34	13.78	17.97	14.96	12.18	13.62
	11.71		12.70	13.65	14.96	18.03	15.34	13.78	17.97	14.96	12.18	13.53
	11.71		12.70	13.65	14.91	18.03	15.34	13.78	17.97	14.96	12.18	13.49

	11.71	12.70	13.65	14.89	18.01	15.29	13.75	17.97	14.96	12.18	13.47
	11.70	12.70	13.65	14.88	18.01	15.29	13.75	17.97	14.96	12.18	13.47
	11.58	12.70	13.47	14.88	18.01	15.26	13.71	17.97	14.88	12.18	13.47
	11.58	12.70	13.47	14.88	17.98	15.26	13.71	17.87	14.88	12.18	13.47
	11.58	12.70	13.47	14.88	17.98	15.26	13.66	17.87	14.88	12.18	13.47
	11.55	12.70	13.47	14.88	17.98	15.26	13.66	17.87	14.88	12.18	13.47
	11.37	12.42	13.47	14.87	17.97	15.26	13.65	17.87	14.87	12.15	13.47
	11.37	12.42	13.47	14.87	17.97	15.25	13.65	17.87	14.87	12.15	13.47
	11.37	12.42	13.30	14.87	17.97	15.22	13.63	17.87	14.87	12.15	13.45
	11.37	12.42	13.30	14.82	17.97	15.22	13.62	17.84	14.87	12.15	13.30
	11.37	12.42	13.30	14.82	17.97	15.19	13.62	17.81	14.82	12.15	13.30
	11.37	12.42	13.25	14.82	17.97	15.17	13.62	17.78	14.82	12.15	13.30
	11.37	12.42	13.25	14.82	17.92	15.17	13.62	17.74	14.82	12.09	13.30
	11.35	12.42	13.25	14.82	17.92	15.14	13.62	17.74	14.80	12.09	13.30
	11.35	12.32	13.25	14.80	17.92	15.14	13.62	17.73	14.80	12.06	13.26
	11.35	12.32	13.25	14.80	17.92	15.14	13.53	17.73	14.75	12.06	13.25
	11.34	12.29	13.25	14.80	17.87	15.14	13.53	17.73	14.72	12.06	13.25
	11.34	12.18	13.25	14.78	17.87	15.13	13.49	17.73	14.72	12.04	13.25
	11.22	12.18	13.25	14.78	17.84	15.10	13.49	17.73	14.72	12.03	13.25
	11.22	12.18	13.16	14.78	17.84	15.10	13.49	17.73	14.72	12.03	13.25
	11.22	12.18	13.16	14.78	17.81	15.06	13.49	17.73	14.72	12.03	13.25
	11.22	12.18	13.16	14.75	17.81	15.06	13.49	17.73	14.72	12.03	13.25
	11.22	12.18	13.16	14.72	17.78	15.06	13.49	17.73	14.72	12.03	13.17
	11.22	12.03	13.16	14.72	17.78	15.06	13.45	17.73	14.71	12.00	13.17
	11.22	12.03	13.16	14.72	17.78	15.06	13.40	17.73	14.71	12.00	13.17
	11.19	11.98	13.16	14.72	17.78	15.06	13.40	17.72	14.67	12.00	13.17
	11.19	11.98	13.16	14.72	17.78	15.06	13.35	17.72	14.67	11.99	13.16
	11.19	11.98	13.16	14.67	17.78	15.03	13.35	17.67	14.67	11.96	13.16
	11.11	11.98	13.12	14.67	17.73	15.03	13.35	17.64	14.67	11.95	13.12
	11.11	11.98	13.12	14.67	17.73	15.03	13.30	17.60	14.67	11.95	13.12
	11.09	11.96	13.12	14.67	17.73	14.99	13.30	17.60	14.67	11.78	13.12
	11.09	11.78	13.12	14.67	17.73	14.99	13.30	17.58	14.67	11.78	13.12
	11.08	11.78	13.12	14.67	17.73	14.99	13.26	17.58	14.67	11.78	13.12
	11.08	11.78	13.12	14.66	17.73	14.96	13.25	17.57	14.67	11.78	13.12
	11.08	11.78	13.12	14.66	17.73	14.96	13.17	17.57	14.61	11.78	13.12
	11.08	11.78	13.12	14.64	17.73	14.96	13.17	17.57	14.61	11.78	13.12
	11.08	11.78	13.12	14.61	17.72	14.88	13.17	17.57	14.61	11.76	13.12
	10.95	11.78	13.12	14.61	17.67	14.87	13.17	17.57	14.53	11.73	13.12
	10.95	11.78	13.12	14.59	17.64	14.87	13.17	17.57	14.53	11.73	13.12
	10.95	11.78	13.12	14.58	17.64	14.87	13.17	17.57	14.50	11.73	13.12
	10.95	11.73	13.07	14.58	17.64	14.87	13.16	17.54	14.50	11.73	13.12
	10.95	11.73	13.07	14.58	17.64	14.87	13.16	17.46	14.47	11.70	13.12
	10.95	11.73	13.07	14.54	17.58	14.87	13.13	17.46	14.47	11.70	13.12
	10.95	11.58	13.07	14.54	17.58	14.87	13.12	17.46	14.42	11.69	13.08
	10.89	11.58	13.07	14.53	17.54	14.87	13.12	17.46	14.42	11.66	13.07
	10.89	11.58	12.75	14.53	17.54	14.87	13.09	17.43	14.42	11.66	13.07
	10.89	11.58	12.75	14.53	17.51	14.82	13.09	17.43	14.42	11.64	13.07
	10.89	11.58	12.75	14.53	17.51	14.82	13.09	17.43	14.42	11.58	13.07
	10.89	11.37	12.75	14.53	17.51	14.82	13.09	17.43	14.39	11.58	13.07
	10.89	11.37	12.75	14.51	17.46	14.82	13.07	17.43	14.39	11.58	13.07
	10.89	11.37	12.75	14.50	17.46	14.75	12.99	17.43	14.39	11.55	13.07
	10.89	11.22	12.70	14.50	17.44	14.72	12.99	17.43	14.39	11.55	12.99
	10.87	11.22	12.70	14.47	17.44	14.72	12.99	17.38	14.39	11.55	12.99
	10.73	11.22	12.70	14.47	17.44	14.72	12.95	17.38	14.38	11.54	12.95
	10.73	11.22	12.70	14.42	17.44	14.71	12.95	17.37	14.38	11.54	12.95
	10.73	11.08	12.70	14.42	17.44	14.71	12.95	17.34	14.38	11.45	12.82
	..	…	…	…	…	…	…	…	…	…	…

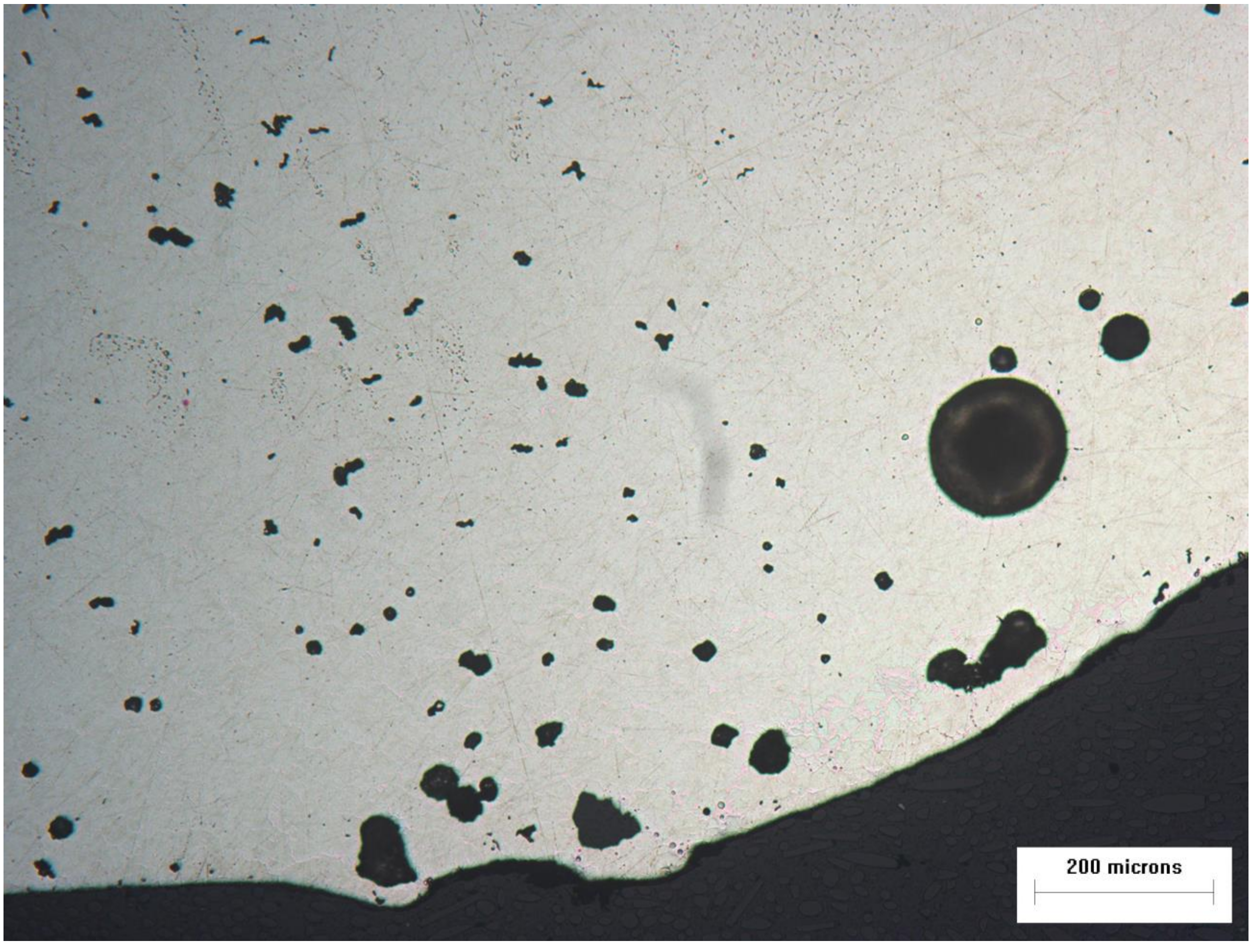
Appendix C – Micrographs of Welded Cross-Sections, Transverse



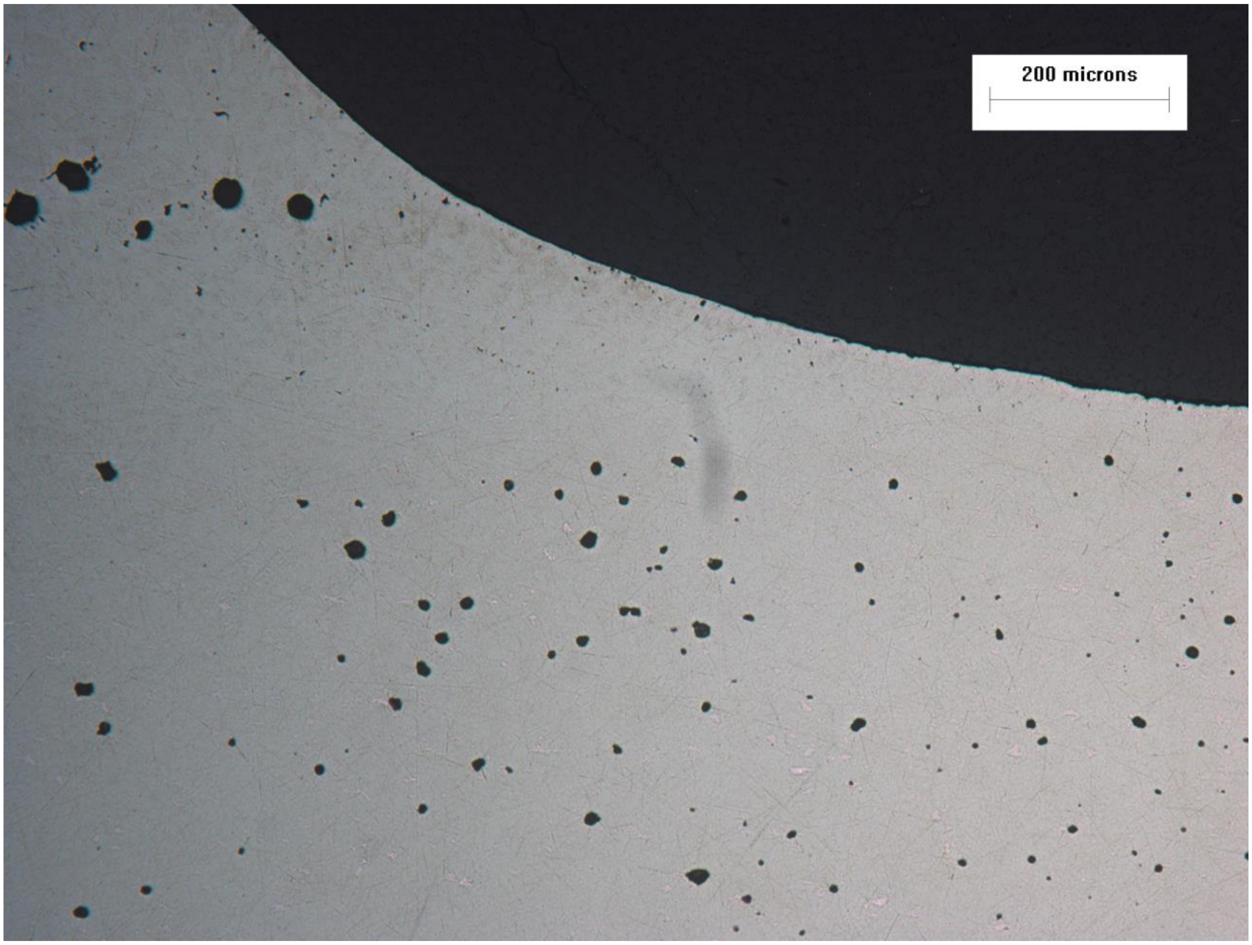
1B1



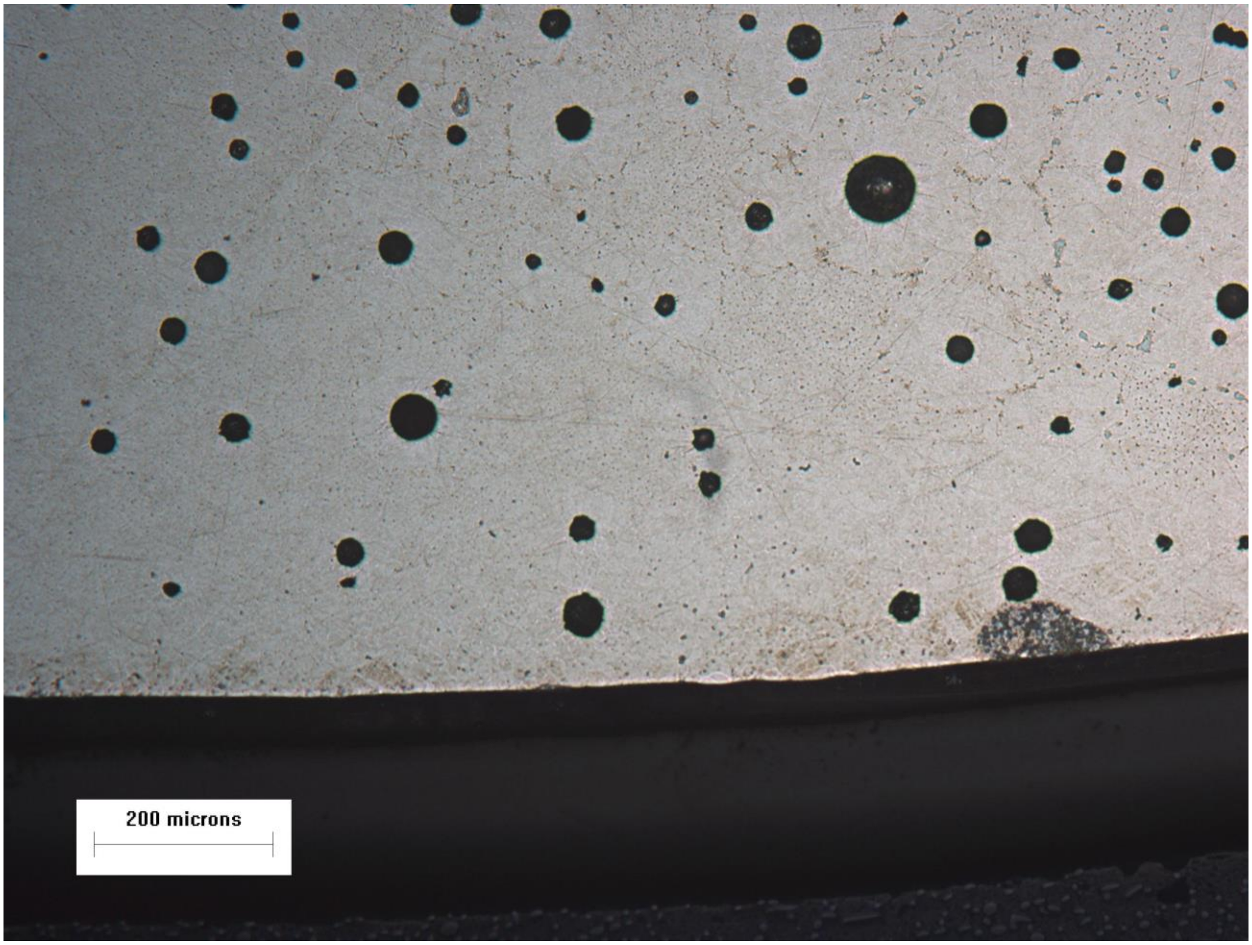
1C2



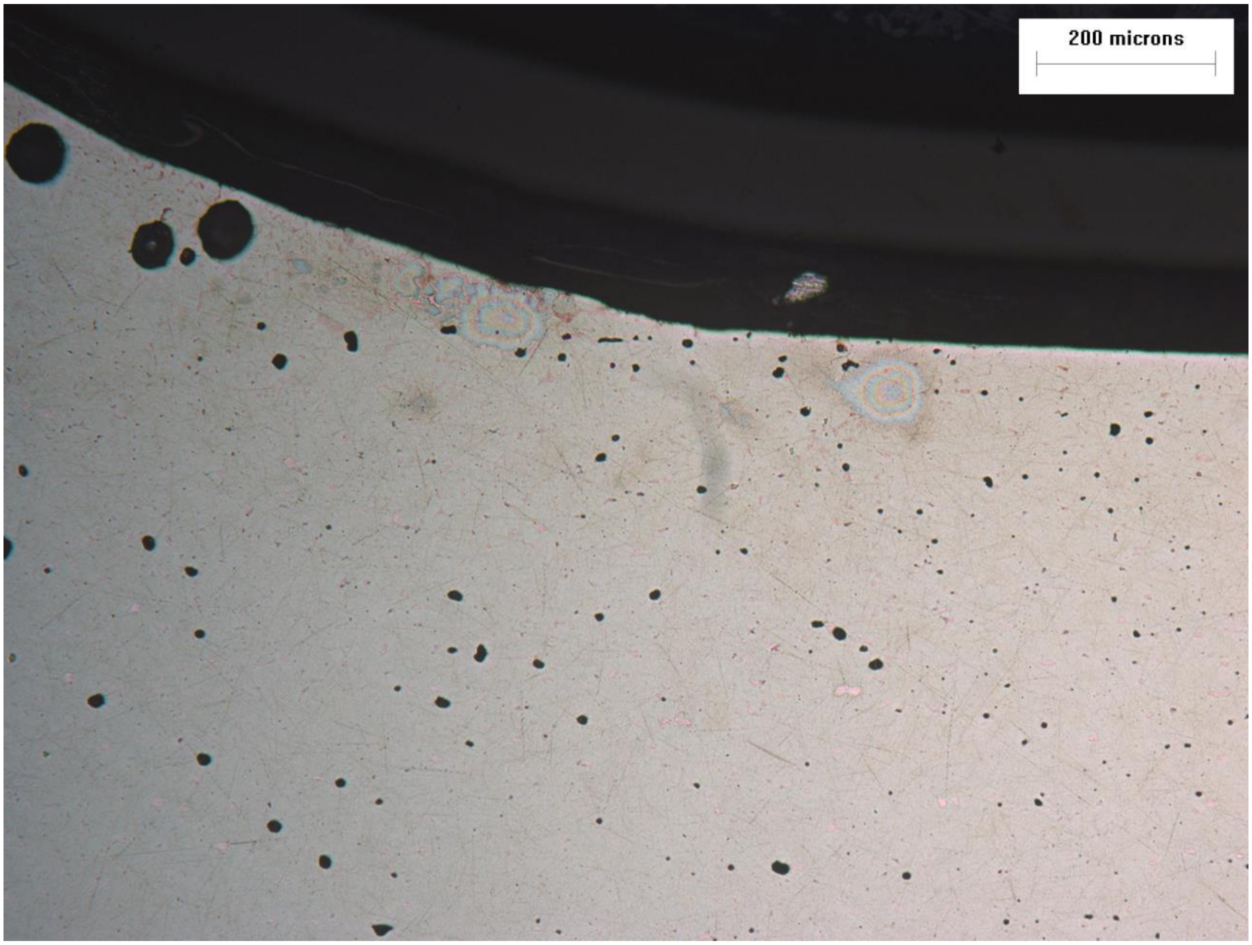
1D2



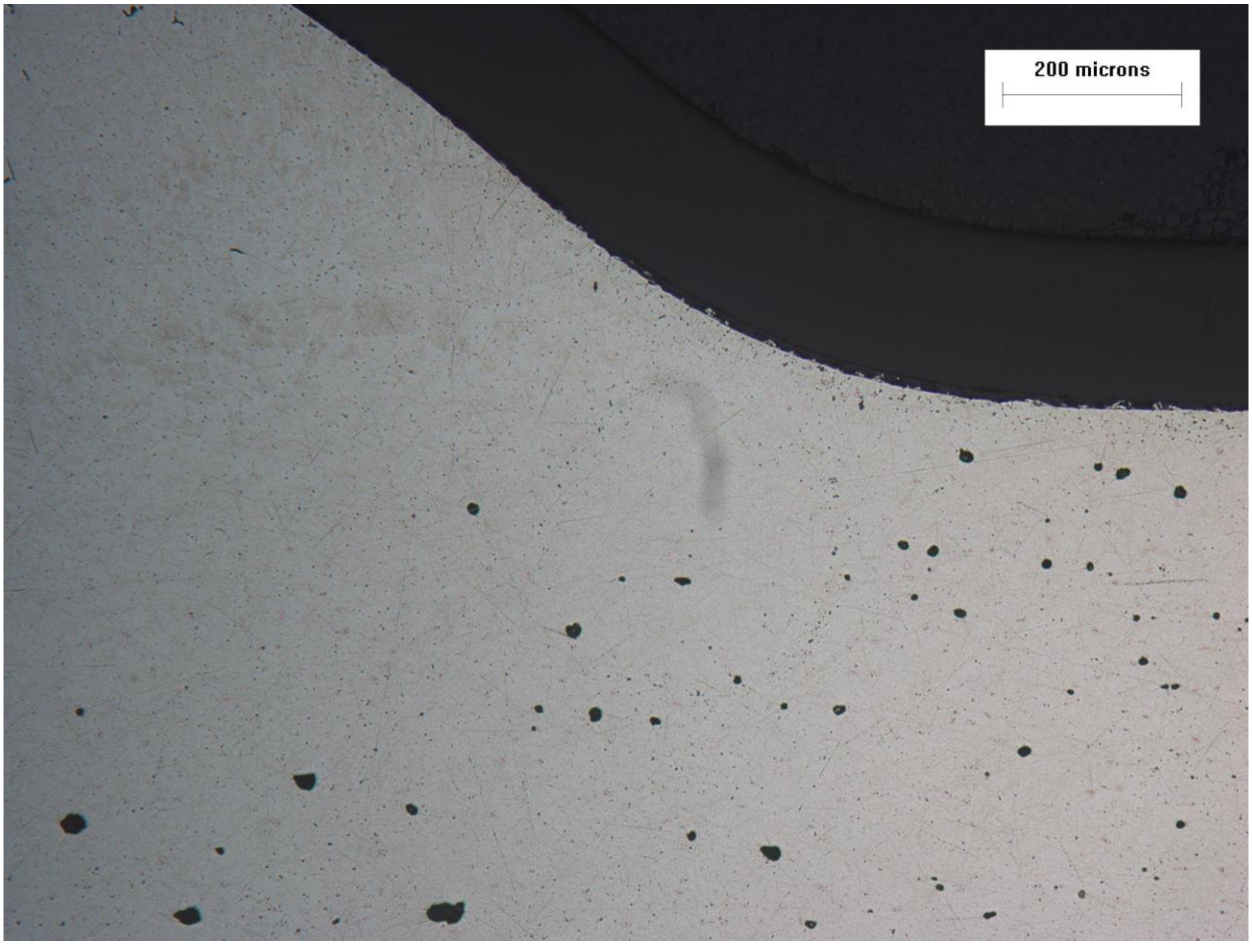
2C1



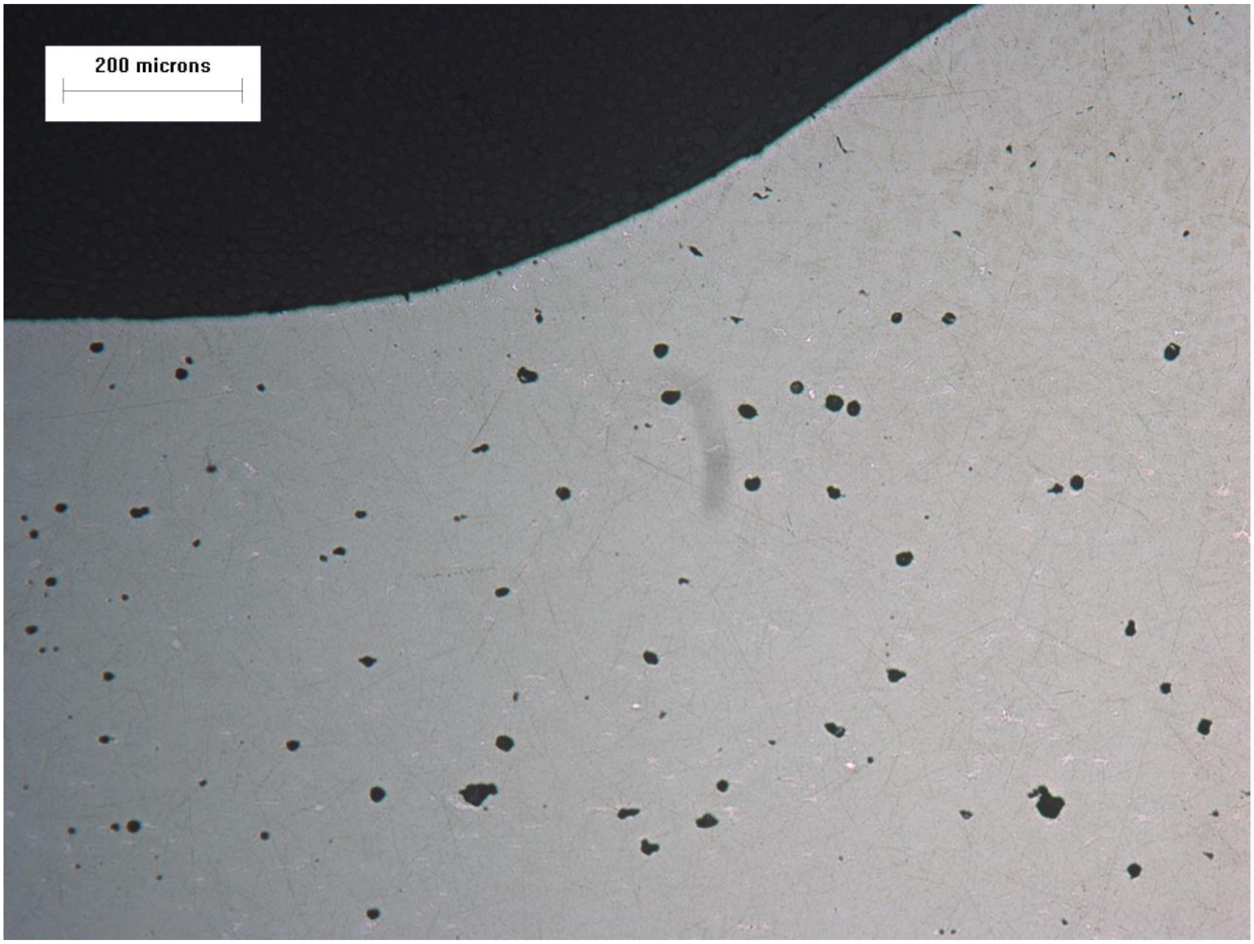
2C3



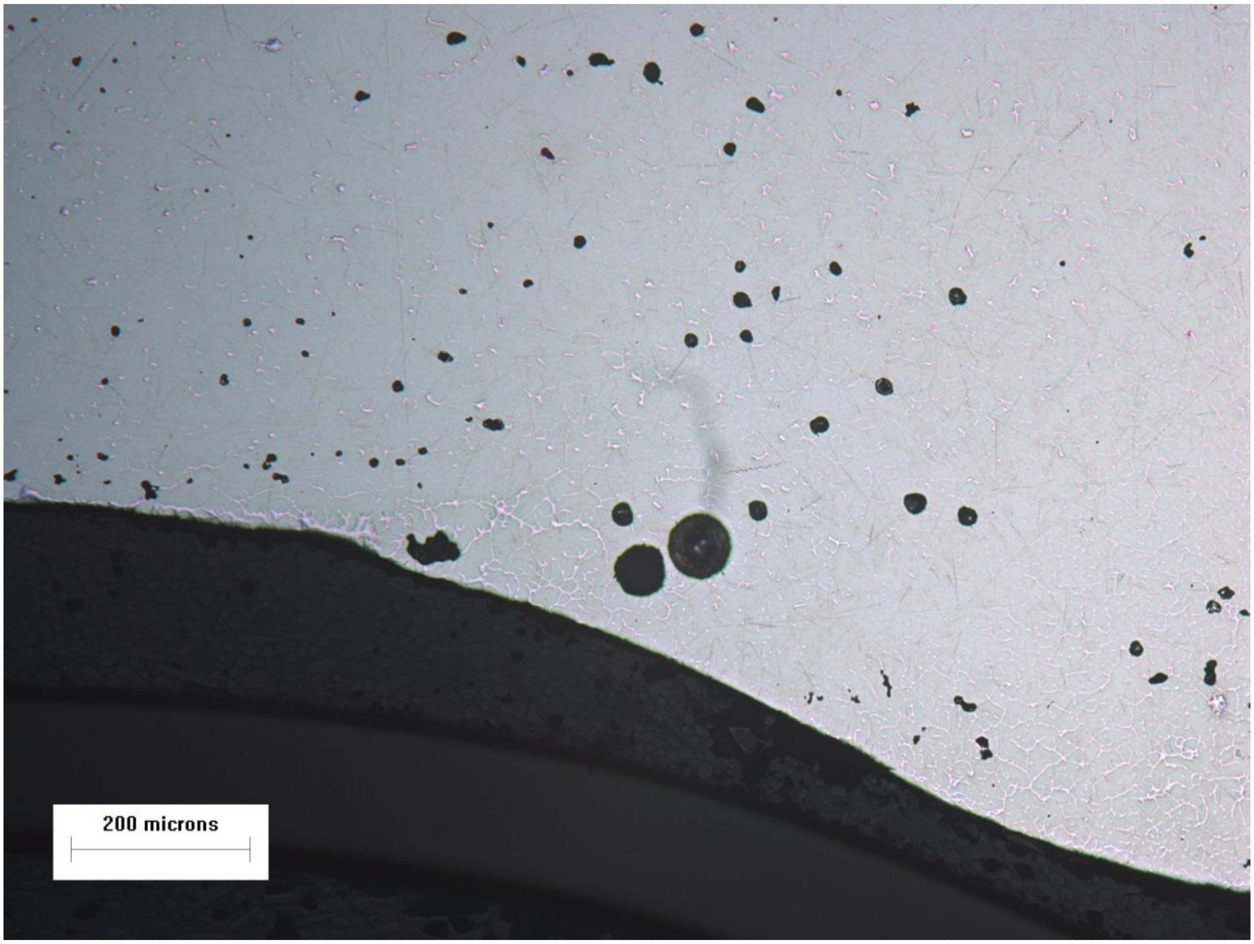
2D3



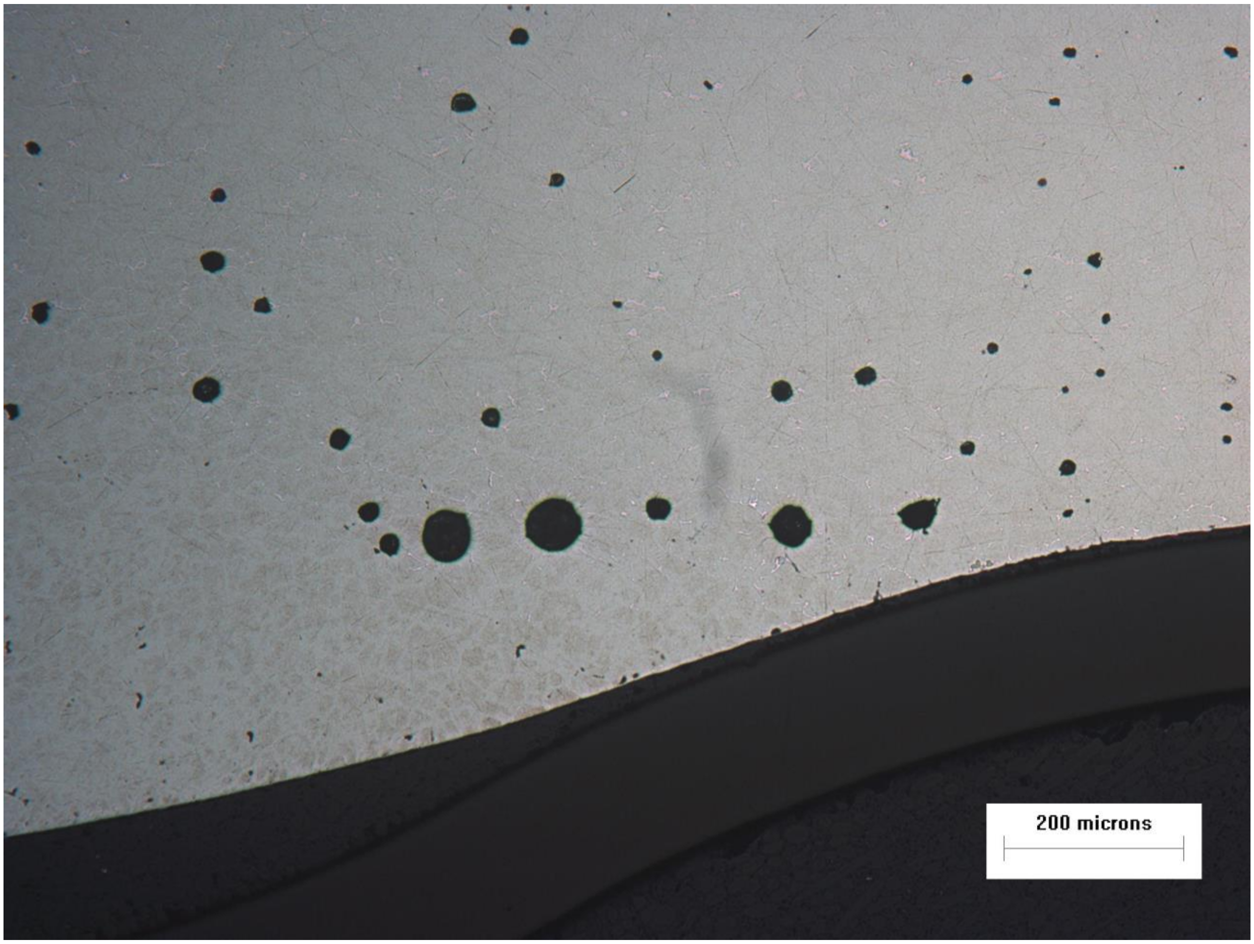
3B1



3B2

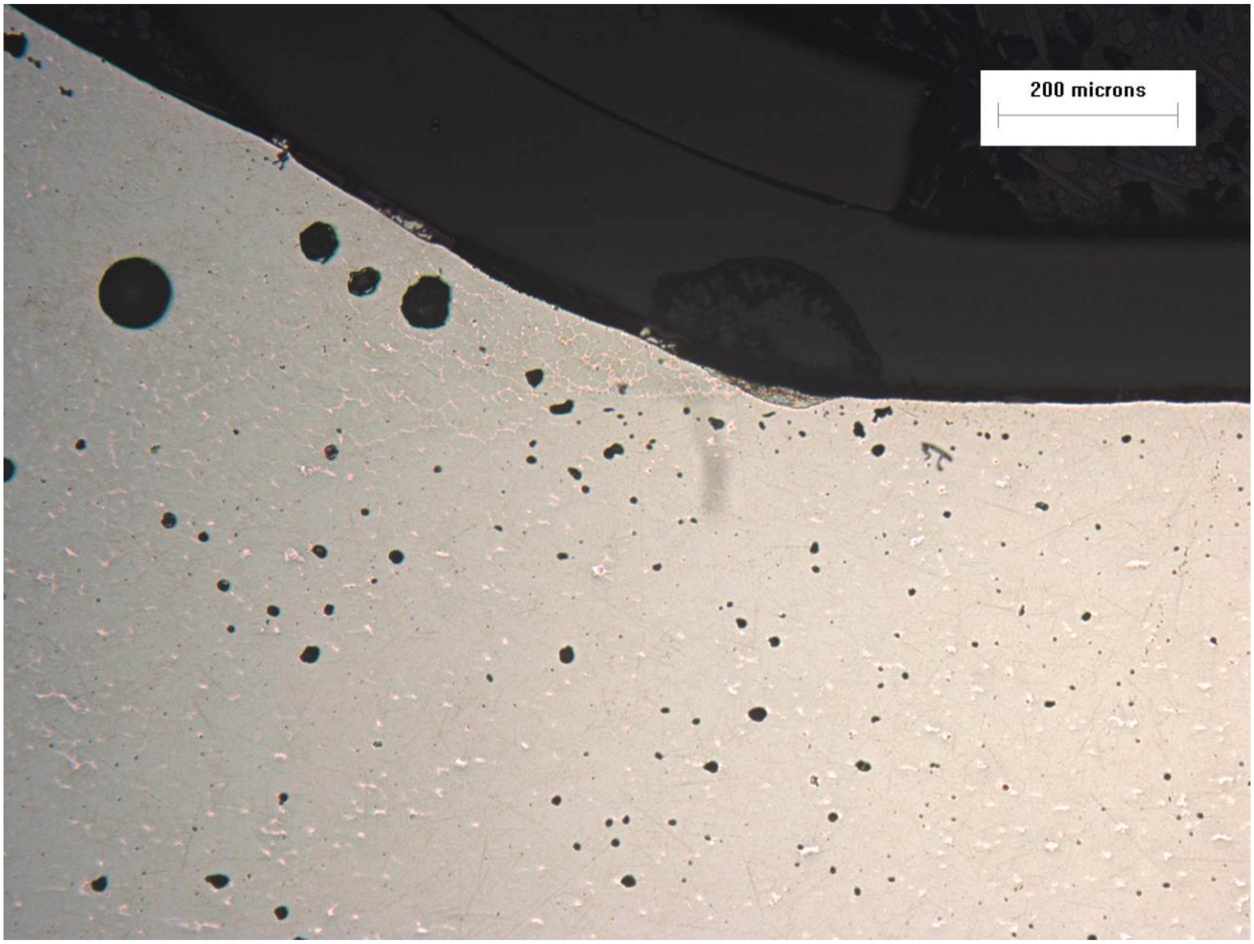


3C3



4B3

4D2



4D3