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KICKING HORSE MOUNTAIN SKI RESORT
GOLDEN EAGLE EXPRESS
LEITNER-POMA OF AMERICA GONDOLA

HANGER ARM FAILURE

Prepared for:

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Attention:

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File Number: 605-J215610
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TABLE OF CONTENTS

CONTENTS

EXECUTIVE SUMMARY

The gondola arm fractured due to sudden brittle cleavage preceded by fatigue cracking at 4 distinct areas in the pipe cross section. The following causes contributed to the arm fracture:

1. The arm was fabricated from ASTM A500 B steel pipe. This material may not be suitable for dynamic loading conditions requiring low temperature fracture toughness as stated in the ASTM A500 specification. Low temperature requirements for steel used in dynamic loading conditions should be specified.
2. The arm was cold bent into shape which further reduced the toughness of the material in the bend area through a phenomenon known as strain age embrittlement. Strain age embrittlement occurs due to cold work in combination with the heating cycle associated with galvanizing.
3. A multi-step fracture sequence occurred which included 4 zones of fatigue cracking followed by a final overload consisting of brittle cleavage. Cracking was not found during daily (operator) or bi-yearly (professional inspection company) inspections.
4. The fracture origin was a multi-mode thumbnail shaped precrack that contained both fatigue cracking and shallow brittle cleavage crack growth mechanisms. The initial shallow brittle fractures (within the thumbnail) were likely created by very short duration high strain rate loading. Impact dents found in the upper arm support bracket would account for this type of loading.
5. A larger brittle fracture initiated when the thumbnail reached a depth of 5mm. This crack arrested for a period of time when the tougher material associated with the pipe seam weld was encountered. Fatigue cracks grew through the tougher weld zone and final brittle overload occurred when a critical through-wall circumferential crack length of 26 cm was reached.

The steel arm was not overloaded by in-service stresses. The poor fracture toughness of the steel, in combination with cold bending fabrication practices and impact loads at the station in normal service, were the primary contributors to the failure.

1.0 INTRODUCTION

A gondola arm from a Leitner- Poma gondola lift at the Kicking Horse Ski Area suffered a catastrophic failure during normal operations. The arm was in service for approximately 25 years and had been inspected regularly using visual and magnetic particle (MT) techniques required by the manufacturer and CSA Z98 requirements. The gondola was last inspected in 2023. The failure resulted in the gondola falling approximately 3 m to the ground and rolling to a stop.

The failed gondola arm had serial number 026400 stamped into the welded plate at the end of the arm. An undamaged gondola arm from the same lift and vintage was submitted to the Acuren lab for inspection at the same time (Serial number 026600). It is understood that the number of gondolas operated on the line was increased from 29 to 55 in 2006.

Acuren was asked to perform failure analysis on the fractured arm. The undamaged arm was used for test comparisons. The failed arm and the undamaged arm were brought to the Acuren Facility on 14 March, 2025. Another 3 intact arms were brought to the laboratory for further testing on 30 June, 2025.

2.0 GONDOLA ARM HISTORY

The Kicking Horse Gondola was originally built with 29 gondolas and operated this way for a number of years. The gondola was upgraded to 55 gondola cars in 2006 and has operated this way continuously since 2006. It is understood that the arm was fabricated from carbon steel meeting the specification requirements of ASTM A500 grade B and was cold bent into its final form. The arm was hot- dip galvanized after fabrication.

The gondola arm that failed had suffered a severe impact on the upper arm guideway bracket that resulted in permanent bending of the bracket. This damage is remote from the arm failure location. Evidence of smaller impacts on this and other arm brackets was reported.

3.0 NON-DESTRUCTIVE TESTING AT SITE

Technical Safety B.C. requested than an NDT technician be sent to the site to check other arms for cracking using magnetic particle inspection (MT) techniques. No cracks in other support arms were found at this time (NDT Report 1; Appendix C) After preliminary failure analysis was complete, another 24 gondola arms were checked for cracks using an ultrasonic technique (UT) developed specifically for looking for cracks in the intrados of the arm at the same location where the failure took place. No cracks were found (NDT report 2; Appendix C) at the intrados of any of the arm bends using these techniques.

4.0 FAILURE ANALYSIS

4.1 VISUAL EXAMINTION

Overall views of the fractured arm are shown in Figures 1 – 7. The bend intrados is arbitrarily labelled as the 6:00 o'clock position. The fracture origin is at roughly the 07:00 position (looking forward toward the bolted connection) near the intrados of the bend in a small thumbnail shaped area shown in Figure 8. A higher magnification view of the thumbnail feature is shown in Figure 9. The red mark is at the centerline of the intrados of the bend. Discolouration on the thumbnail fracture surface reveals notable features:

1. The thumbnail fracture surface contains 3 small origins and 5 distinct growth zones. The zones have varying amount of corrosion product on them, indicating a certain amount of time had passed between the formation of each zone.
2. The galvanized layer cracked uniformly through the thumbnail zone. No evidence of previously molten zinc is present on the fracture surface.
3. Zone 1 and zone 2 have a brittle appearance.
4. Zone 3 has a fine texture typical of fatigue cracking.
5. Zone 4 has a brittle appearance similar to zones 1 and 2.
6. Zone 5 has a fine texture similar to zone 3 and is typical of fatigue cracking.

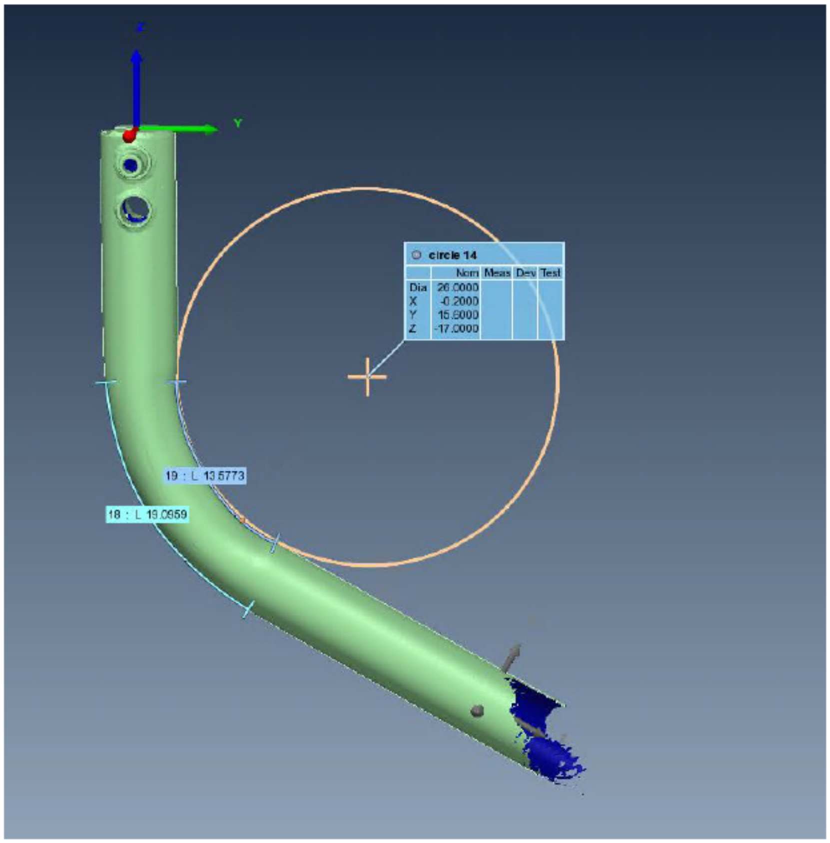
Beyond the thumbnail feature, the fracture appearance is brittle around the circumference of the pipe until the pipe seam weld is reached. At this point, the brittle fracture arrested and fatigue cracking occurred through the weld zone (Figure 10). A similar crack arrest and fatigue crack initiation occurred on the pipe cross section opposite to the weld at the same relative location (Figure 11). Once the tougher weld metal was passed through by fatigue cracking, a final brittle overload of the pipe occurred suddenly in bending.

A large open crack would have been visible to the naked eye for a period of time while the fatigue crack grew through the weld metal. The last inspection of the arm by a professional inspection company (Intermountain Inspection) was in 2023. It is probable that the fatigue cracking through the weld zone grew over a period of at least a few weeks and the brittle crack between the thumbnail and the weld metal would have been visible at this time. The visible evidence shows that the crack had a total length of 12 cm before weld metal fatigue cracking started. The final brittle fracture traversed approximately 26 cm of the pipe circumference in an irregular brittle fracture path. A scratch mark was found on the external surface of the pipe which originated on one side of the crack. It is understood that all of the hanger arms were visually inspected by a millwright 3 days before the incident. It is possible that an inspector noticed something resembling a crack and picked at it with a sharp tool. The scratch is precisely at the center of the thumbnail (Figure 12).

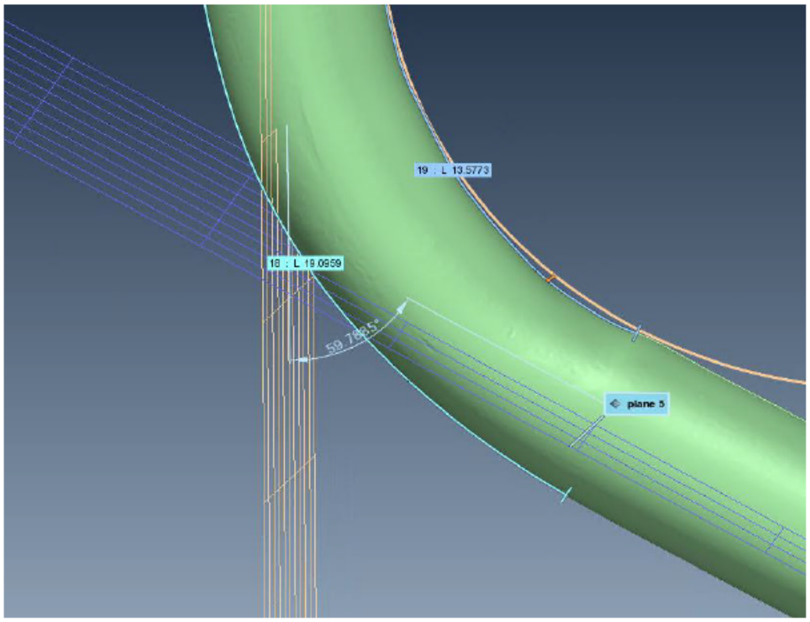
No other cracks were found on the fractured galvanized surface. Evidence of rubbing was found at one location on the arm surface (Figure 13), and a large dent was present on a reinforcing bracket near the upper attachment pin (Figure 14). This damage likely occurred from contact with the some of the station hardware while the gondola was in operation. The impact required to create the observed bracket deformation was severe and likely contributed to some part of the arm fracture history.

4.1.1 Laser Scanning of Arm and Fracture Surface

An optical laser scanner was used to determine the shape of the fractured pipe arm at the location of the bend and the overall angle of the bend at the fracture location. An exemplar arm was used to determine the bend angle (Chair No. 21).



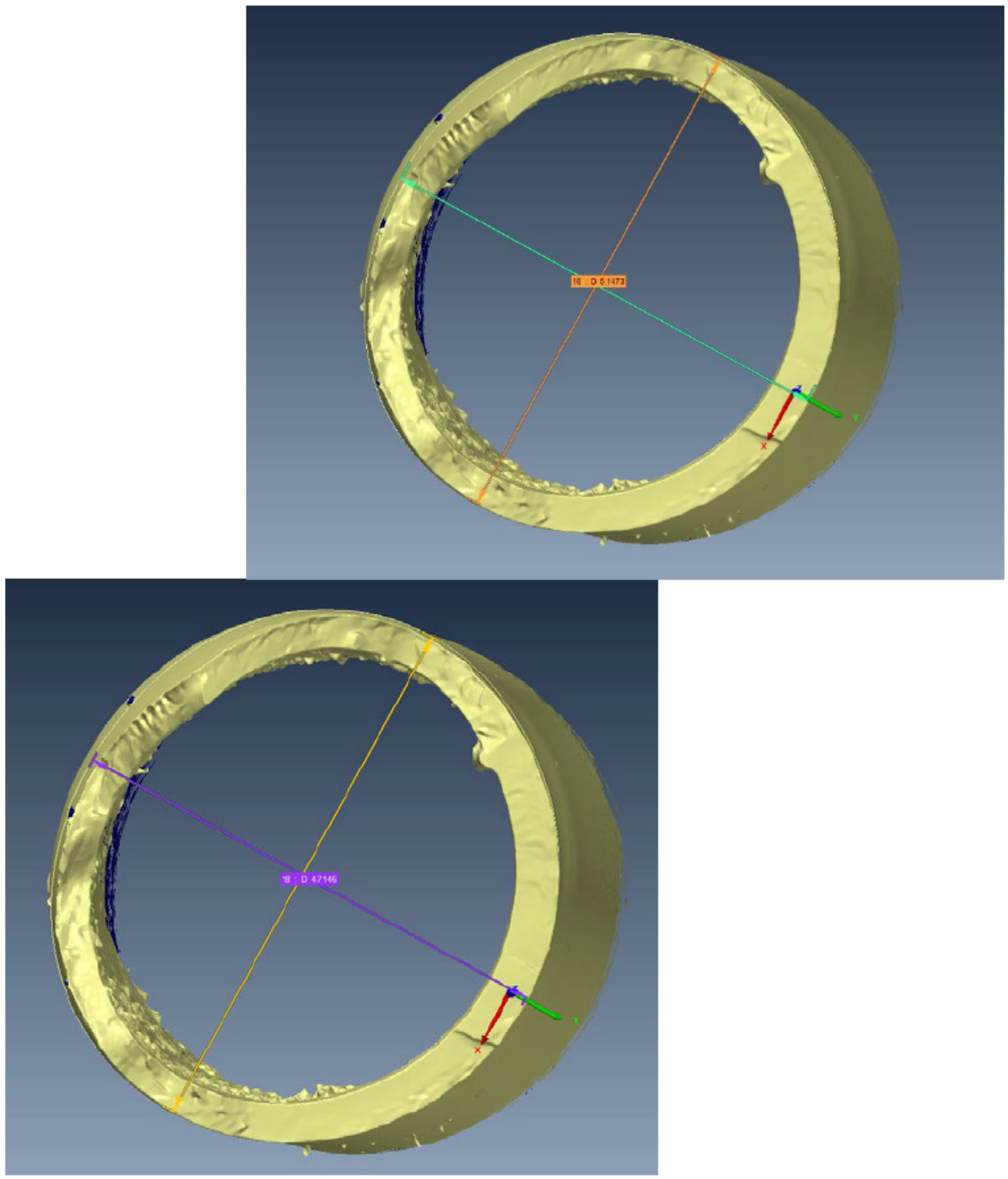
Scan of Exemplar Arm Chair No.21 (no serial Number)



Bend Angle - Chair No. 21 (no serial number)

A further scan at the fracture location shows the degree of permanent ovality caused by the cold bending operation . The fracture origin thumbnail is near the point where the pipe ovality is most pronounced. (highest amount of cold work).

The observed ovality is caused by the cold bending method used to form the hanger. There was no apparent attempt to reduce or eliminate pipe deformation during the cold forming operation. A roughly 1 cm difference in ID exists between the two planes of the bend.



Pipe Ovality at Fracture Surface

4.2 KEYANCE EVALUATION OF FRACTURE SURFACE

Segments of the arm fracture surface were examined with a Keyence light microscope. This microscope is capable of viewing surfaces up to 5000 times with good depth of field by taking images over small areas and assembling the views to make a single in-focus image.

The fracture origin area near the intrados of the bend is shown in Figure 15. The thumbnail shaped origin initially started as three small thumbnails which eventually joined together to form a single crack front. The larger thumbnail contains 5 distinct zones beneath the fractured outer galvanized layer as numbered on Figure 15. Each zone was examined using a scanning electron microscope to confirm the fracture mode in each zone (Section 4.3).

Magnified views of the entire fracture surface are shown in segments around the circumference of the pipe. The fracture features on each segment is described in Table 1:

Table 1 – Description of Fracture Features

Approximate Position	Figure No.	Description
0 7:00 origin	16	Multi-zone thumbnail shaped fracture origin
1	17	Full thumbnail
2	18	Brittle Cleavage
3	19	Brittle Cleavage
4	20	Brittle Cleavage
5	21	Fatigue starting at HAZ of weld

6	22	Brittle cleavage; edge smearing
7	23	Brittle cleavage; edge smearing
8	24	Brittle Cleavage; edge smearing
9	25	Brittle Cleavage; edge smearing
10	26	Brittle Cleavage; edge smearing
11	27	Brittle cleavage; edge smearing
12	28	Brittle cleavage
13	29	Brittle cleavage edge smearing
14	30	Brittle Cleavage edge smearing
15	31	Brittle Cleavage edge smearing
16	32	Brittle Cleavage
17	33	Brittle Cleavage
18	34	Brittle Cleavage
19	35	Brittle Cleavage
20	36	Cleavage plus fatigue opposite weld
21	37	Brittle Cleavage
22	38	Brittle Cleavage
23	39	Brittle cleavage
24	40	Brittle Cleavage
25	41	Cleavage plus thumbnail origin

There are fatigue features in two zones (zones 3 and 5) in the origin thumbnail. Fatigue features are also found at the pipe weld, and at roughly a position 15 cm circumferentially from the pipe weld. It is clear that the brittle fracture below the thumbnail and around the circumference of the pipe was arrested when it reached the tougher modified microstructure of the pipe weld metal and heat affected zone. Fatigue cracking with fine striations started after the initial arrest of the brittle crack at these locations . Striation spacing in the weld metal fatigue zone was very fine (approximately 0.3 µm), (Section 4.3), which indicates that nominal dynamic stresses were very low relative to the yield strength of the steel.

Very similar features were found in the fatigue zone opposite the weld metal. Although the microstructure was not altered at this location, the running brittle fracture arrested when the weld metal was encountered on the opposite side of the crack. Fatigue cracking originated at this location in an identical manner as the opposite side of the pipe at the weld metal.

The majority of the fracture surface was brittle cleavage outside of the small fatigue zones This indicates that the fracture toughness of the ASTM A500 grade B pipe was poor at the ambient temperature on the day of the failure.

4.3 SCANNING ELECTRON MICROSCOPE EVALUATION OF FRACTURE SURFACE

A scanning electron microscope was used to examine fracture features on the arm fracture surface. The areas examined include each zone in the thumbnail shaped fracture origin, the fatigue indications in pipe weld zone and area opposite the weld zone, and in select areas between the fatigue areas and the last areas to fail. Table 2 lists the locations of SEM examinations and the image number representing the areas examined.

Table 2 - SEM Images of Fracture Features

Image Location	Figure Number	Description
Thumbnail origin zone 0	42,43,44	Zinc oxide haze; Mixed cleavage and dimples on edge; areas of intergranular separation

Thumbnail origin zone 1	45	Brittle cleavage
Thumbnail origin zone 2	46	Brittle cleavage
Thumbnail origin zone 3	47	Fatigue striations
Thumbnail origin zone 4	48	Brittle cleavage
Thumbnail origin zone 5	49	Fatigue striations
Below thumbnail	50	Brittle cleavage
Between thumbnail and ID of pipe	51	Brittle cleavage
Between thumbnail and weld zone	52	Brittle cleavage
Fatigue at weld zone	53, 54	Fatigue striations
Between weld zone fatigue and final overload	55	Brittle cleavage
Final Overload	56	Brittle cleavage
Fatigue zone opposite weld metal	57	Fatigue striations
Area adjacent to fatigue zone	58	Brittle cleavage

opposite weld metal		
Fracture origin	59 (EDXA)	Zinc oxide washed onto fracture origin thumbnail

The SEM images confirm the fracture evidence shown in the Table 1 descriptions. The zone 0-zone 5 images show that the initial origin produced brittle cleavage in two separate events from three small origins on the external surface of the intrados of the pipe bend. These are followed by a thin zone of fine fatigue striations (zone 3). Once a critical depth was reached, a third brittle cleavage event took place over a small distance of about 0.8 mm(Zone 4) This was followed by a thin zone of fatigue over a further depth of 0.8mm (zone 5). A relatively large brittle cleavage step then took place through the pipe wall and around the pipe circumference until the brittle fracture was arrested by the tougher altered microstructure in the weld metal and heat affected zone. The crack arrested on the opposite side of the pipe as well since the overall tearing action was arrested when the weld metal was encountered. Fatigue cracks grew from the tougher weld zone. Once the fatigue crack at the weld metal (and the fatigue crack opposite the weld metal fatigue zone) reached a critical size, the remaining pipe cross section failed completely through by brittle cleavage caused by tensile bending stresses.

The white haze found on the thumbnail before cleaning was checked using EDXA and found to be zinc oxide (Figure 59). The zinc oxide likely washed onto the upper fracture surface during wet weather.

4.4 STEEL PHYSICSAL PROPERTIES

4.4.1 CHEMICAL ANALYSIS

Chemical analysis using optical emission spectroscopy (OES) was used to determine the chemical content of the failed arm steel. The results are shown in Appendix B. The steel meets the chemical requirements of ASTM A500 grade B.

4.4.2 TENSILE TESTS

The manufacturer's drawings show that the arm is specified to be made from steel pipe meeting the requirements of ASTM A500 Grade B. This specification contains a warning in the Scope, Note 1, ***"Products manufactured to this specification may not be suitable for those applications such as dynamically loaded elements in welded structures, etc., where low temperature notch toughness properties may be important"***. In this case, the arm is both dynamically loaded and requires good low temperature notch toughness.

The arm steel tensile results are shown in Appendix B. The arm steel meets the requirements of ASTM A500 grade B in terms of ultimate strength, yield strength, and elongation.

4.4.3 CHARPY IMPACT TESTING

ASTM A500 grade B steel does not have any specified toughness properties. Charpy Impact tests were performed on samples taken from the fractured arm and from samples removed at the same locations on an exemplar un-cracked arm. The results of impact testing are shown in Appendix B. All Charpy samples are 2/3 size due to pipe wall thickness limitations.

4.4.3.1 Charpy Impact Testing of Failed Arm Serial Number 026400

Impact samples taken from the intrados of the bend near the fracture surface (see figure B-1) revealed low Charpy values at room temperature along the center-line of the bend, and higher values on the right and left sides of the bend nearer the neutral bending axis (11 o'clock and 1 o'clock positions) (Appendix C). One low value was obtained along the 1 o'clock position (7 joules).

4.4.3.2 Charpy Impact Testing of Exemplar Arm Serial Number 02600

Samples taken from the intrados of the exemplar arm did not display the same low toughness at room temperature as did the failed unit. One sample, taken from the 1 o'clock side of the bend axis, displayed a relatively low Charpy value of 19 joules. All other Charpy values were in the 52 Joule to 112 joule range.

4.4.3.3 Further Charpy Testing of Chair Arm No. 21 (No serial number) Intrados, Chair Arm N0.21 Straight Section , and Failed Arm Straight Section

Chair arm No.21 contained impact damage on the arm upper pin reinforcement bracket similar to that found on the failed arm. Charpy tests were performed on the intrados and straight section of this sample to determine the Charpy transition temperature of the steel in the most heavily cold worked area. As a comparison , a Charpy transition temperature was determined from the straight section of the failed arm, and a straight section of the chair arm No 21.

4.4.5 METALLOGRAPHY

Metallographic samples were taken through the fracture origin and correlated to the features found across the fracture surface.

An overall view of the pipe microstructure away from the fracture is shown in Figure 60. The microstructure consists of fine grained pearlite and ferrite. The longitudinal plate rolling direction is indicated by the elongated grain structure visible in the micrograph.

The fracture origin area through the thumbnail is shown at low magnification in Figure 61. Cold work is visible in the direction of the pipe forming operation (transverse). The distances shown on the micrograph match the distances shown in Figure 15 on the thumbnail fracture surface.

No metallurgical anomalies were found with the fractured steel pipe microstructure.

5.0 DISCUSSION OF FINDINGS

The fracture evidence shows a thumb nail shaped fracture origin at approximately the 7:00 o'clock position (looking toward the fractured end of the arm and from the center of the bend intrados). The thumbnail is older than the rest of the fracture surface as indicated by the amount of corrosion product present. The larger thumbnail was created in five distinct steps, but originated from three small origin areas on the intrados surface of the pipe. The initial step (including the 3 origin spots) on the pipe outer surface has a depth of approximately 1 mm and is comprised of brittle cleavage. The second step is also a brittle cleavage mechanism, and has a total maximum depth of 2.8 mm. The brittle crack arrested and stayed dormant for an unknown period.

The crack then restarts in a fatigue mode and travels to a depth of 0.4mm before brittle cleavage again occurs and arrests after growing another 0.6 mm of depth. The last crack zone grew by fatigue over a depth of 0.5 mm before a brittle cleavage fracture took place over a larger portion of the remaining pipe wall cross section in opposite directions from the thumbnail.

This larger brittle fracture arrested when it reached the heat affected zone of the pipe weld seam. The crack then begins to grow by fatigue in the tougher HAZ and weld metal in the weld zone. The crack also arrests on the opposite side of the pipe fracture plane where cold work from the pipe bending operation is less severe. Fatigue cracking also restarted at the location opposite the weld metal and travelled for a distance of approximately 5 – 6 mm .

Final fracture occurred when the mid-diameter fatigue cracks reached a critical size and brittle cleavage fracture occurred over the remaining cross section. The low fracture toughness inherent to the cold bent arm determined the critical depth and length at which final fracture occurred. In general terms, there is a geometric relationship between the fracture toughness number and the critical crack size. The lower the fracture toughness, the lower the tolerable crack depth in accordance with the following equation:

$$K = Y\sigma\sqrt{\pi a}$$ (Paris Equation)[1]

Where : K = stress intensity factor or fracture toughness number

Y = Geometrical Factor

σ = applied stress

1 Paris and Sih, ASTM STP 381, 1965

a = crack depth

Toughness is basically a measure of the resistance to crack growth once a crack has originally formed and is a material property, like tensile strength. If fracture toughness is low, fatigue cracks will grow more quickly and the final critical crack depth for a given applied stress will be smaller.

An important question is the sequence of events that took place on the gondola lift over a period of 25 years without the transverse crack being discovered by regular nondestructive testing. The evidence shows that molten zinc did not penetrate the crack, indicating that the crack was not present when galvanizing took place. The following theory is postulated and is supported by the evidence:

1. Cold bending of the pipe created high residual tensile stresses (from spring back) at the intrados of the bend. This can sometimes cause immediate "spring back" cracking a few grains deep, but will leave high residual tensile stresses if cracking does not occur. No cracking occurred since the pipe was initially in a relatively tough, ductile condition at the manufacturing temperature.
2. Galvanizing caused "strain-age embrittlement[2]" of the pipe in the intrados of the bend. Some strain aging might also have been experienced from the original cold bending of the plate into pipe. The bend area would have more severe cold work and would therefore have a more pronounced strain aging effect. Strain aging has the effect of raising the ductile-brittle transition temperature of the steel. Where the steel might have had an original glass transition temperature of -10 ˚C, strain aging could create an upward glass transition temperature shift to +10˚ C. The exact amount of strain aging effect is unpredictable in a given steel. A number of factors, including the steel chemistry, the temperature of the galvanizing bath, the degree of cold work, and the time in the bath can all be contributors to

[2] ASTM A143 - Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

strain aging. The heating cycle of the cold worked steel is the most significant factor. The heating cycle can be provided by the galvanizing bath, by welding (heating adjacent to the weld) , by preheat, or any other heating method applied to the steel.

3. The uncracked highly stressed surface of the steel suffered a small cleavage crack beneath the galvanized layer due to the high residual tensile stresses and a reduction in toughness caused by strain aging.

   This initial crack would have "popped in" below the galvanized surface when the residual stress level and glass transition temperature reached critical values. The initial crack was approximately 1 mm deep and arrested when the residual stress from forming (spring back) was relieved by the cracking. The galvanized layer was not broken at this time. A deeper initial crack through the galvanizing layer would be expected from impacts or operating loads.

4. The 2nd zone of brittle fracture likely occurred during first impact loading of the gondola arm due to contact with lateral rail hardware (evidence of impact damage on arm bracket). The crack arrested when a lack of sustained loads removed the driving force for the low energy brittle crack to proceed.

5. Fatigue cracking started at the edge of the brittle origin crack and progressed for approximately 0.4mm in depth due to applied dynamic loads. This may have occurred over several seasons under specific weather and loading conditions.

6. A 3rd zone of brittle fracture occurred due to sudden short duration high strain rate loading. This may have been something like another impact load as indicated by the dent on the guide bracket.

7. The final zone in the thumbnail was again fatigue caused by applied dynamic loads

8. The multistep thumbnail grew over an unknown period of time. It is difficult to explain why the crack was not discovered by professional inspectors over the 25 year operating life of the gondola. The galvanized layer may have survived the initial cracking at the "pop in" period, but would have been visible once the fatigue crack began to grow.

9. The visible zinc oxide that washed onto the fracture surface shows that the crack was open to the atmosphere for an unknown period of time

The larger brittle fracture that took place between the thumbnail origin and the tougher weld metal occurred when the thumbnail reached a critical size by fatigue. Fatigue cracking occurred over a length of 5 - 6 mm through the entire cross section of the pipe and would have been visible through both visual (VT) and magnetic particle (MT) inspection methods. The final pipe overload occurred when the total circumferential crack length (initial brittle fracture plus fatigue cracking) reached a length of 15 cm.

A Charpy specimen study of straight pieces of pipe and cold bent pieces of pipe show that strain age embrittlement occurred as a result of the cold bending of the pipe during fabrication. Strain age embrittlement occurred as a result of cold work plus the heating cycle introduced during galvanizing. The ductile-brittle transition temperature of the raw galvanized pipe away from the bends was determined to be between 0 and -10 ˚ C. The bend area on the failed unit displayed a ductile-brittle transition of +20 degrees (or higher).

6.0 CONCLUSIONS

The gondola arm fractured due to sudden brittle fracture preceded by fatigue cracking at 3 distinct areas in the pipe cross section. The following causes contributed to the arm fracture:

1. The steel arm was not overloaded by in-service stresses.

2. The arm was cold bent ASTM A500 B pipe. This material may not have been suitable for dynamic loading conditions requiring low temperature fracture toughness as stated in the

ASTM A500 specification. Even if strain aging did not occur in the cold bent areas, the toughness s of the original steel pipe was inadequate for dynamic loading conditions at normal winter operating temperatures (-5 ˚ C to -15˚C).

3. The toughness properties of the steel pipe varied from hanger to hanger, and at different positions along the hanger shape. The lowest Charpy values were found along the intrados of the bends where cold work was most severe.
4. The arm was cold bent into shape which further reduced the original toughness of the material through a phenomenon known as strain-age embrittlement. Strain-age embrittlement occurs due to cold work in combination with the heating cycle associated with galvanizing.
5. A multi-step fracture sequence occurred which included 4 zones of fatigue cracking followed by a final overload consisting zone of brittle cleavage. Small brittle cleavage steps were likely caused by guide rail impacts which caused impact damage to upper arm brackets.
6. The fracture origin was a multi-mode thumbnail shaped precrack that contained both fatigue cracking and brittle cleavage growth mechanism. The critical defect depth which lead to sudden brittle fracture was approximately 5 mm.
7. Brittle fracture was arrested for a period of time at the tougher material associated with the pipe seam weld. Fatigue cracks grew through the tougher weld zone and final brittle overload occurred with a through-wall circumferential crack length of 26 cm .

7.0 ADDITIONAL CONSIDERATIONS

Structural components destined for use in cold weather should be made from steels with known fracture toughness properties. This will ensure adequate low temperature toughness and prevent sudden brittle fracture of structural components in the presence of small fatigue cracks.

Steel components that are formed by bending and then galvanized should be hot bent or stress relieved after bending to prevent strain age embrittlement. The fabrication rules stated in ASTM A143 should be followed at all times.

Please contact the undersigned with any questions.

ACUREN GROUP INC.

PROVINCE OF R. W. A. MILNE BRITISH COLUMBIA

28/1/26

Bob Milne, P.Eng.

ACUREN

APPENDIX A

FIGURES 1 - 61

Figure 1 Overall view of gondola attachment arm failure as shown in Global news photo. Fracture occurred at the top of the bend outside of the "H frame" attachment point (arrow).

Figure 2 Overall view of straight section of hanger arm containing fracture as received at the Acuren Facility.

Figure 3 Overall view of the opposite side of the fracture (short 60˚ bend section) as it exists the gondola cover.

Figure 4 Serial number on fractured hanger arm.

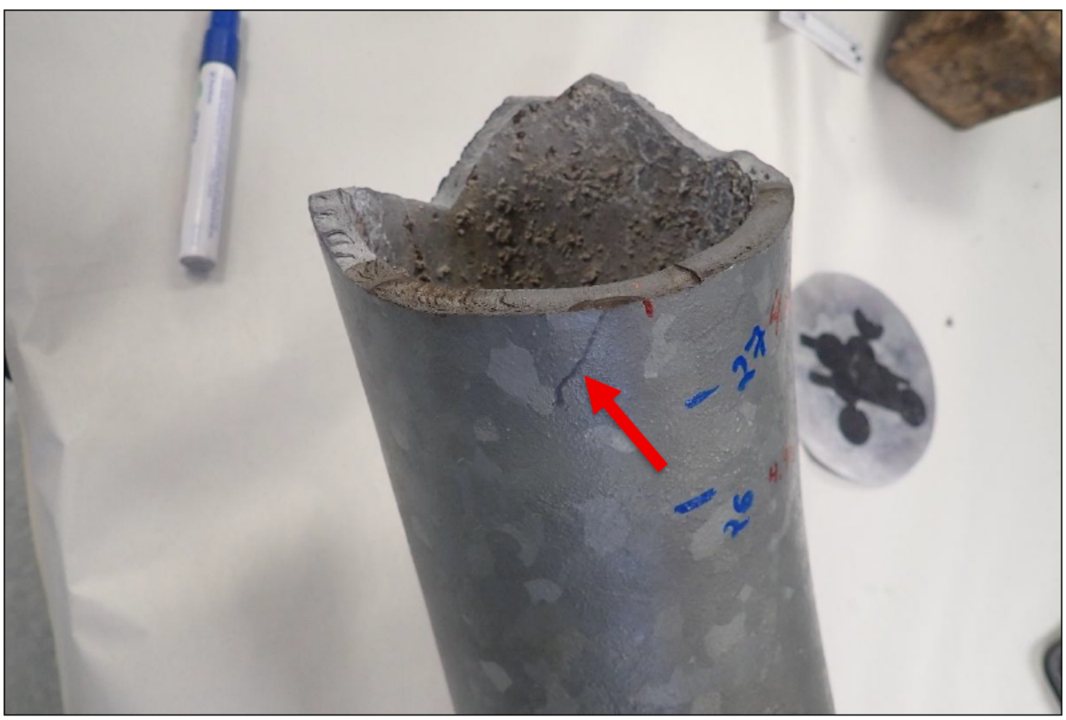


Figure 5 Scratch on intrados of the bend aligning with center of thumbnail.

Figure 6 Deformation on upper reinforcing bracket cause by impact with lateral rail at drive station.

Figure 7 Shiny area on hanger arm galvanized surface indicating light contact during normal operation.

Figure 8 Thumbnail shaped fracture origin at roughly the 7 o'clock position from the intrados of the bend (intrados centerline at 6 0'clock position)

Figure 9 Close-up view of thumbnail area showing brittle fracture lines leading back to the thumbnail origin. The red mark is at the centerline of the intrados of the bend. The grey line is a scratch coming from the middle of the thumbnail (unknown origin).

Figure 10 Crack arrest at the pipe seam weld. Fatigue crack grew until reaching a critical size and brittle cleavage proceeded. Microstructure change at weld arrested brittle fracture

Figure 11 Fatigue crack initiation and growth on opposite side of thumbnail at the same relative location as the pipe weld fatigue crack. .

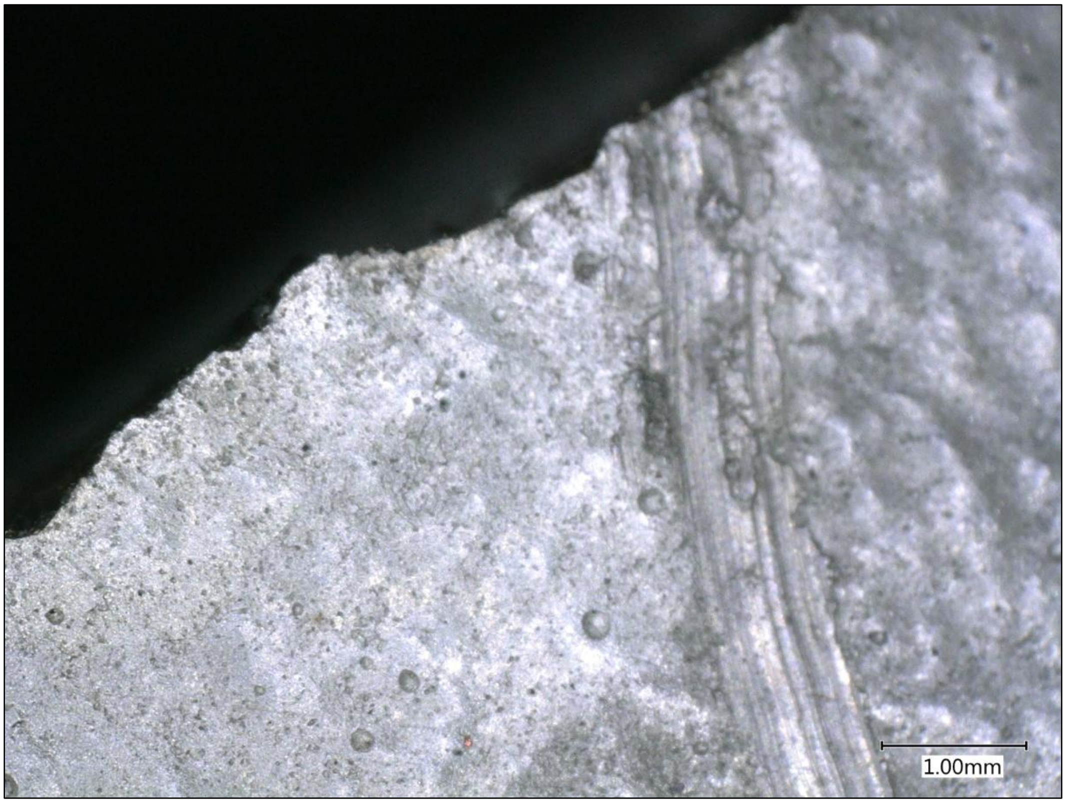


Figure 12 Close-up view of scratch in galvanizing shown at low magnification in Figure 5.

Figure 13 Shiny galvanizing from contact with unknown hardware during normal operations.

Figure 14 Close-up view of deformation in upper reinforcing bracket.

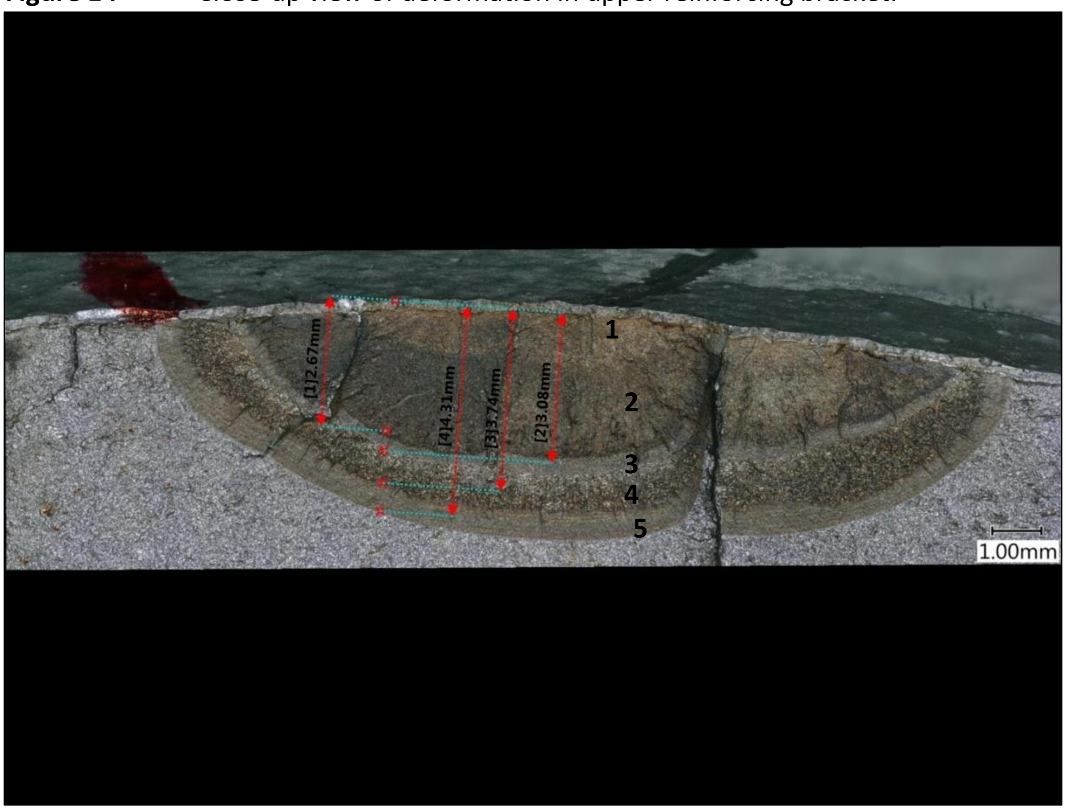


Figure 15 Close-up view of thumbnail origin showing multiple steps before final overload occurred. Progressive zones are arbitrarily labelled 1 – 5 for reference.

Figure 16 Keyence microscope view of fracture at the 6:00 position (black vertical mark) on the external surface of the intrados of the bend. Zones are arbitrarily labelled 1 – 5.

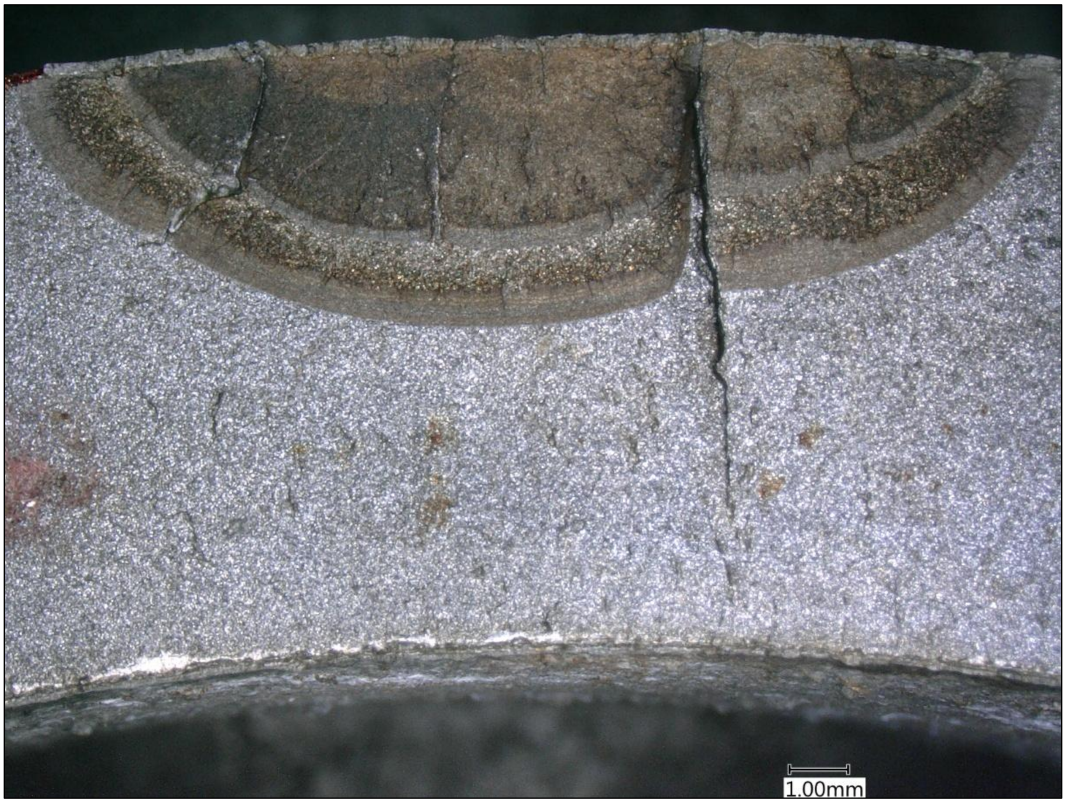


Figure 17 Reference 1 at roughly the 7:00 position.

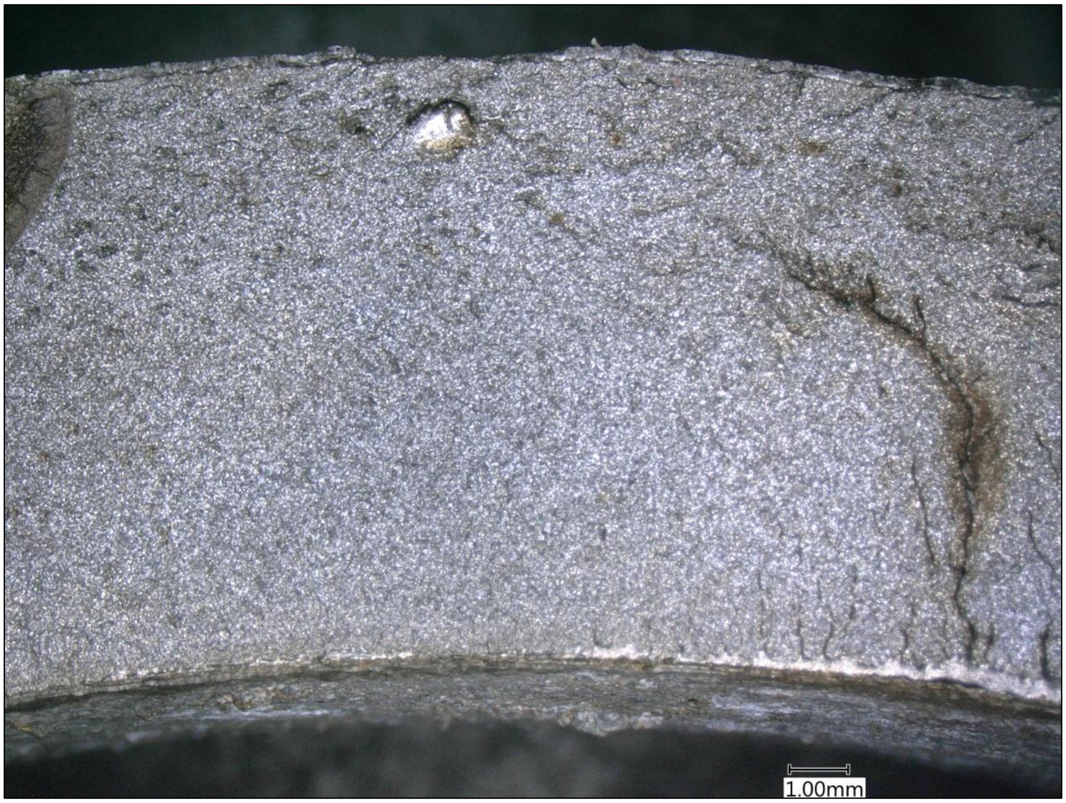


Figure 18 Reference 2 moving toward the seam weld (100% brittle)

Figure 19 Reference 3 moving toward the seam weld (100% brittle)

Figure 20 Reference 4 brittle fracture arrested at seam weld HAZ.

Figure 21 Reference 5 brittle fracture on either side of fatigue cracking through seam weld HAZ

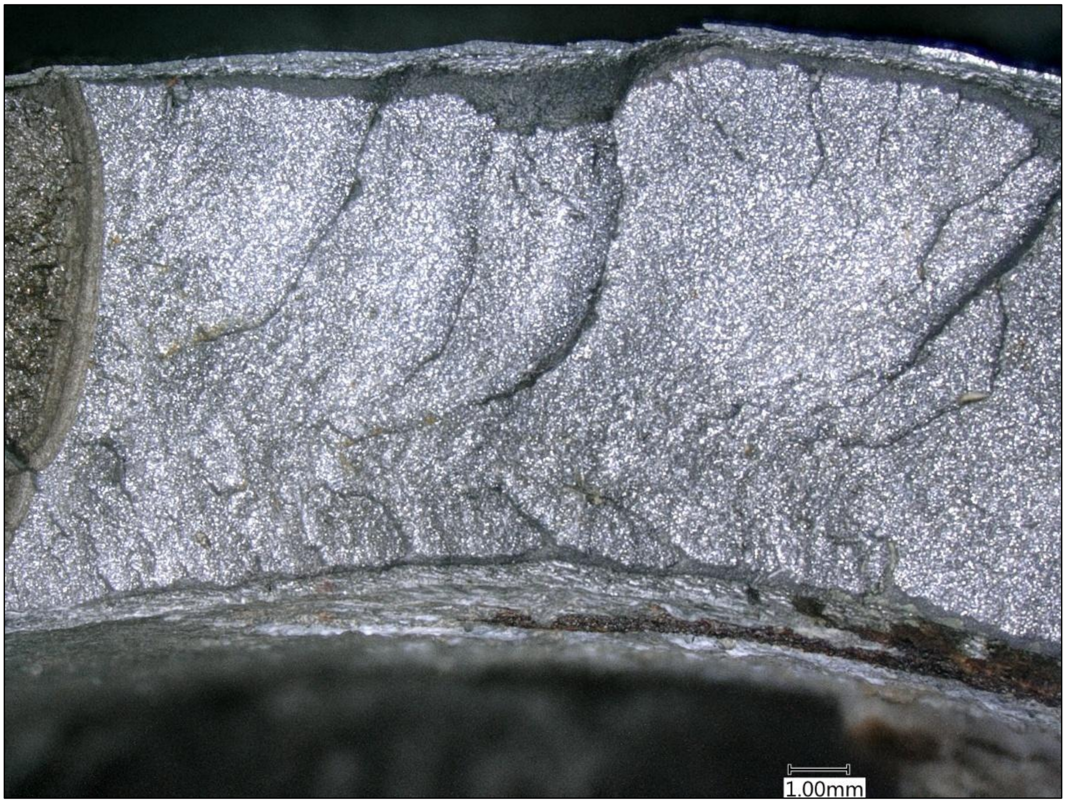


Figure 22 Reference 6 brittle fracture starting at tip of HAZ fatigue zone.

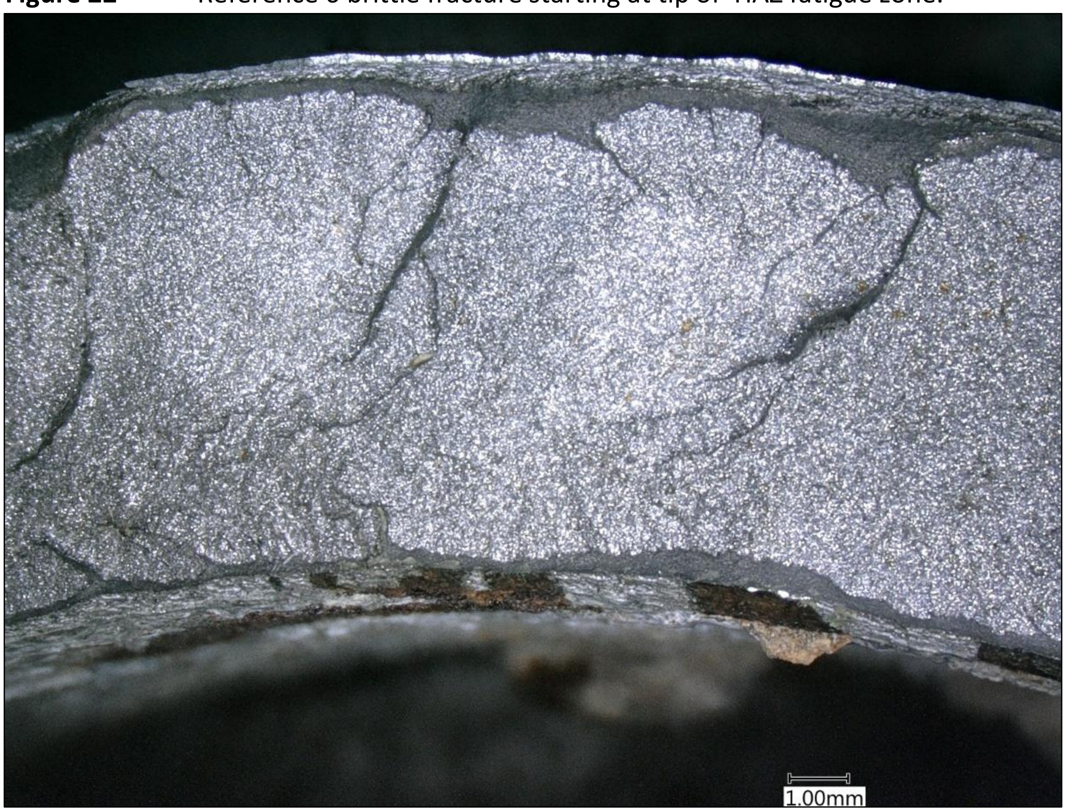


Figure 23 Reference 7 brittle fracture in overload zone.

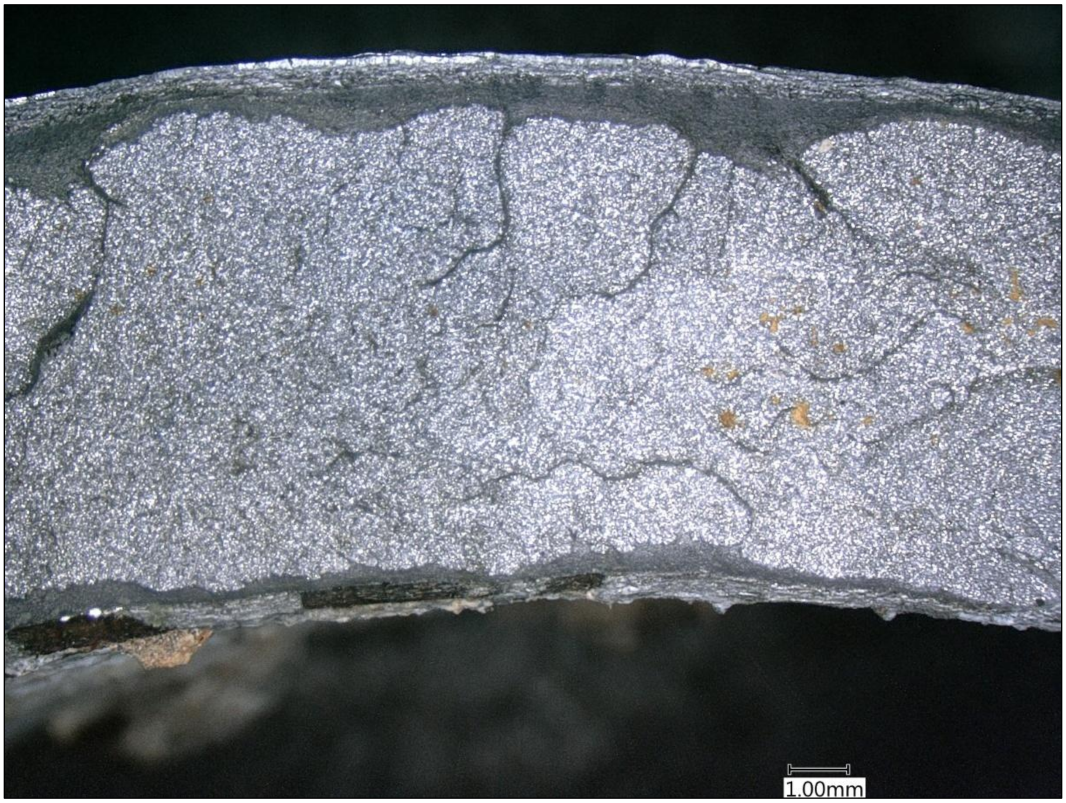


Figure 24 Reference 8 brittle fracture in overload zone

Figure 25 Reference 9 brittle fracture in overload zone

Figure 26 Reference 10 brittle fracture in overload zone

Figure 27 Reference 11 brittle fracture in overload zone.

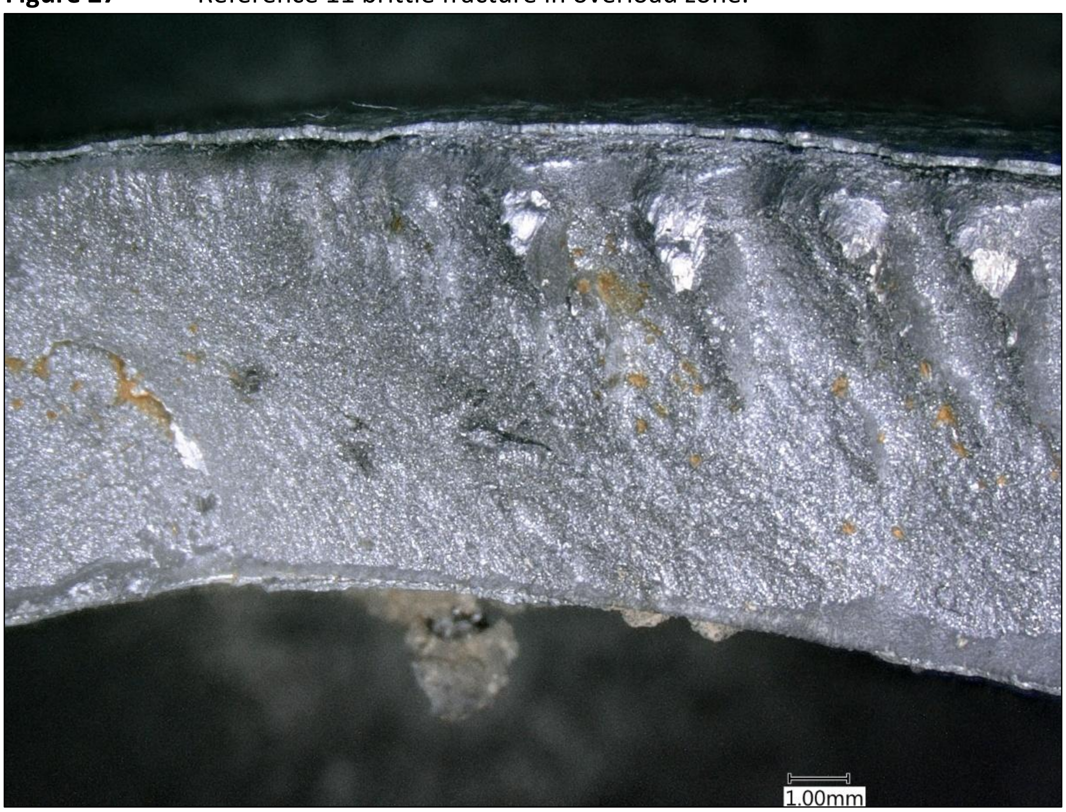


Figure 28 Reference 12 brittle fracture in overload zone.

Figure 29 Reference 13 brittle fracture in overload zone.

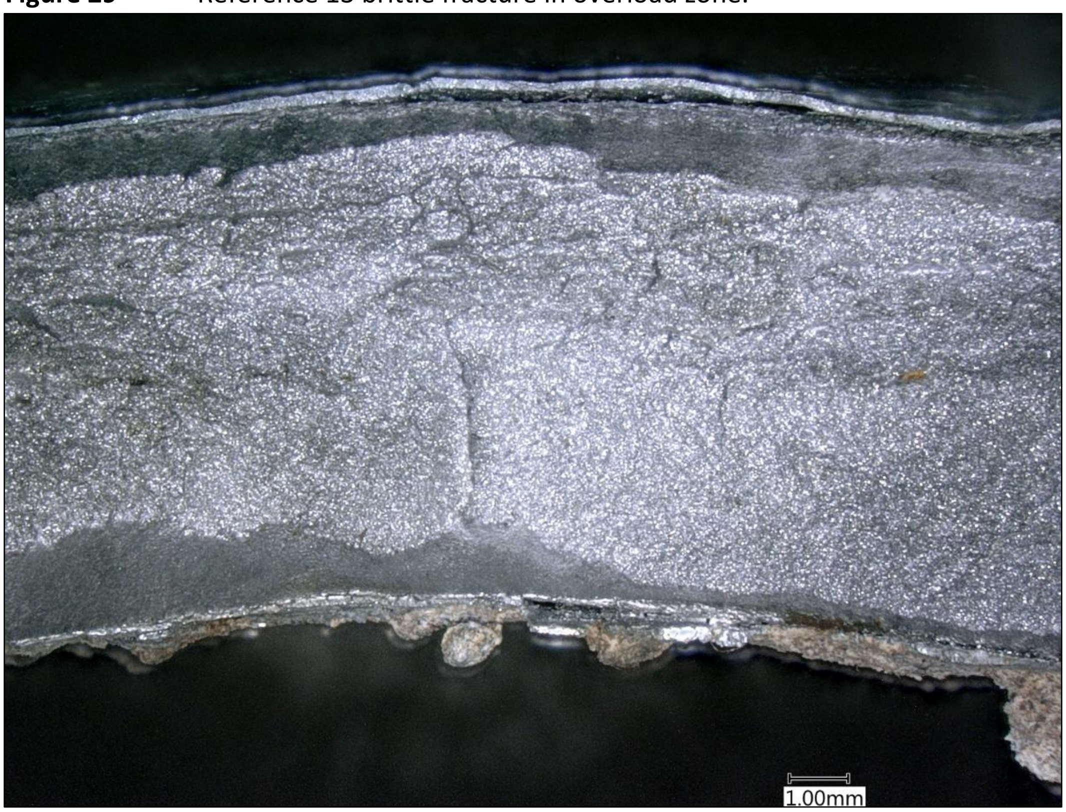


Figure 30 Reference 14 brittle fracture in overload zone.

Figure 31 Reference 15 brittle fracture in overload zone. Note dross on inside of pipe

Figure 32 Reference 16 brittle fracture in overload zone.

Figure 33 Reference 17 brittle fracture in overload zone.

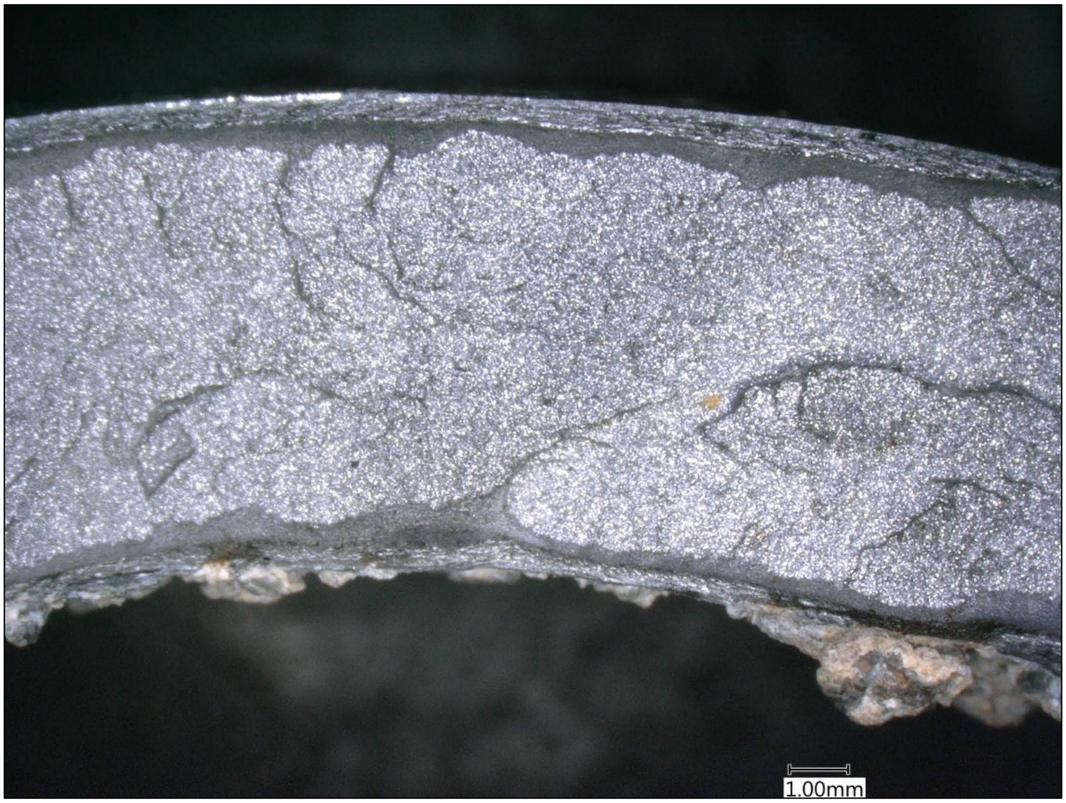


Figure 34 Reference 18 brittle fracture in overload zone.

Figure 35 Reference 19 brittle fracture in overload zone.

Figure 36 Reference 20 brittle fracture arrested . Beginning of fatigue crack at toe of brittle fracture zone. Position of fatigue zone roughly corresponds to position of HAZ fatigue zone on opposite side of thumbnail.

Figure 37 Reference 21 end of fatigue and start of brittle fracture heading away from thumbnail.

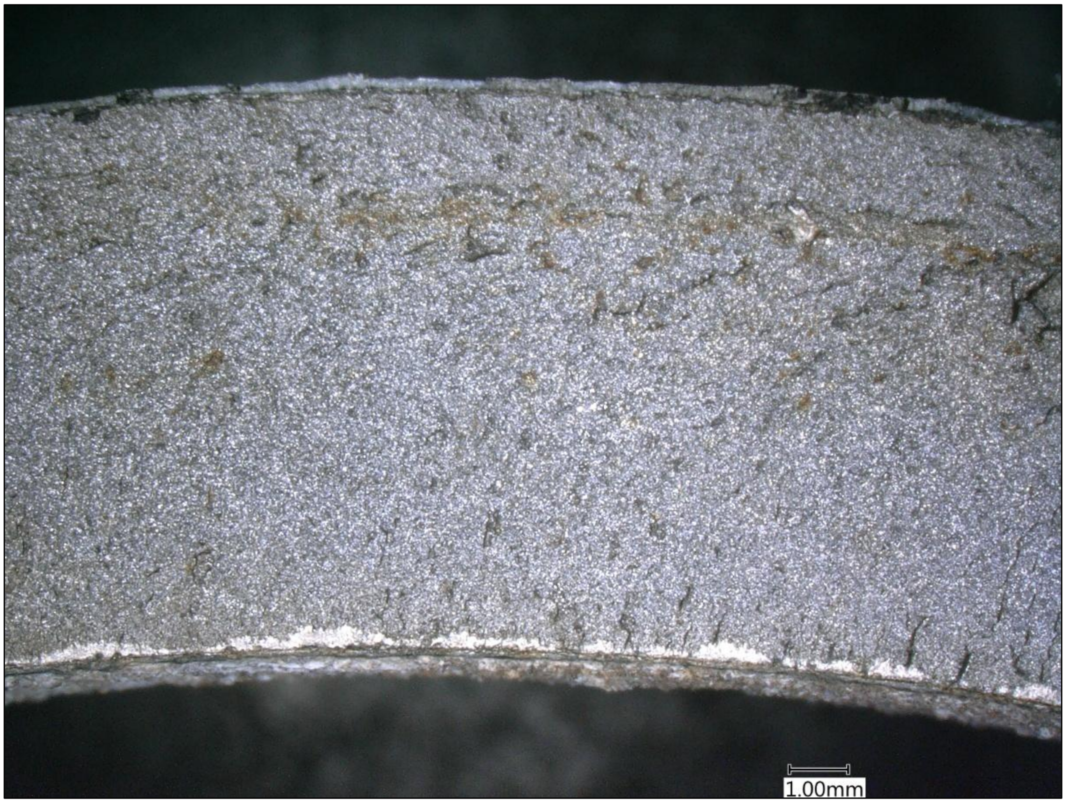


Figure 38 Reference 22 brittle fracture heading toward fatigue zone.

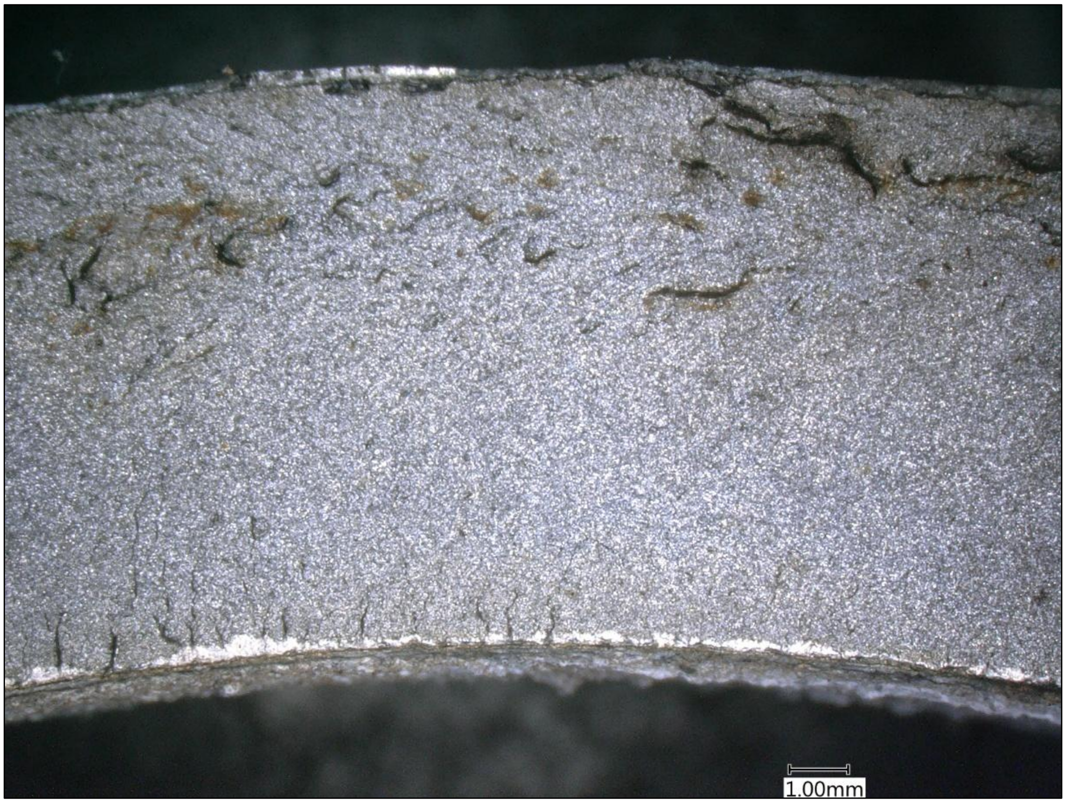


Figure 39 Reference 23 brittle fracture heading toward fatigue zone.

Figure 40 Brittle fracture near large thumbnail containing small thumbnail.

Figure 41 Back to intrados at 6:00 position.

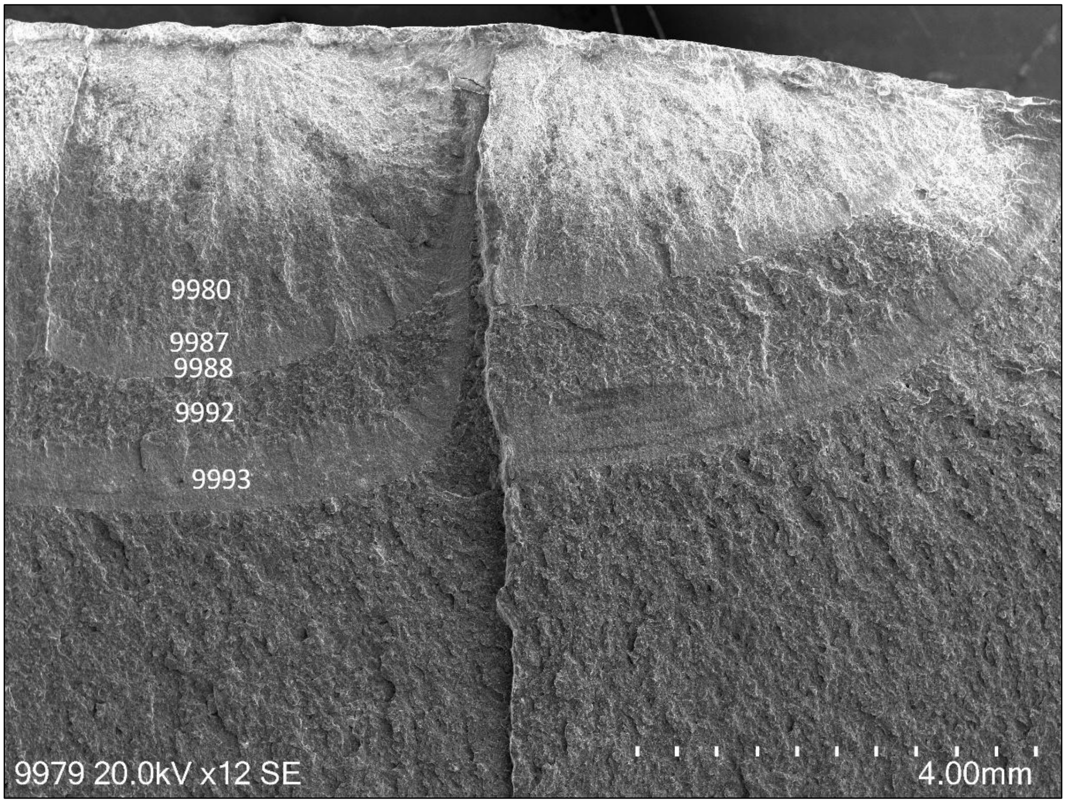


Figure 42 SEM view of uncleaned thumbnail. White haze is zinc oxide washed onto surface after initial cracking took place.

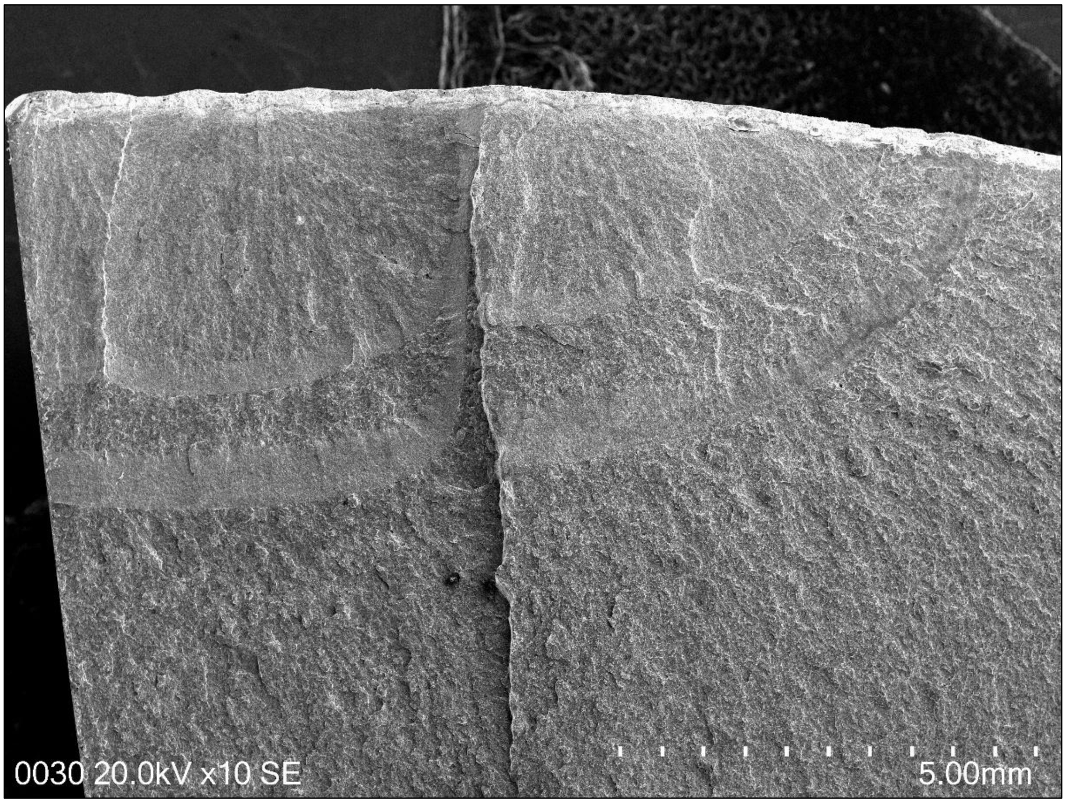


Figure 43 Thumbnail after cleaning with detergent in ultrasonic bath . Zones are labelled 1 – 5

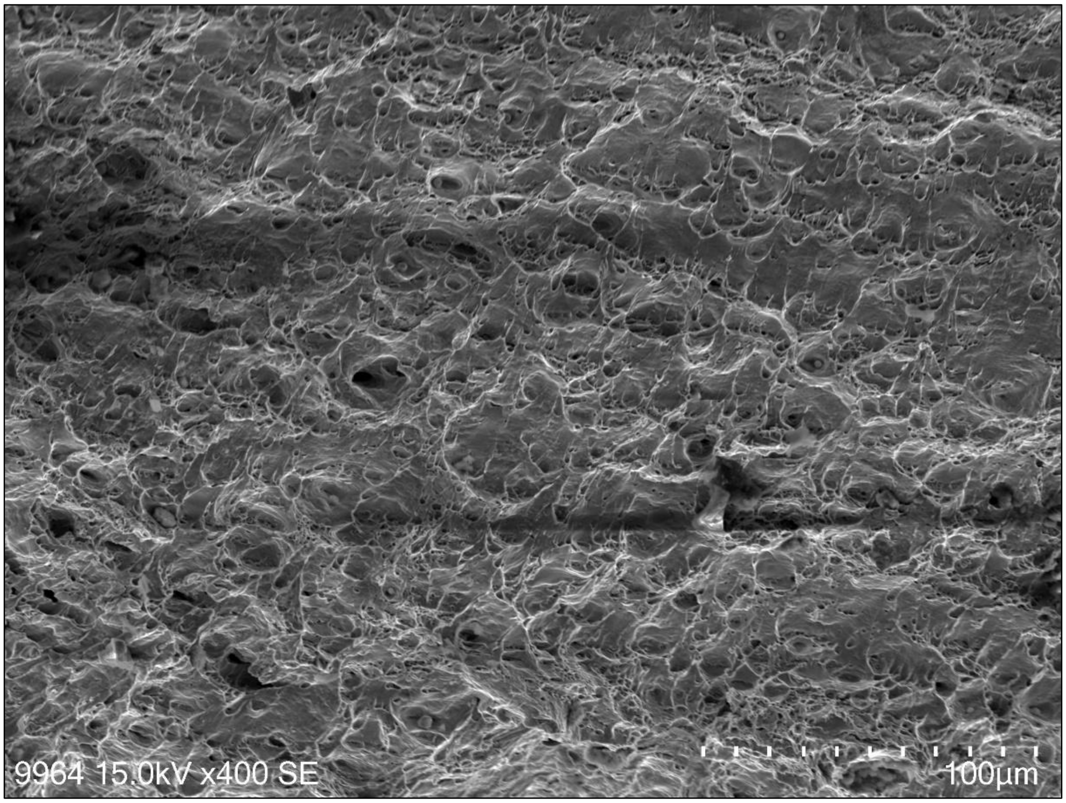


Figure 44 Features in origin area right at the surface. Features are a mixture of ductile and brittle cleavage.

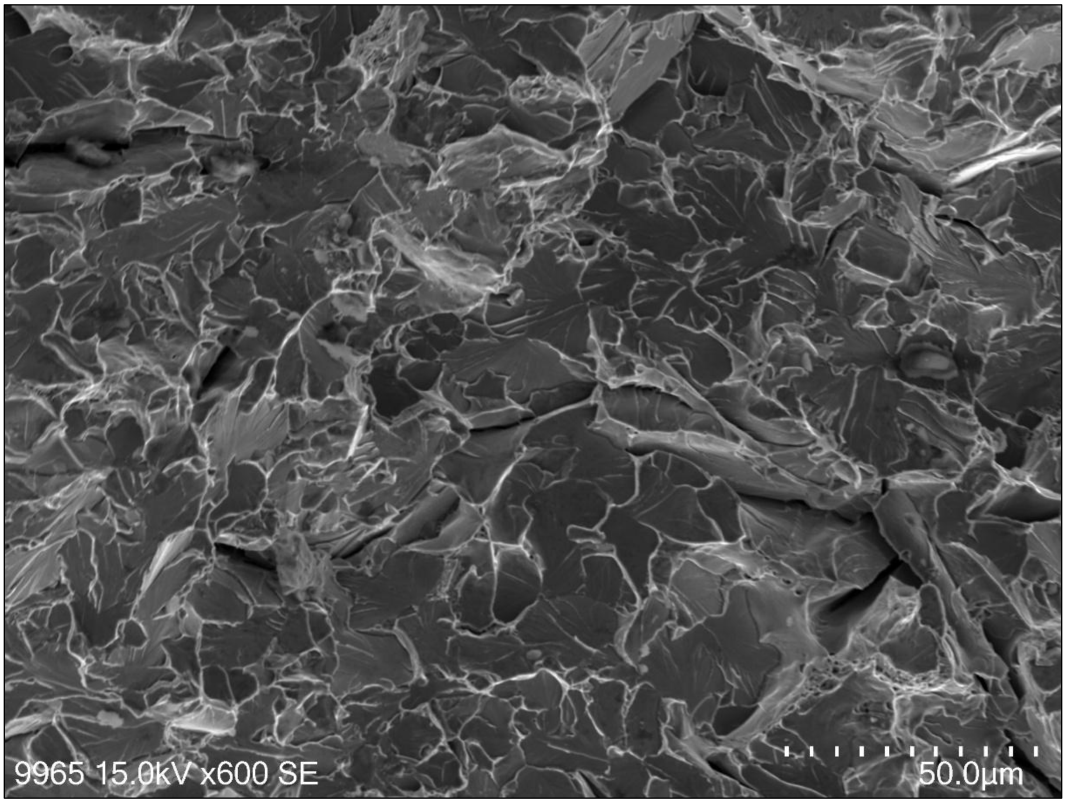


Figure 45 Features in Zone 1 containing 100% brittle cleavage.

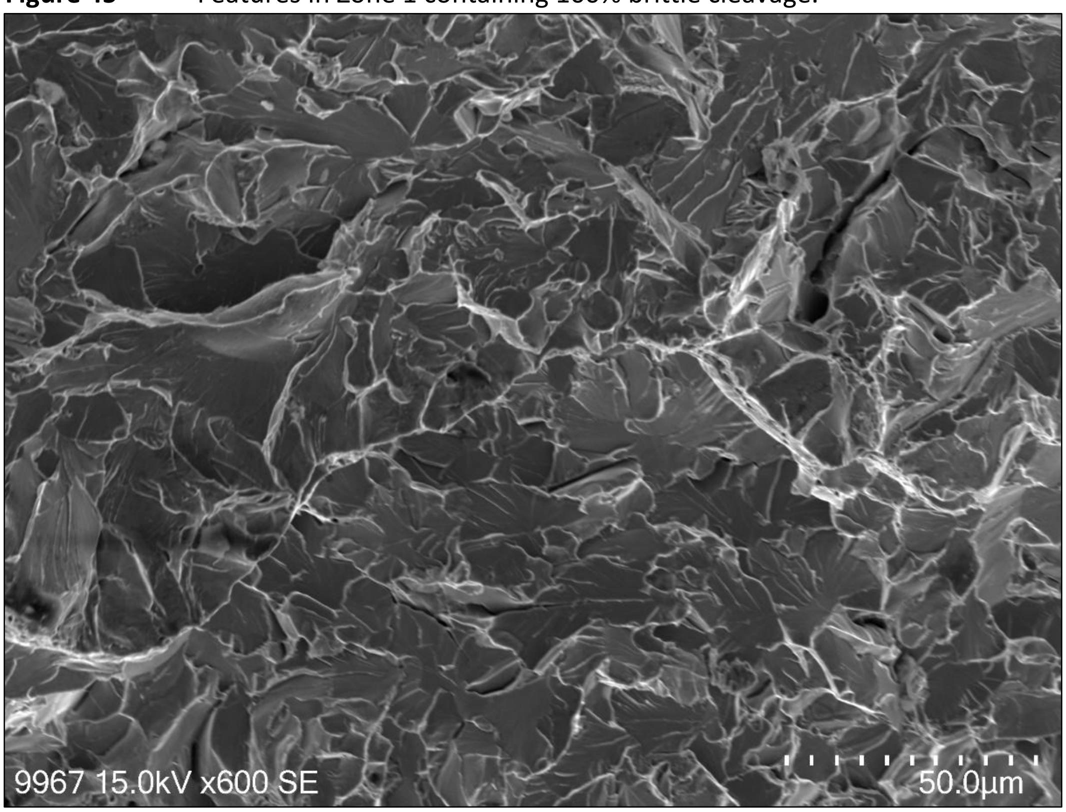


Figure 46 Features in Zone 2 containing 100% brittle cleavage.

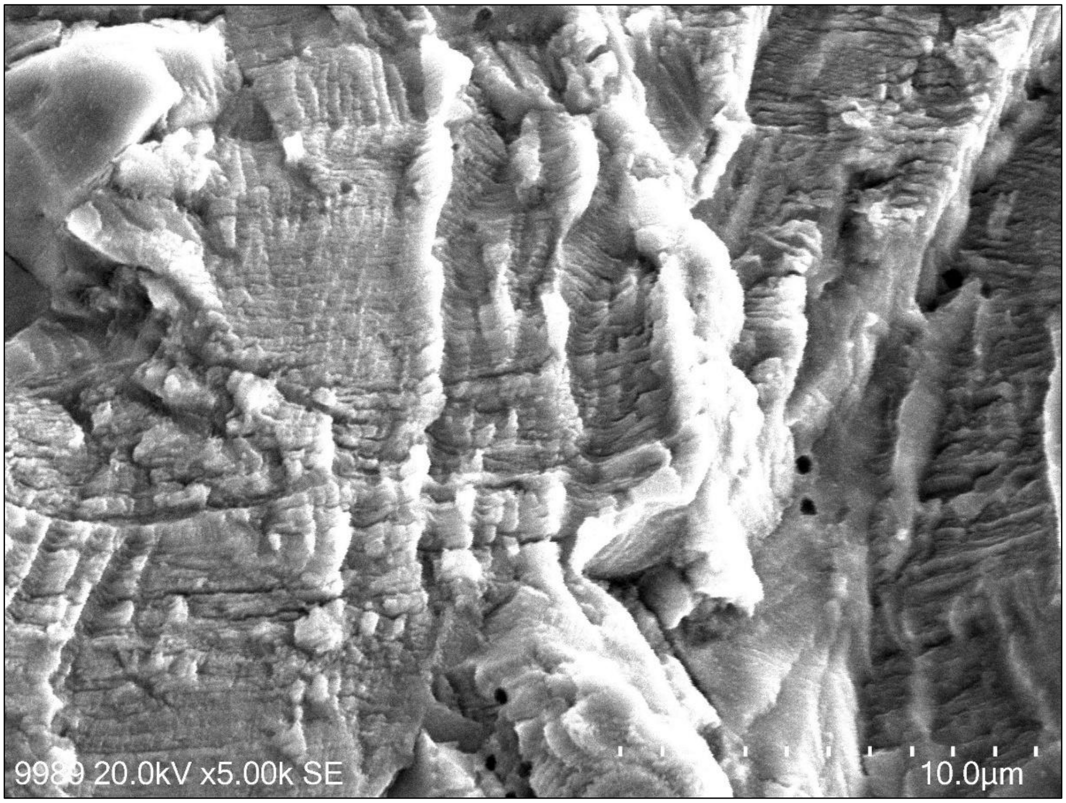


Figure 47 Features in Zone 3 containing fine fatigue striations. Striation spacing is approximately 0.3 microns

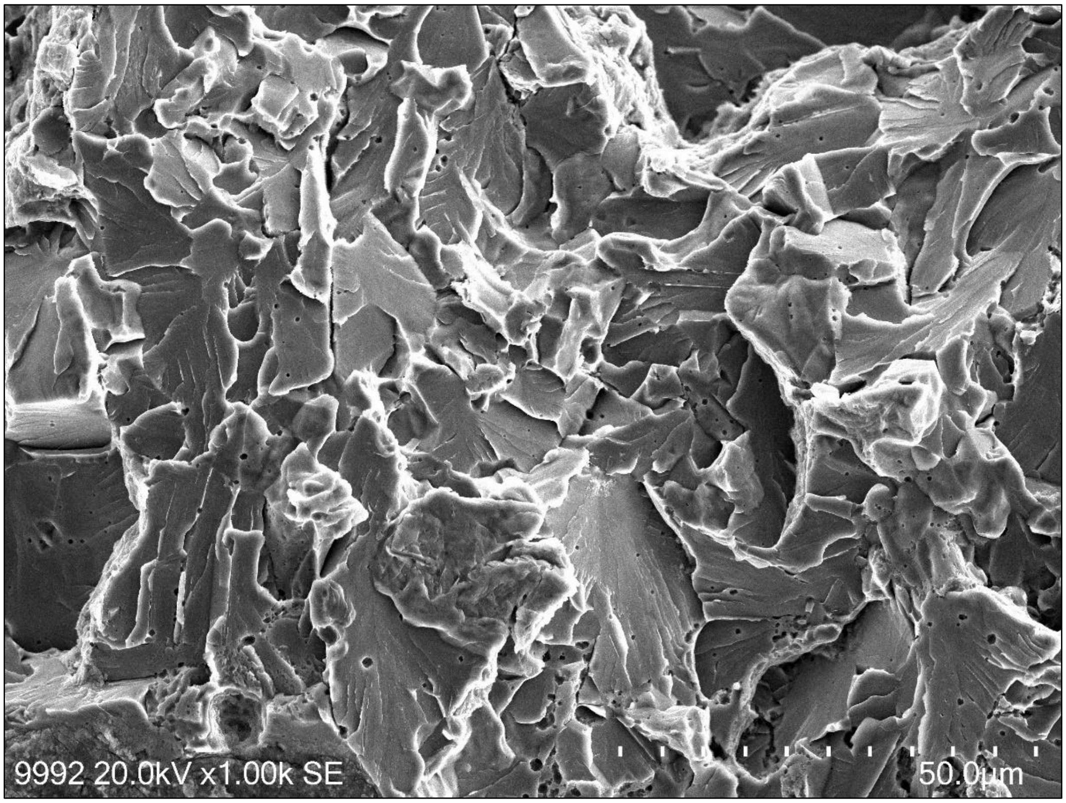


Figure 48 Features in Zone 4 containing 100% brittle cleavage.

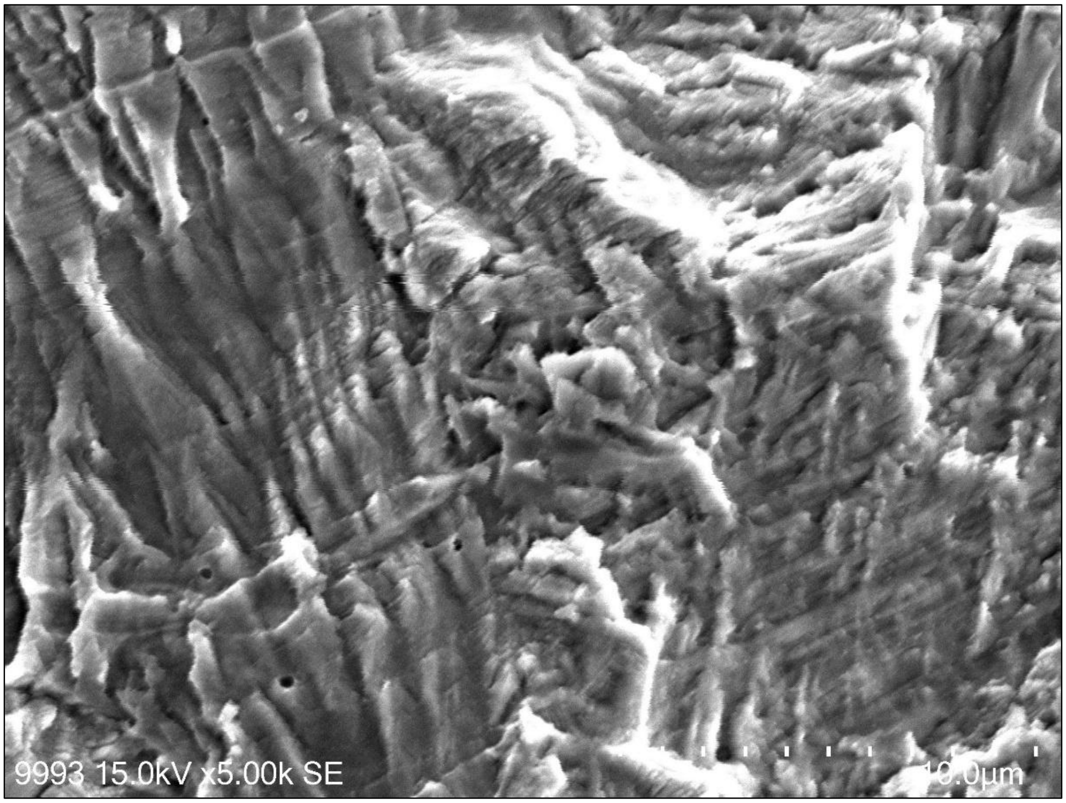


Figure 49 Features in Zone 5 containing fatigue striations. Striation spacing is approximately 0.3 microns.

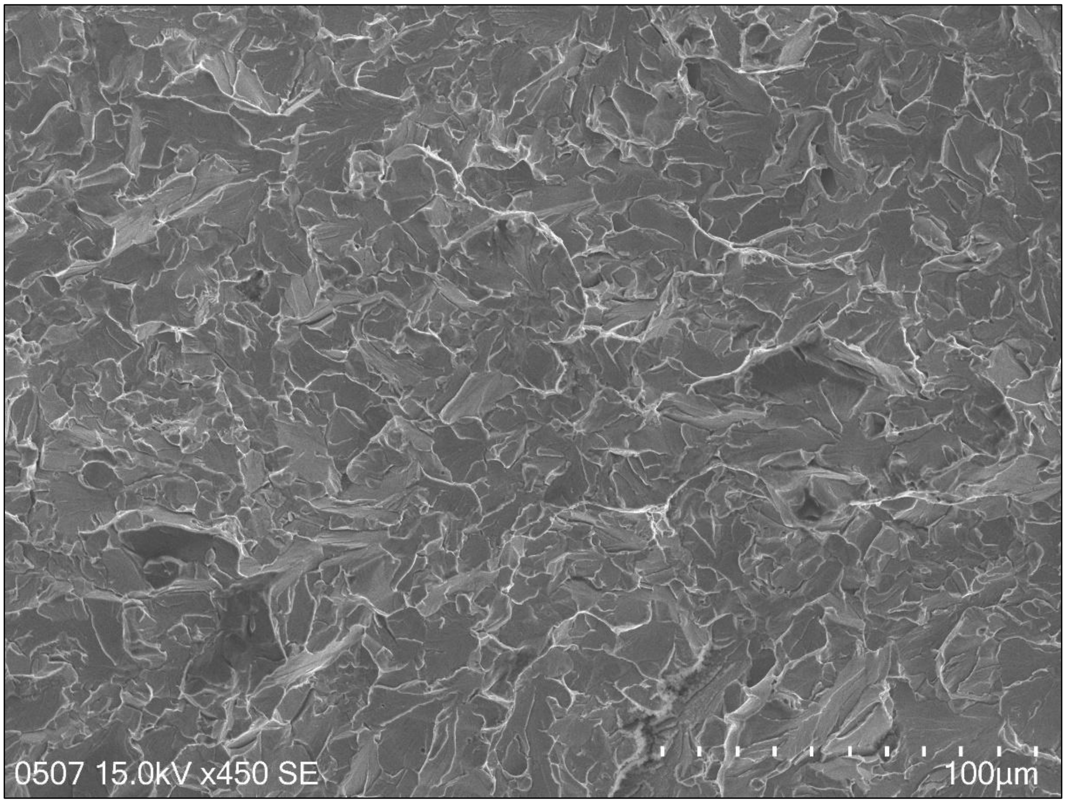


Figure 50 100% brittle cleavage below thumbnail.

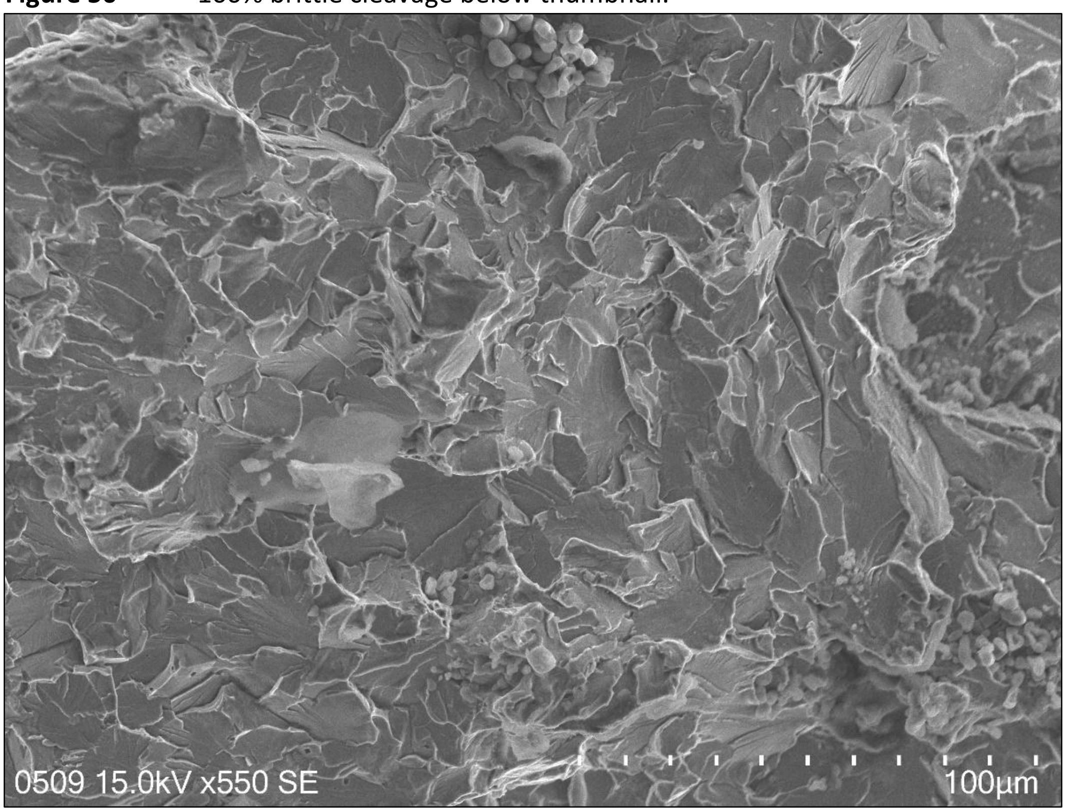


Figure 51 100% brittle cleavage between thumbnail and ID of pipe

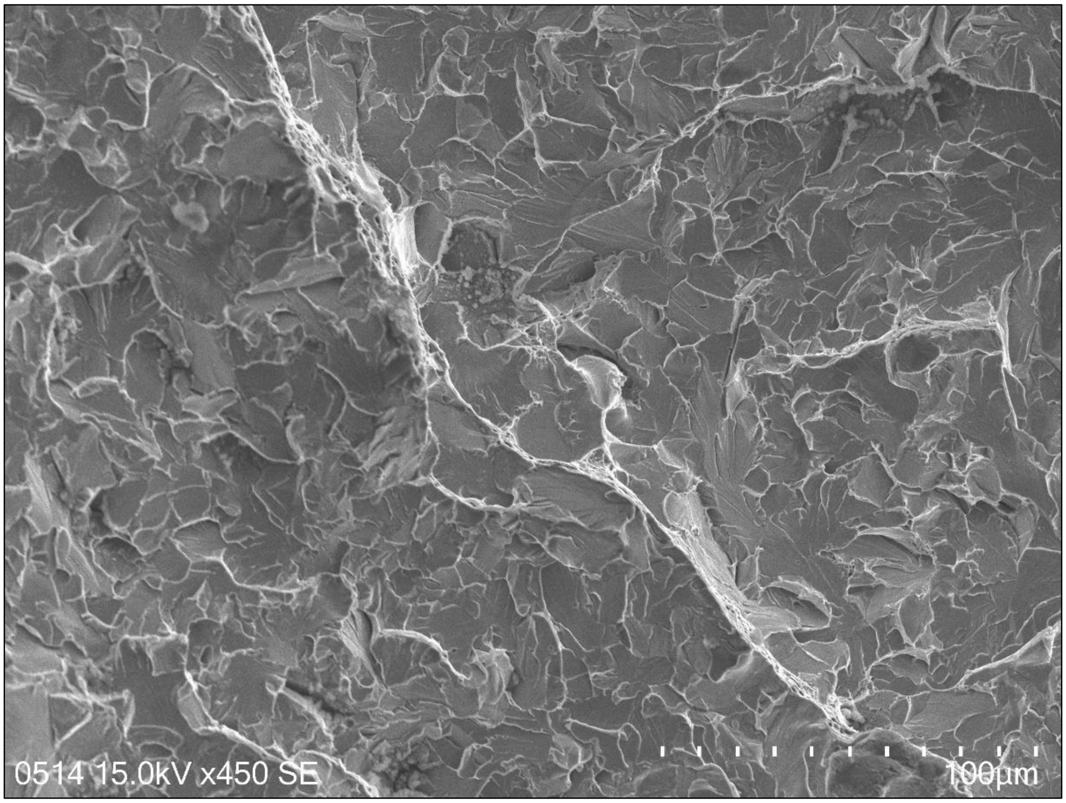


Figure 52 100% brittle cleavage between thumbnail and weld zone.

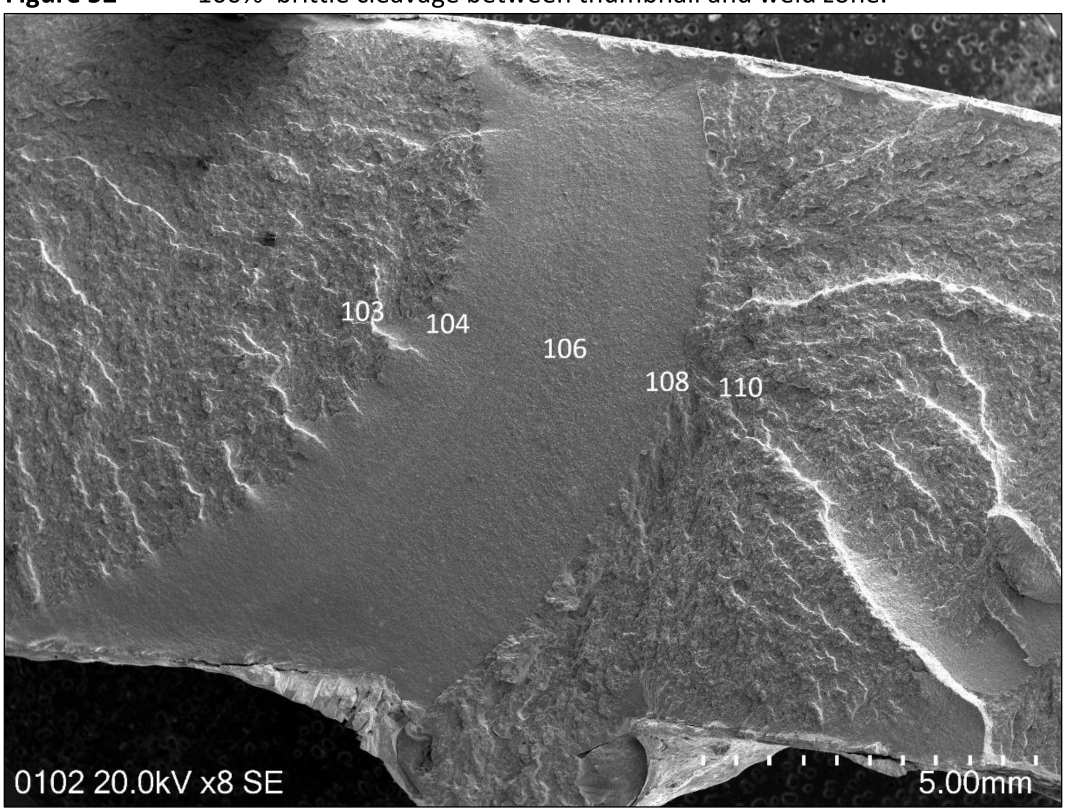


Figure 53 Fatigue zone starting at brittle fracture arrest in weld metal HAZ

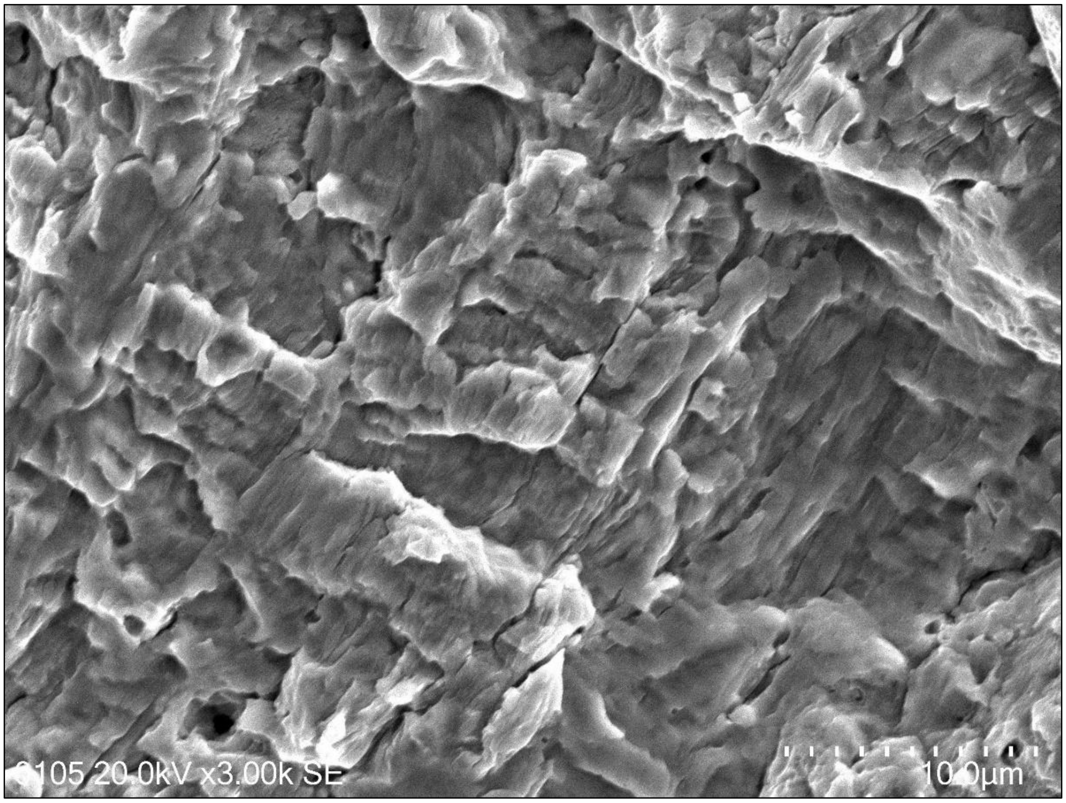


Figure 54 Fine fatigue striations in weld metal fatigue zone

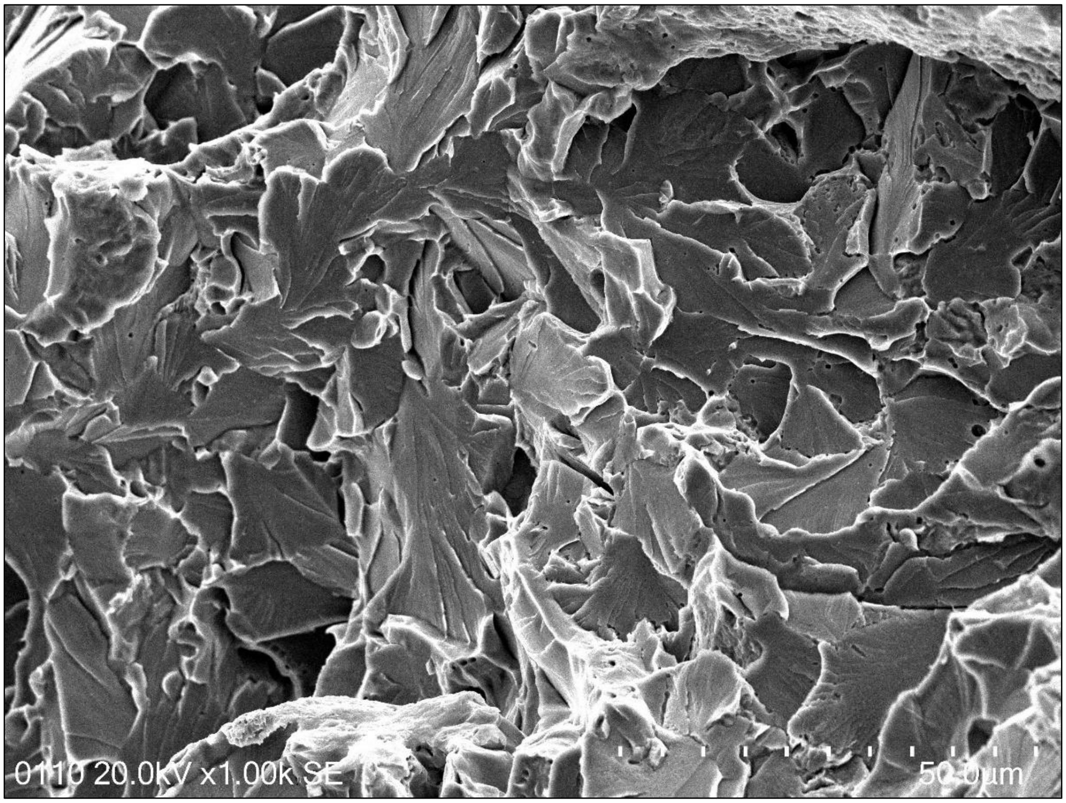


Figure 55 100% brittle cleavage in overload zone

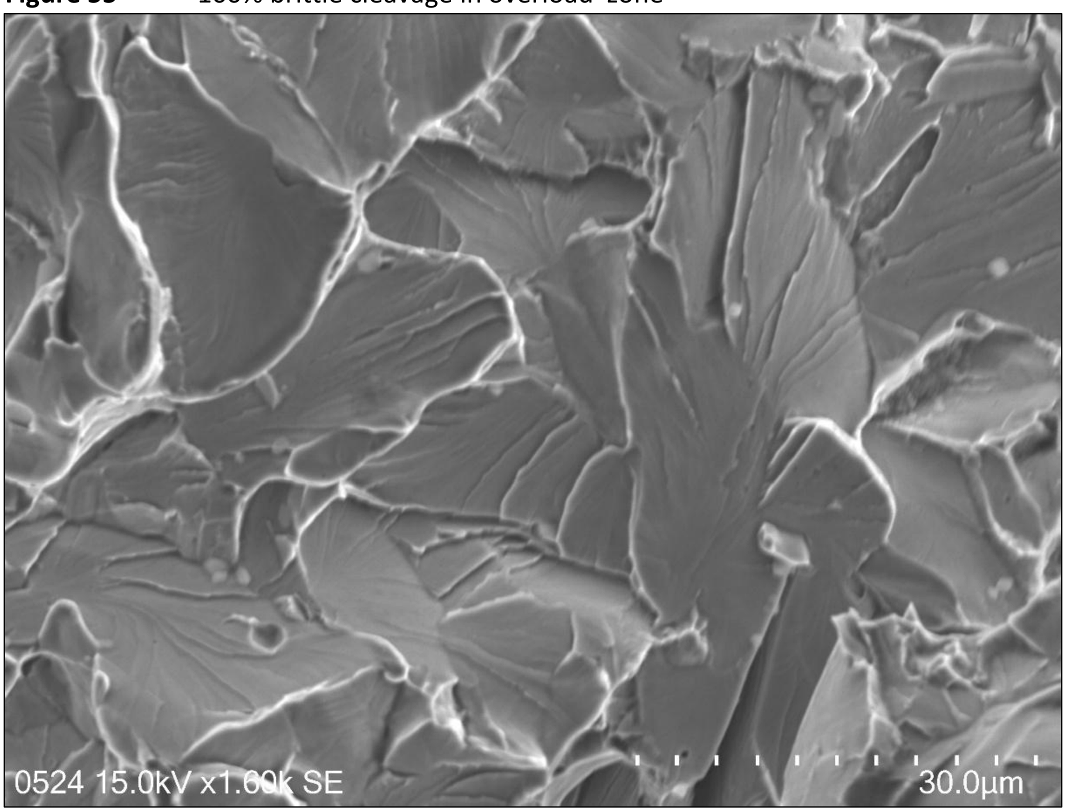


Figure 56 100% brittle cleavage in last area to separate.

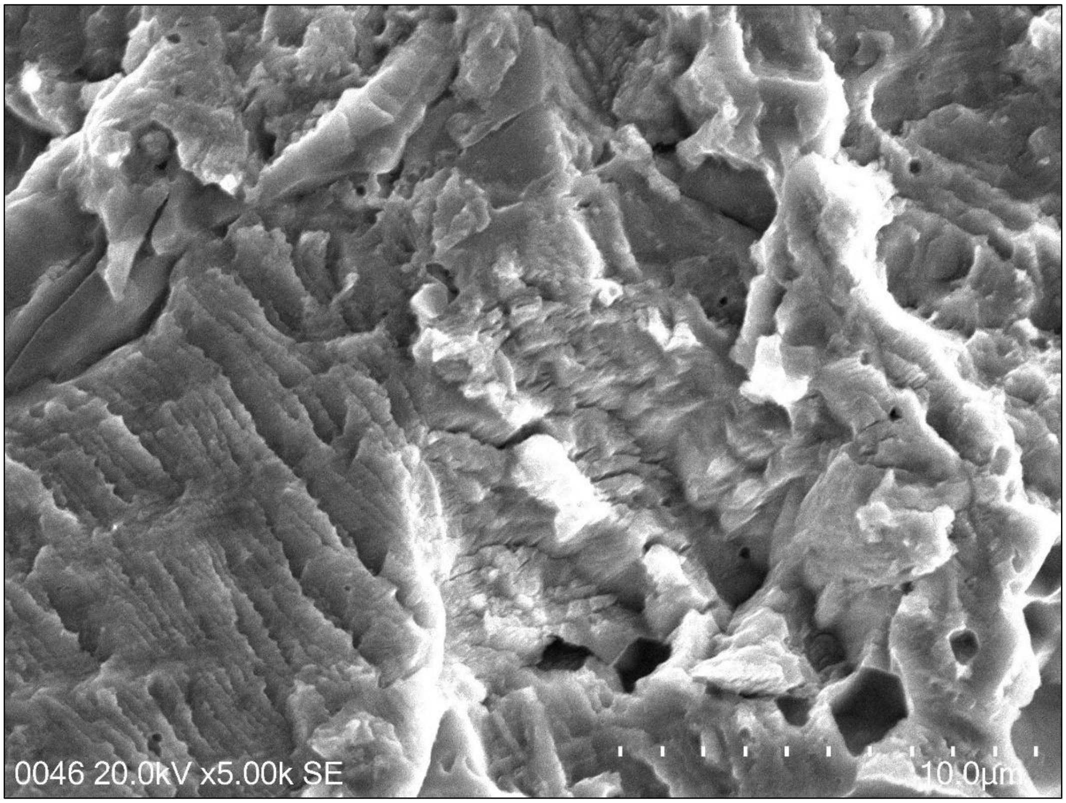


Figure 57 Fine fatigue striations in fatigue zone on opposite side. Striation spacing is 0.2 - 0.3 microns

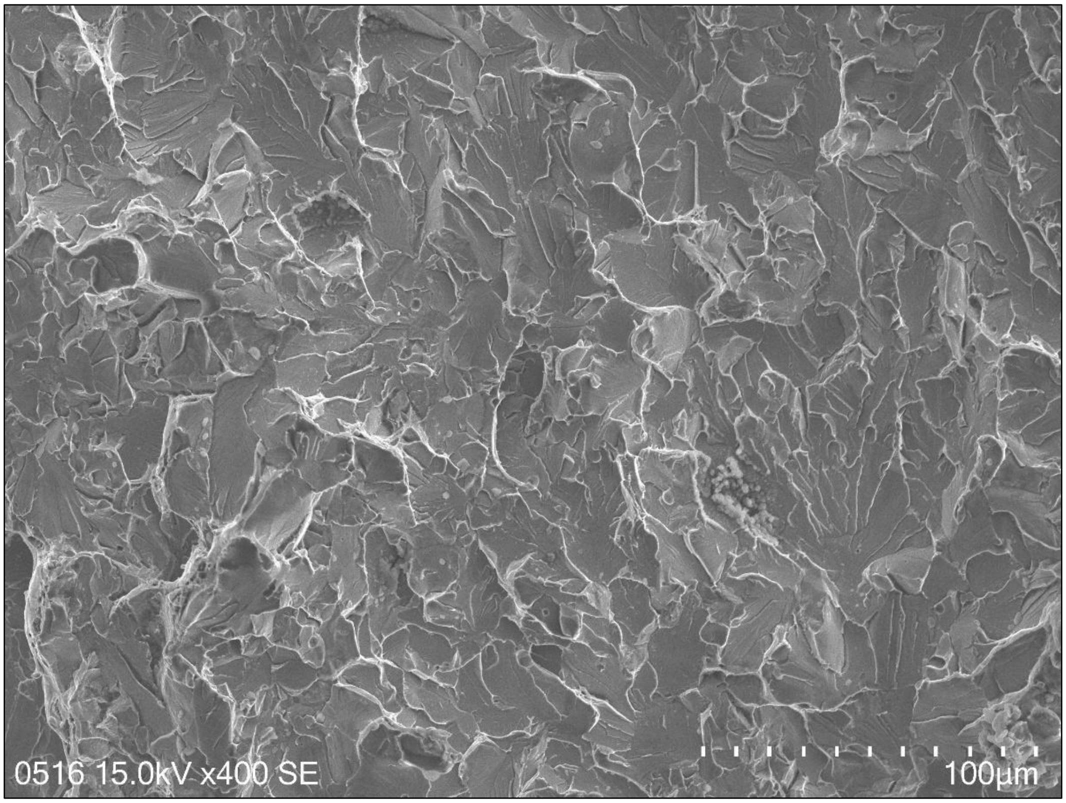


Figure 58 100% brittle fracture toward thumbnail

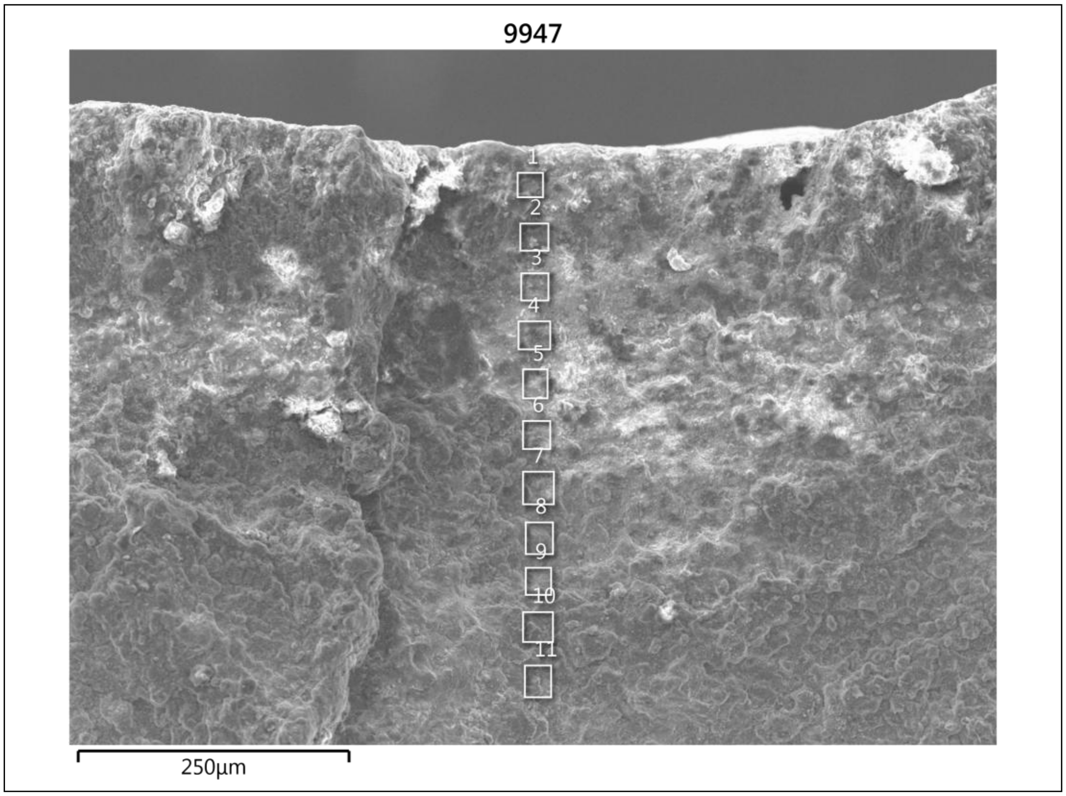


Figure 59 EDXA of haze showing decreasing zinc content toward the bottom of the thumbnail

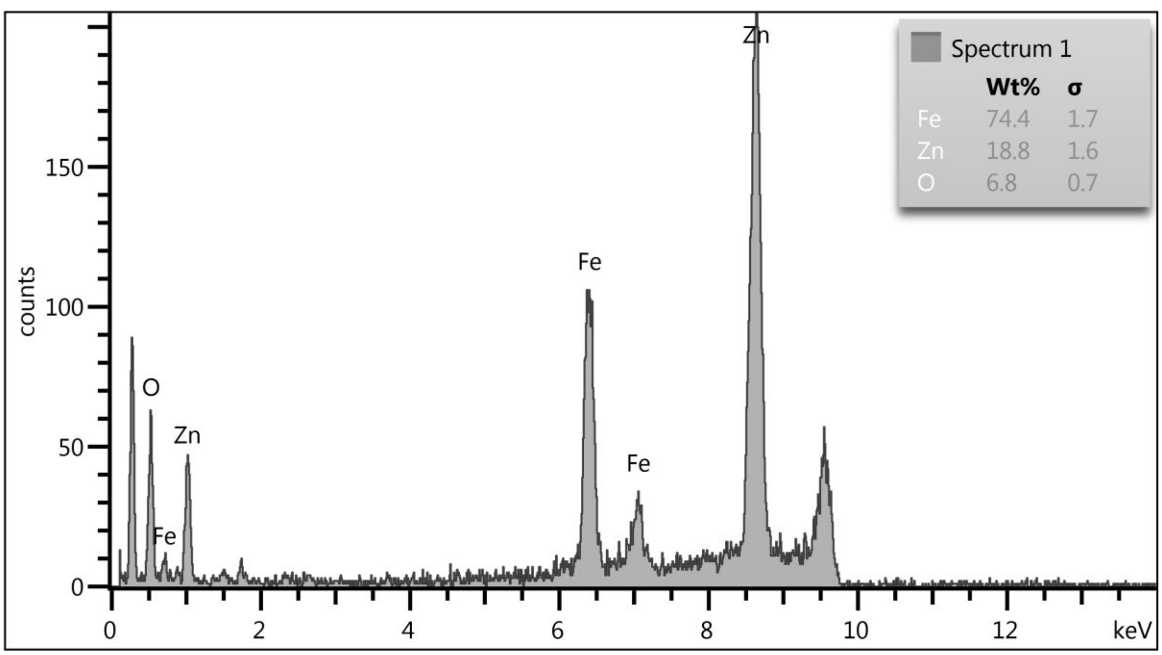


Figure 59b

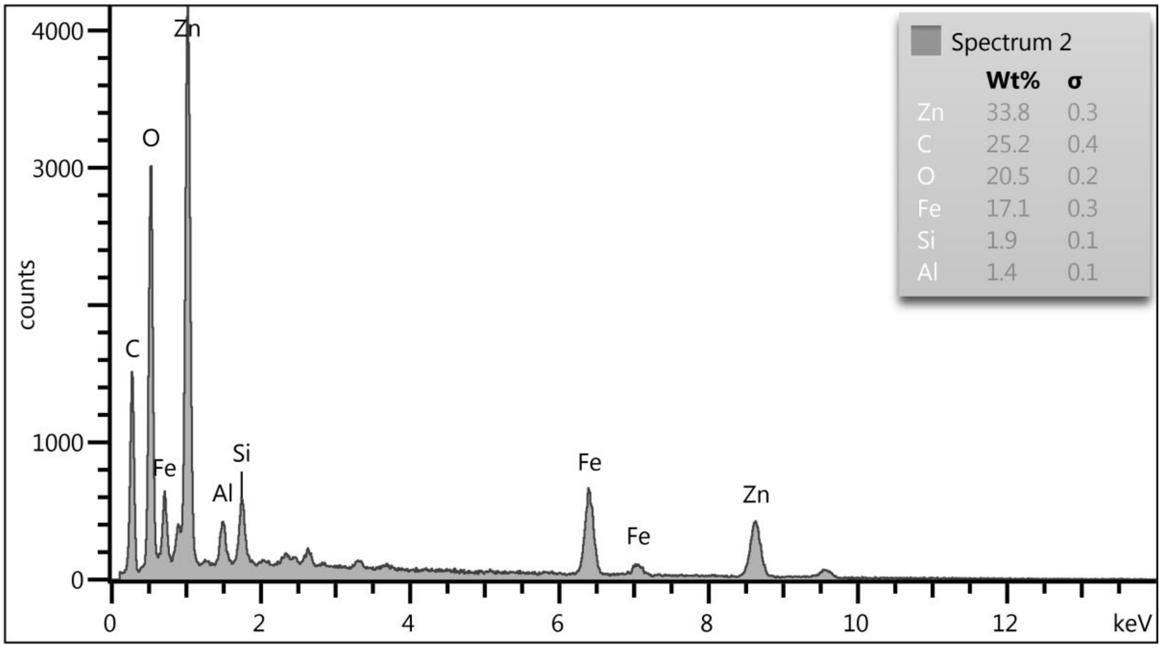


Figure 59c

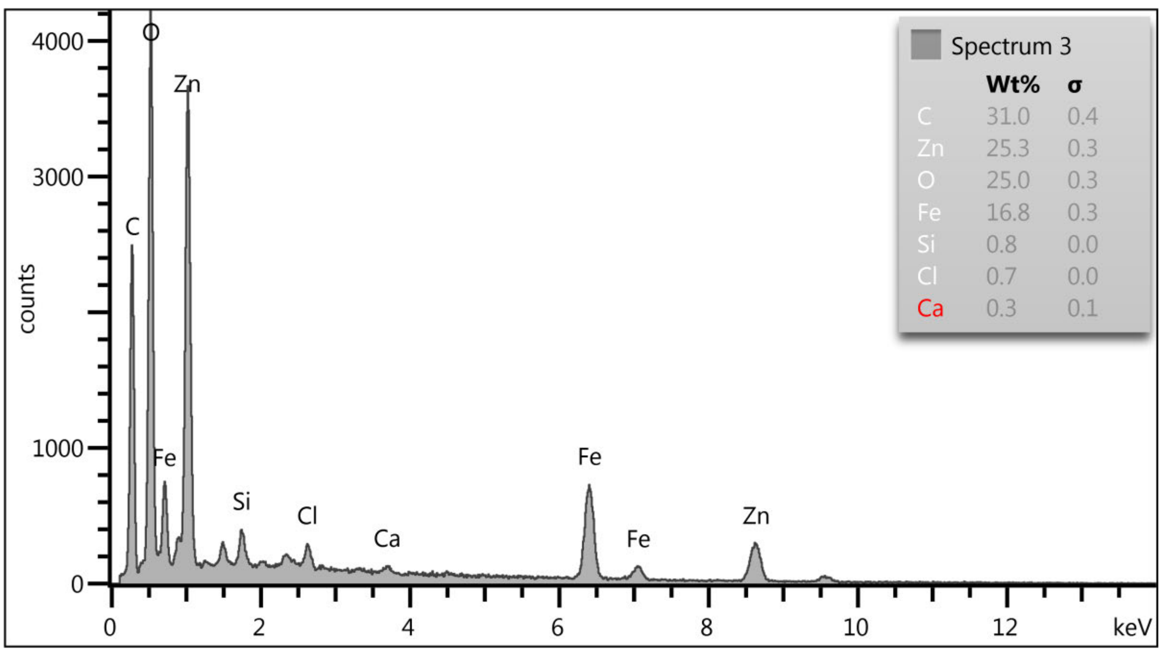


Figure 59d

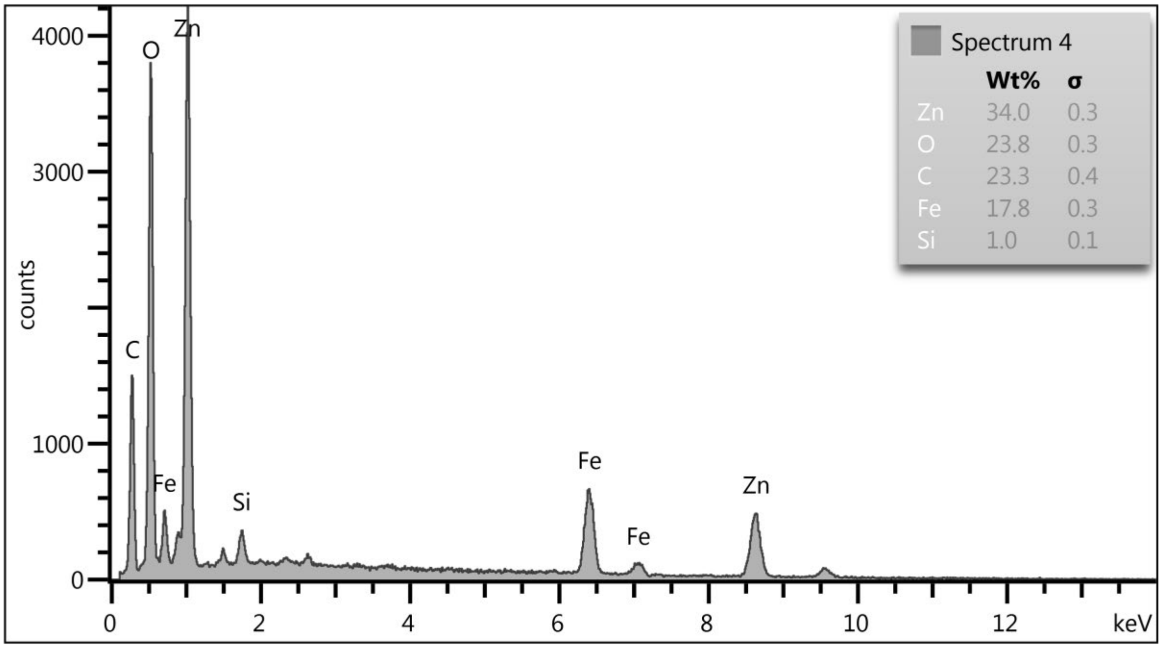


Figure 59e

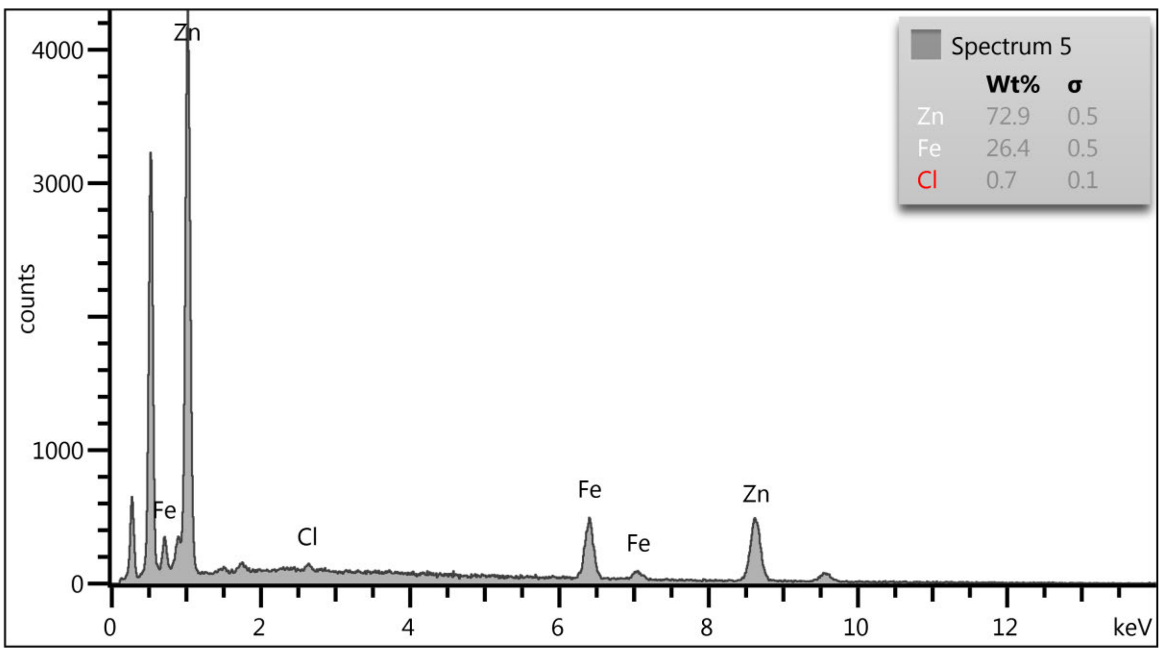


Figure 59f

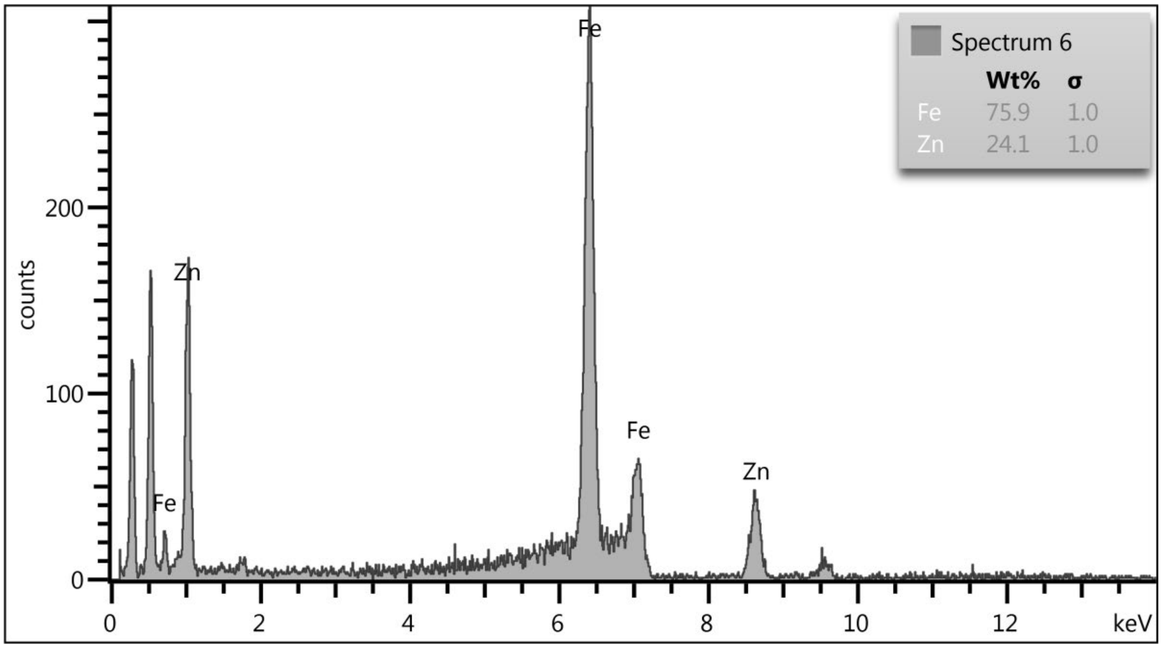


Figure 59g

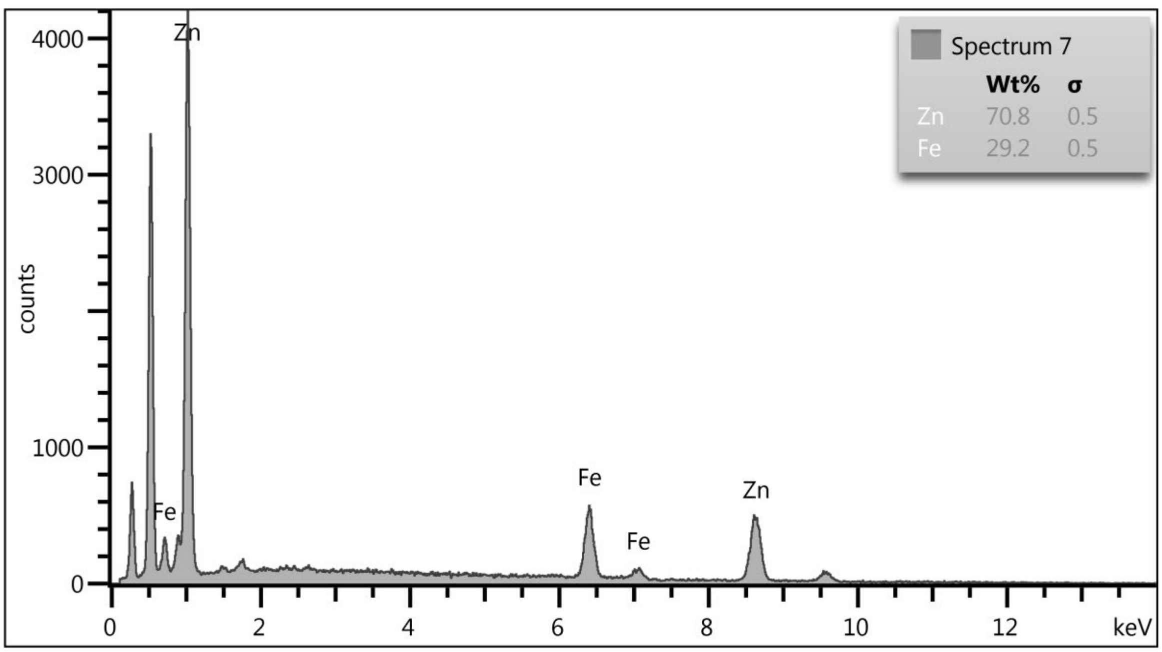


Figure 59h

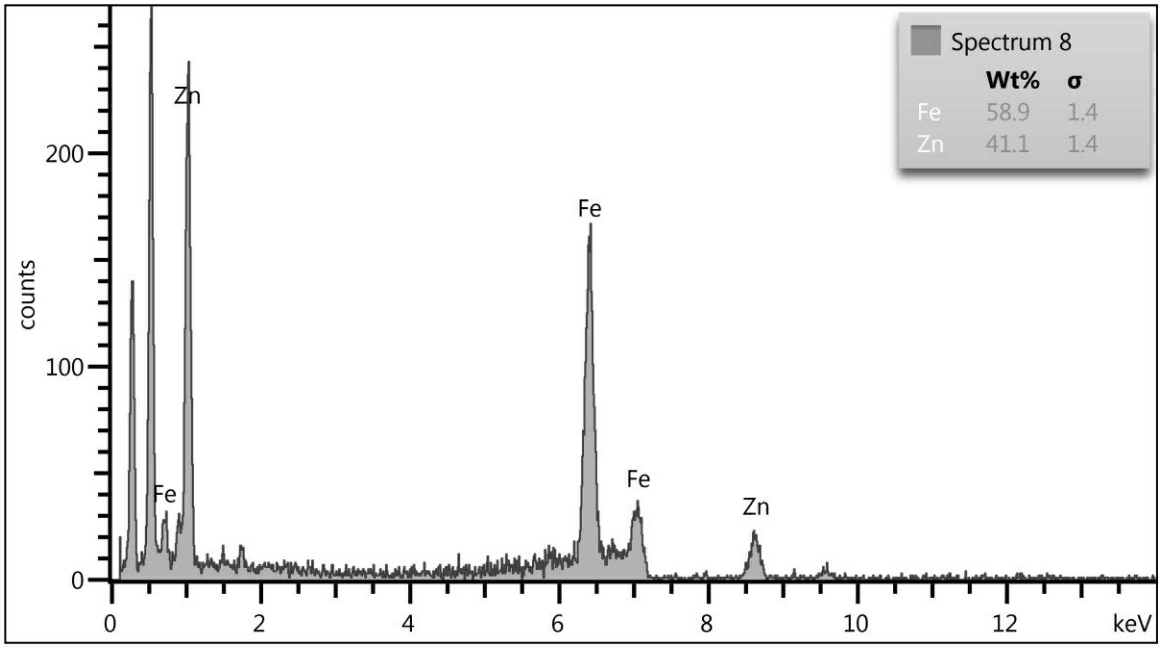


Figure 59i

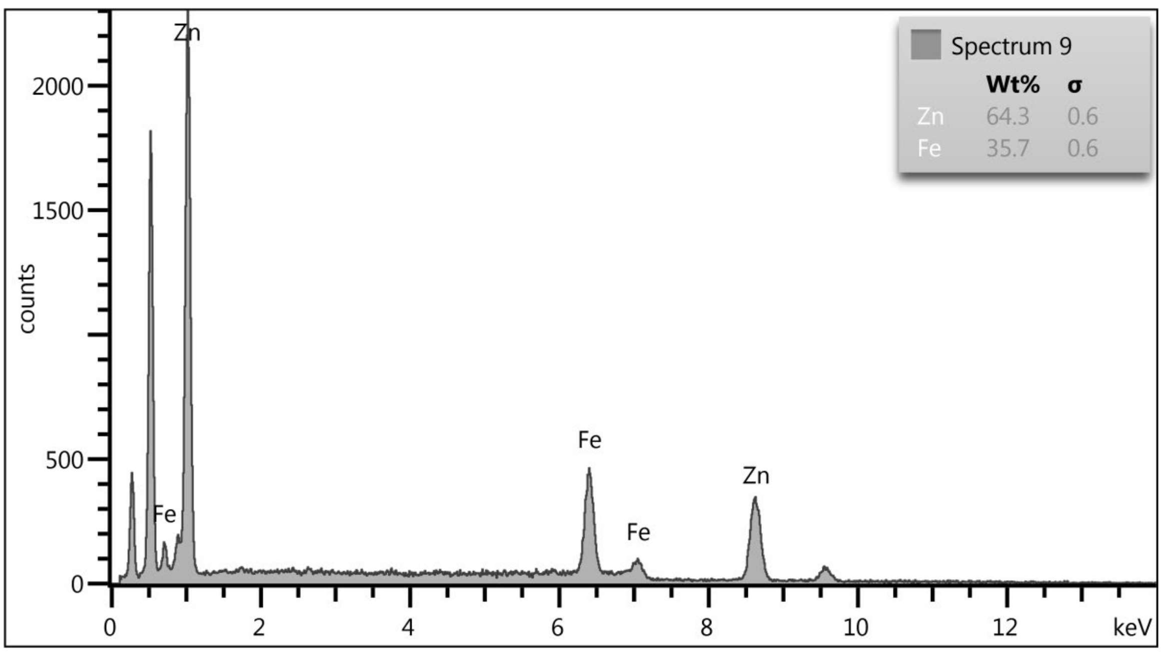


Figure 59j

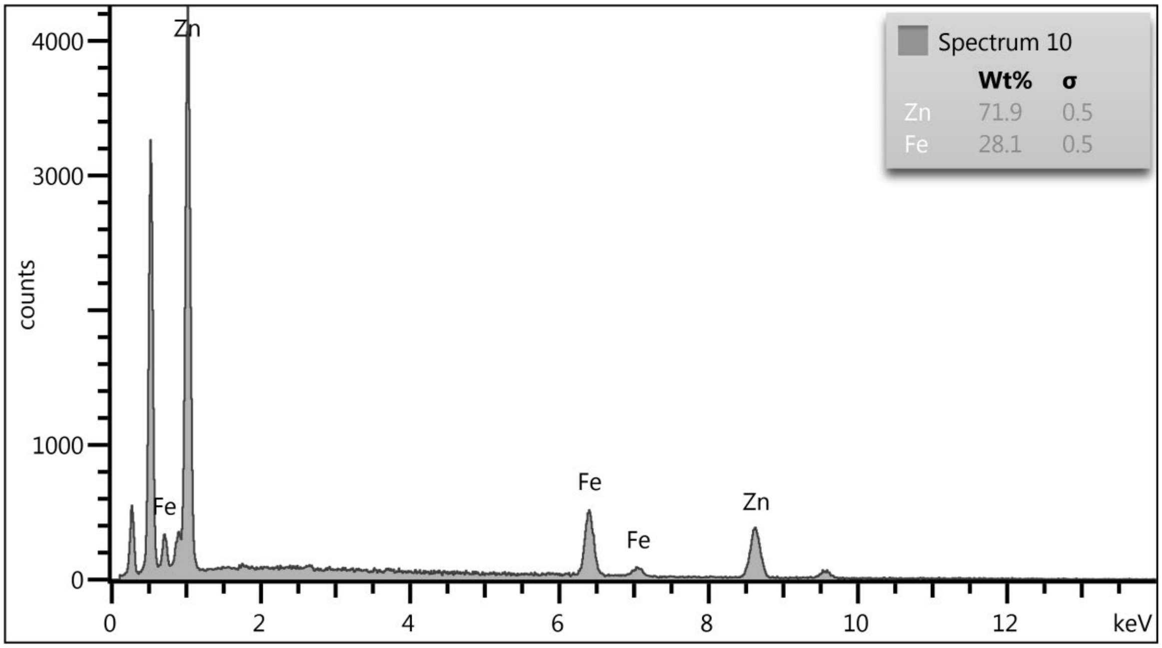


Figure 59k

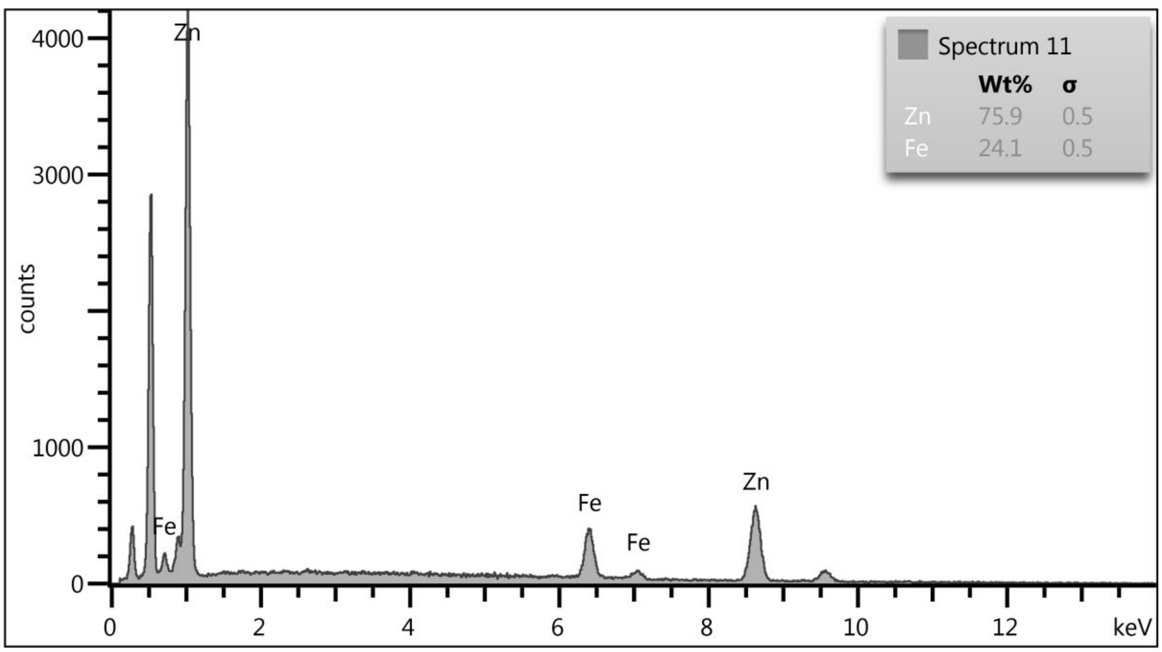


Figure 59l

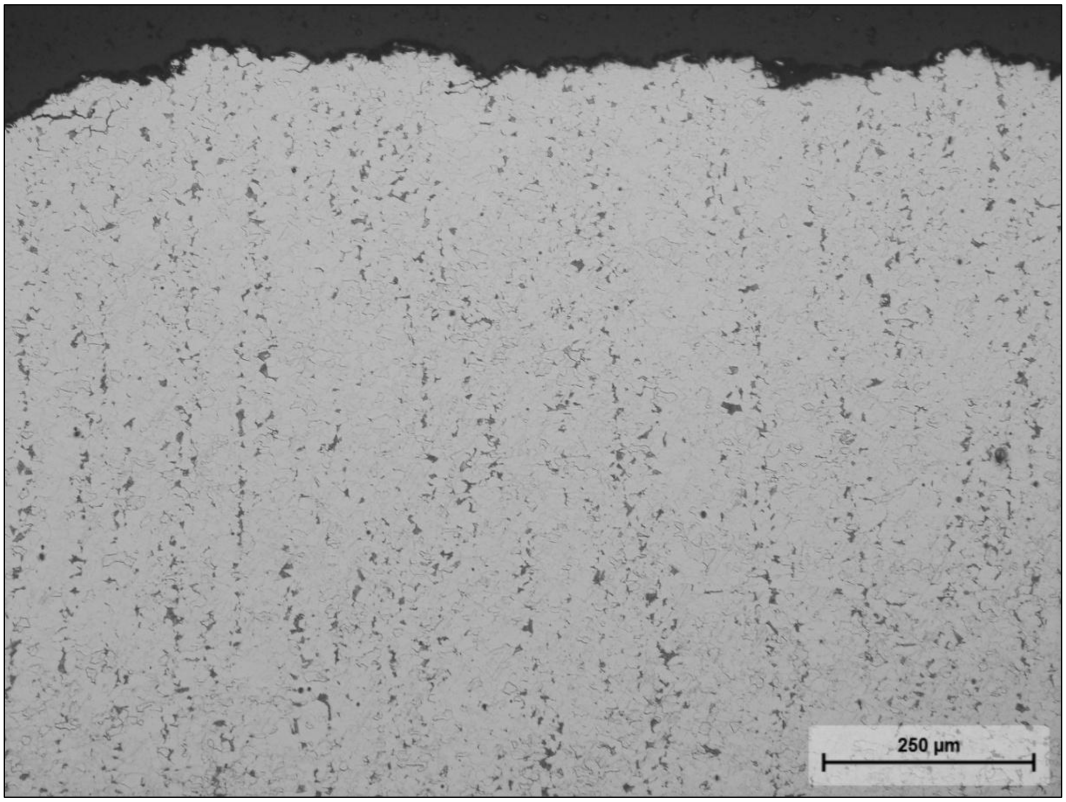


Figure 60 Hanger microstructure through fracture. Steel is relatively low carbon ferrite – pearlite microstructure.

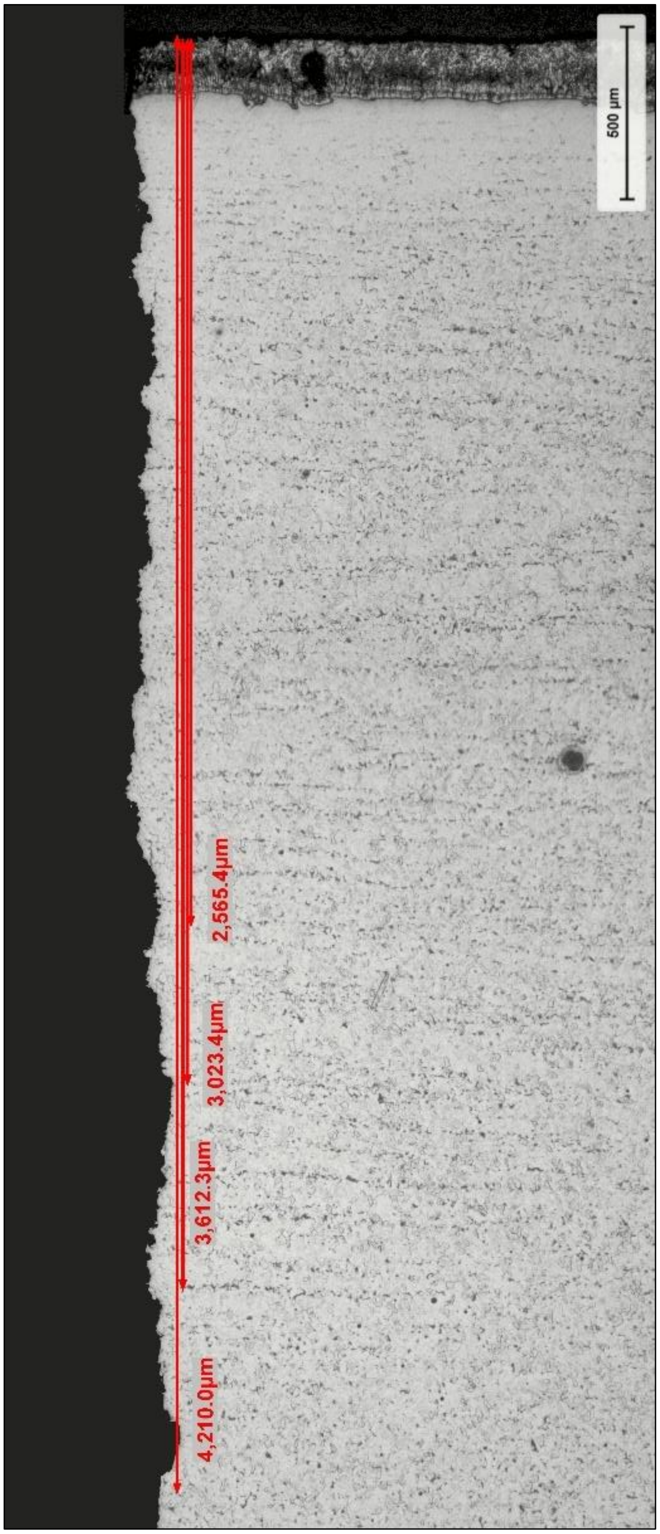


Figure 61 Locations of zones 1 – 5 through large thumbnail. Distances correspond to Figure 15 fracture surface measurements

ACUREN

APPENDIX B

LABORATORY REPORTS

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
www.acuren.com
Phone: 604.275.3800
Fax: 604.274.7235

A Higher Level of Reliability

ACCREDITED CERT #3977.03

CHEMICAL ANALYSIS REPORT

Technical Safety B.C.

DATE: March 19, 2025
OUR FILE NO: 605-J215610
PO NO: -
REPORT NO: 07
PAGE: 1 of 1

ATTENTION: **RYAN HAZLETT**

DESCRIPTION: Steel Pipe - Gondola Hanger
TEST METHOD: ASTM E415-21 (Optical Emission Spectroscopy – Spectro MAXx LMM04 – S/N08003788)

TEST RESULTS

Element	Chemical Composition (wt %)	
	Hanger Pipe s/n 0026400	ASTM A500 B
Carbon	0.057	0.26 max
Manganese	1.06	1.35 max
Phosphorus	0.010	0.035 max
Sulphur	0.010	0.035 max
Silicon	0.035	--
Copper	0.132	--
Nickel	0.050	--
Chromium	0.058	--
Molybdenum	0.015	--
Vanadium	0.056	--
Niobium	0.003	--
Grain Refining Elements (V+Nb)	0.005	--
Boron	0.0004	--
Carbon Equivalent**	0.25	--
Iron	Balance	Balance

* Hanger pipe meets the chemical requirements of ASTM A500 grade B
**Carbon Equivalence as per CSA W59-23 Clause 3.2.1: $CE = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Ni+Cu)}{15}$

Reported by: [redacted]

Reviewed by: Bob Milne P.Eng.

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
www.acuren.com

Phone: 604.275.3800
Fax: 604.274.7235

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TENSILE TEST REPORT

Technical Safety BC

DATE: March 19, 2025
OUR FILE NO: 605-J215610
PO NO: -
REPORT NO: 08

ATTENTION: **RYAN HAZLETT**

DESCRIPTION: Longitudinal tensile test of Failed Gondola Hanger Pipe
TEST SPECIFICATION: ASTM A370
MATERIAL SPECIFICATION: ASTM A500 grade B

SPECIMEN IDENTIFICATION	YIELD STRENGTH 0.2% OFFSET (KSI)	TENSILE STRENGTH (KSI)	% ELONGATION (IN 2")	% REDUCTION IN AREA	FAILURE LOCATION
Gondola Hanger s/n 0026400	73.9	82.2	22.75	N/A	Center gauge
Specification Requirements	46	58	23	N/A	

- Technical Safety BC Certificate of Recognition Registration No. CR-5
- Test machine calibrated to ASTM E4 and CSA A23.2-9C specifications.
- Specimens will be disposed of after 30 days unless alternate provisions are made.

Reported by: [redacted]

Reviewed by: [signature]
Bob Milne P.Eng.

ACUREN

APPENDIX C

CHARPY IMPACT TESTING

ACUREN

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
www.acuren.com

Phone: 604.275.3800
Fax: 604.274.7235

A Higher Level of Reliability

ISO 9001 : 2015 CWB REGISTERED Acuren: An ISO 9001 certified company

CHARPY IMPACT TEST REPORT

Technical Safety BC
2889 E 12th Ave suite 600,
Vancouver, BC
V5M 4T5

DATE: May 5, 2025
OUR FILE NO: 605-J215610
PO NO:
REPORT NO: 1

ATTENTION: **RYAN HAZLETT**

DESCRIPTION: Charpy Samples Fractured Arm (Position See Figure 1)

SPECIMEN TYPE: Standard V Notch | TEST SPECIFICATION: ASTM A370

SPECIMEN SIZE: 10 mm x 6.7 mm | MATERIAL SPECIFICATION: ASTM A500 grade B

SPECIMEN IDENTIFICATION	TEST TEMPERATURE (˚ C)	IMPACT ENERGY (J)	SHEAR FRACTURE (% ESTIMATE)
Intrados centre line (1) (12 o'clock)	20	10	5
Intrados centre line (2)	20	11	5
Intrados centre line (3)	20	7	2
1 o'clock (4)	30	6	2
1 o'clock (5)	30	143	100
1 o'clock (6)	30	150	100
11 o'clock (7)	30	155	100
11 o'clock (8)	20	129	95
11 o'clock (9(	20	7	2
Average			
Specification Requirements			

- Technical Safety BC Certificate of Recognition Registration No. CR-5
- Instrument calibrated annually to N.I.S.T. and ASTM E23.
- Specimens will be disposed of after 30 days unless alternate provisions are made.

Reported by: [redacted]

Reviewed by: R. Mi

Bob Milne P.Eng.

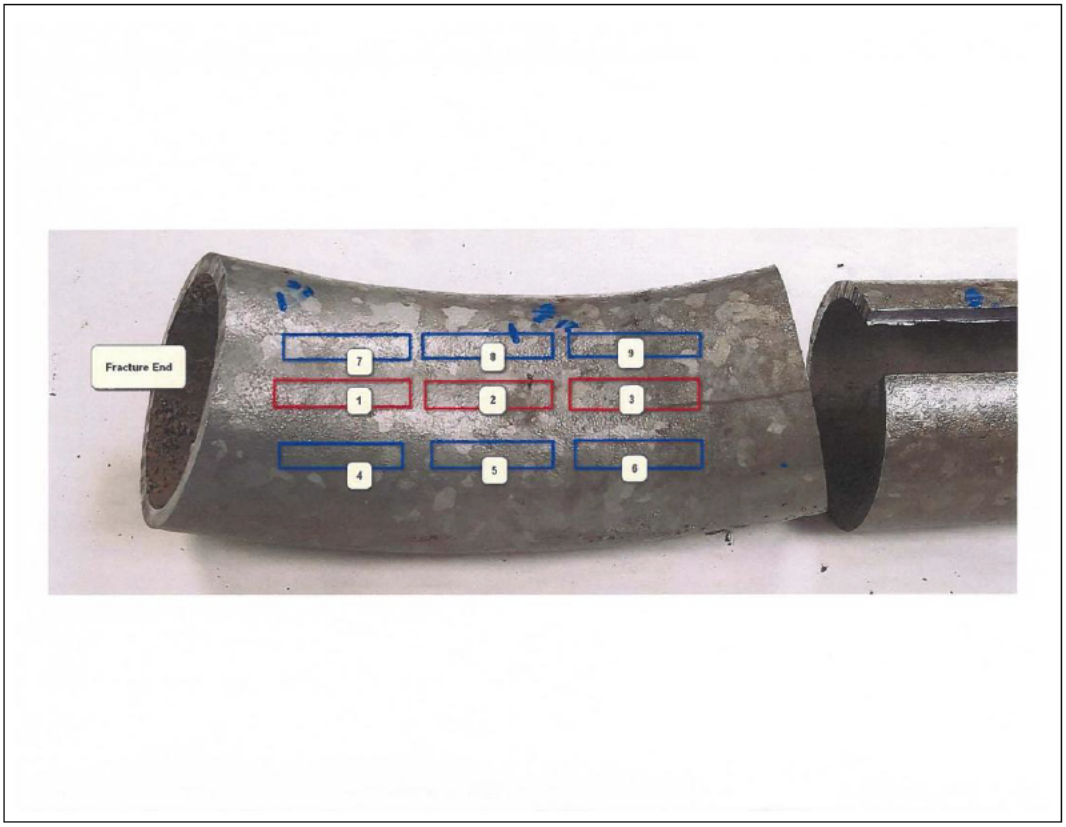

Figure 1 Charpy Sample Positions

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
www.acuren.com

Phone: 604.275.3800
Fax: 604.274.7235

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CHARPY IMPACT TEST REPORT

Technical Safety BC
2889 E 12th Ave suite 600,
Vancouver, BC
V5M 4T5

DATE: May 5, 2025
OUR FILE NO: 605-J215610
PO NO:
REPORT NO: 2
PAGE: 1 of 2

ATTENTION: **RYAN HAZLETT P.ENG.**

DESCRIPTION: Charpy Samples Intact Arm (Position See Figure 1)
SPECIMEN TYPE: Standard V Notch
SPECIMEN SIZE: 10 mm x 6.7 mm
TEST SPECIFICATION: ASTM A370
MATERIAL SPECIFICATION: ASTM A500 grade B

Specimen Identification	Test Temperature (˚ C)	Impact Energy (J)	Shear Fracture (% Estimate)
Intrados centre line (1) (12 o'clock)	20	97	65
Intrados centre line (2)	20	52	35
Intrados centre line (3)	20	106	75
1 o'clock (4)	20	93	65
1 o'clock (5)	20	19	15
1 o'clock (6)	20	112	100
11 o'clock (7)	20	90	50
11 o'clock (8)	20	53	35
11 o'clock (9(	20	105	65
Average			
Specification Requirements			

- Technical Safety BC Certificate of Recognition Registration No. CR-5
- Instrument calibrated annually to N.I.S.T. and ASTM E23.
- Specimens will be disposed of after 30 days unless alternate provisions are made.

Reported by: [redacted]

Reviewed by:
Bob Milne P.Eng.

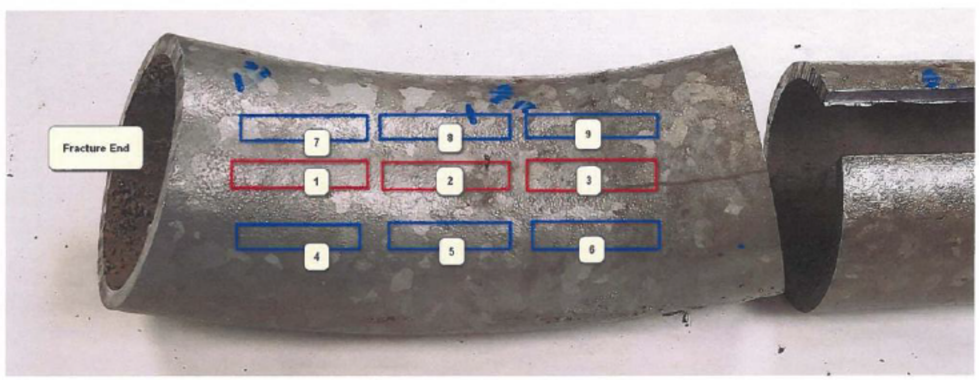

Figure 1 Charpy specimen locations

ACUREN

APPENDIX D

NDT REPORTS FROM SITE

Acuren Group Inc.
12271 Horseshoe Way
Richmond, BC, Canada V7A 4V4
www.acuren.com
Phone: 604.275.3800
Fax: 604.274.7235

A Higher Level of Reliability

NONDESTRUCTIVE EXAMINATION

CLIENT: Technical Safety BC

DATE: April 10, 2025
ACUREN JOB #: 605-J215610
REPORT #: 01
CONTRACT/PO: - WO: -
WORK LOCATION: Kicking Horse Resort, Golden, BC

ATTENTION: **DEAN SCHMITKE**
PROJECT: Gondola Arms
ITEM(S) EXAMINED: Gondola Arms

PART #: - MATERIAL: Carbon steel THICKNESS: 9 mm to 11 mm

SCOPE: Perform shear wave ultrasonic examinations on the suspect areas of the gondola arms to locate any relevant OD-connected reflectors or OD subsurface reflectors beneath the galvanized coating.

TYPES OF INSPECTION: Magnetic Particle; Ultrasonic

RESULTS:

As requested by the client, shear wave ultrasonic examinations were conducted on the suspect areas of the gondola arms to identify any relevant OD-connected reflectors or OD subsurface reflectors beneath the galvanized coating.

Calibration was referenced using the OD notch on the calibration block, and scanning was performed with a total gain of +9 dB (+3 dB transfer value and +6 dB scanning gain). A 2” x 4” area, centered 28” from the bottom end—corresponding to the location of a previously reported fracture—was scanned in the vertical direction.

A total of 24 gondola arms were examined, including Gondolas #23 through #41, #47, #54, #2, #12, and #20.

- No relevant or reportable reflectors were identified in any of the inspected gondola arms, with the exception of #25.
- Gondola arm #25 exhibited two minor reflectors during ultrasonic examination. Subsequent dry and wet magnetic particle examinations revealed no surface-breaking indications. Scratches on the galvanized coating were observed in the area and were smoothed using a file. The area was then re-examined using ultrasonic testing, with no further reflectors detected.

CLIENT: ______ (CLIENT PRINTED NAME) ______ (CLIENT SIGNATURE ACCEPTED & ACKNOWLEDGED BY)

ACUREN TECHNICIAN: [redacted] ______ (2nd Technician)

REVIEWER: Bob Milne, P.Eng.

TOTAL HOURS	S.T.	O.T.	SHIFT
1ST TECHNICIAN: See DTR			Day ☐
2ND TECHNICIAN:			PM ☐

KILOMETRES: OTHER CHARGES: YES ☐ NO ☐
(IF YES, SEE DAILY OR PROJECT TIME REPORT)

Photo 1:

General view of Gondolas and Gondola Arms.

Photo 2:

Typical view of the suspect area where ultrasonic examinations were performed.

Photo 3:

Typical view of the suspect area where ultrasonic examinations were performed.

TEST DETAILS: MAGNETIC PARTICLE

ACCEPTANCE STANDARD: Client's Information			REVISION: N/A
PROCEDURE/TECHNIQUE: CAN-MT-14P001			REVISION: 19
TYPE: Wet Visible		METHOD: Yoke	
PARTICLE BRAND: Magnaflux	PRODUCT NO.: 7HF	CURRENT: AC	MT INSTRUMENT: Parker B-300
PARTICLE COLOUR: Black		MT INSTRUMENT S/N: 29880	CAL DUE: May 14 2025
SUSPENSION: Oil		LIFT CHECK BEFORE USE: Yes	LIFT WEIGHT S/N: P16-090
CONTRAST PAINT: Magnaflux	PRODUCT NO.: 8901W	LIGHTING EQUIPMENT: Flashlight	
MAG TIME (SECONDS): 5	DEMAG REQUIRED?: No	BLACKLIGHT MAKE: N/A	S/N: N/A
TECHNIQUE DEMONSTRATED OVER A PAINTED SURFACE?: N/A		LIGHT METER S/N: 11010287	CAL DUE: Sept 27 2025
		LIGHT INTENSITY: > 100 fc (1076 lx)	
BATCH NOS. (WHEN REQUIRED): PARTICLES:		SUSPENSION:	CONTRAST PAINT:
TEST SURFACE CONDITION: Clean Bare Metal		TEST SURFACE TEMPERATURE: 0°C to 20°C	

TEST DETAILS: ULTRASONIC

ACCEPTANCE STANDARD: Client's Information			REVISION: N/A
PROCEDURE/TECHNIQUE: CAN-UT-14P002			REVISION: 10
TYPE: Flaw Detection		METHOD: Contact	
INSTRUMENT: Olympus	MODEL: Epoch 650	S/N: 150015301	CAL DUE: Feb 13 2026
CAL. BLOCK: IIW	S/N: 11-5068	CABLE-TYPE: Coaxial	LENGTH: 1.8 m
CAL. BLOCK: ASME	S/N: IDEAL 6422	COUPLANT: Echo Ultrasonics - SoniX UT	

Probe & Technique Details:

	TEST ANGLE (°)	PROBE TYPE	CRYSTAL SIZE	FREQ. (MHZ)	SERIAL NUMBER	DAMPING Ω	TEST FROM	REFERENCE REFLECTOR	TRANSFER VALUE	REFERENCE dB	REFERENCE % FSH	SCAN dB	RANGE
1	45	Single	6.35 mm	5	SC0684	50	OD	OD Notch	+3	37.3	80	+12	75 mm
2	0	Dual	6.35 mm	5	871683	50	OD	Back wall	N/A	As req.	80	+6	30 mm
3													
4													

TEST SURFACE CONDITION: Clean Bare Metal   TEST SURFACE TEMPERATURE: 0°C to 20°C

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NONDESTRUCTIVE EXAMINATION

CLIENT: Technical Safety BC
104 – 9525 201 Street,
Langley, BC
V1N 4A5

DATE: March 14, 2025
ACUREN JOB #: 605-J215610
REPORT #: 02
CONTRACT/PO: N/A WO: N/A

ATTENTION: **Dean Schmitke** WORK LOCATION: Kicking Horse Mountain
PROJECT: Kicking Horse Mountain - Golden Eagle Express Gondola Inspection
ITEM(S) EXAMINED: Four (4) gondola lift spools

PART #: Various MATERIAL: Carbon steel THICKNESS: Not provided
SCOPE: Perform a VT and MT of gondola lift spools as directed by Technical Safety BC in accordance with manufacturers procedure and report findings.
TYPES OF INSPECTION: Magnetic Particle; Visual

RESULTS:

Acuren was called by Technical Safety BC to perform a visual (VT) and magnetic particle (MT) examination as a third-party at Kicking Horse Mountain Resort in Golden, BC on March 12, 2025, and March 13, 2025. This request was in response to the Golden Eagle Express Gondola having an incident where one of its arms sustained a critical failure resulting in the gondola arm fracturing and its cabin falling from a height above the ground.

Four (4) gondola arms were pointed out and made accessible to perform a VT and MT as directed by Technical Safety BC. The first gondola (Serial # 026600) arm was inspected in the Kicking Horse Mountain's shop on March 12, 2025. The remaining three (Cabin 21-Arm serial NA, Cabin 22-Arm serial 024400, Cabin 23 Arm serial 026800) were inspected at the base of the gondola in position on March 13, 2025.

All four arms were inspected visually with MT being conducted at a minimum of the accessible areas at each of the two bends, 6" above, and 6" below each bend as referenced in the manufacturer's procedure as accessible.

See Table 1 below for results.

TABLE 1: VT/MT EXAMINATION RESULTS – SUSPECT INDICATIONS

INDICATION #	CABIN#/ARM SERIAL#	INDICATION / CLUSTER LOCATION	APPROXIMATE LENGTH	ACTION TAKEN	RESULTS
1	Cabin # NA Arm Serial # 026600	Inside section, approximately 10 inches above the lower bend	3"	Grinded/buffed out	VT/MT OK
2	Cabin # NA Arm Serial # 026600	Inside section, near top of arm	26" (total cluster)	Grinded/buffed out	VT/MT OK

CLIENT: Dean Schmitke
CLIENT SIGNATURE ACCEPTED & ACKNOWLEDGED BY

DTR NO.: N/A

ACUREN TECHNICIAN: [redacted]

2nd Technician

REVIEWER: Bob Milne, P.Eng.

INDICATION #	CABIN#/ARM SERIAL#	INDICATION / CLUSTER LOCATION	APPROXIMATE LENGTH	ACTION TAKEN	RESULTS
3	Cabin # 21 Arm Serial # NA	Inside section, approximately 3” below start of bottom bend	2”	Grinded/buffed out	VT/MT OK
4	Cabin # 21 Arm Serial # NA	Inside section, approximately 4” below start of bottom bend	4”	Grinded/buffed out	VT/MT OK
5	Cabin # 21 Arm Serial # NA	Outside section, approximately 1” below start of bottom bend	2”	Grinded/buffed out	VT/MT OK
6	Cabin # 23 Arm Serial # 026800	Inside section, approximately 2” below start of bottom bend	4”	Grinded/buffed out	VT/MT OK
7	Cabin # 23 Arm Serial # 026800	Inside section, approximately 4” below start of bottom bend	2”	Grinded/buffed out	VT/MT OK

Limitations:

Three of the four arms were in position; thus, the top and bottom sections were still connected and not accessible for examination (see pictures below).

These three arms were exposed to elements (intermittent snow)

The fourth arm in the shop had the top section with gussets covered for transportation and for the purposes of this examination not required (see pictures below).

Photo 1:

Arm serial # 026600.

General overview.

Photo 2:

Arm serial # 026600.

Indication 1.

Faint linear indications approximately 10 inches above the lower bend area of interest. These indications were removed with gentle grinding of a flapper disc.

Photo 3:

Arm serial # 026600.

Indication 2.

Overview of approximately 26 inches of suspect indications near top of arm overview as seen with wet visible magnetic particle examination before grinding.

See photos 4 and 5.

Photo 4:

Arm serial # 026600.

Indication 2.

Close-up of approximately 26 inches of suspect indications near top of arm overview as seen with wet visible magnetic particle examination before grinding.

Photo 5:

Arm serial # 026600.

Indication 2.

Close-up of approximately 26 inches of suspect indications near top of arm overview as seen with wet visible magnetic particle examination before grinding.

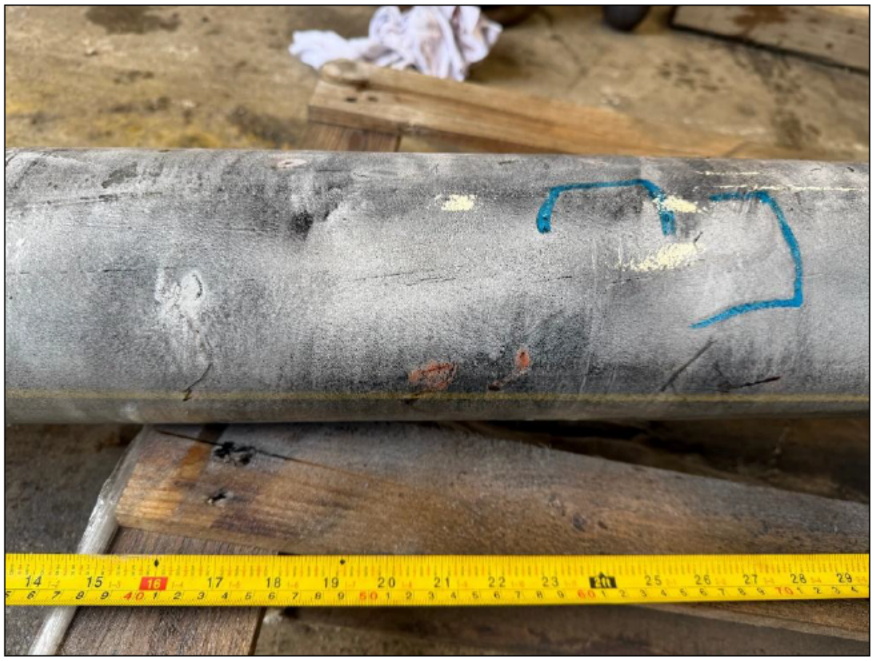

Photo 6:

Arm serial # 026600.

Indication 2.

Overview of approximately 26 inches of suspect indications near top of arm **removed** after light buffing/grinding.

MT performed on suspect areas did not show any more indications.

Photo 7:

Cabin # 21, Arm serial # N/A.

General overview as accessible.

Photo 8:

Cabin # 21, Arm serial # N/A.

Indication 3.

Close-up of suspect areas seen visually prior to MT approximately 3" below start of bottom bend.

Photo 9:

Cabin # 21, Arm serial # N/A.

Indications 3 & 4.

Close-up of suspect areas after MT approximately 3" below start of bottom bend.

The top transverse indication runs approximately 2" axially.

The bottom transverse indication runs approximately 4" axially.

Photo 10:

Cabin # 21, Arm serial # N/A.

Indications 3 & 4.

Close-up of suspect areas after grinding approximately 3" below start of bottom bend.

The top transverse indication runs approximately 2" axially.

The bottom transverse indication runs approximately 4" axially.

Photo 11:

Cabin # 21, Arm serial # N/A.

Indications 3 & 4.

Close-up of suspect areas after grinding, then performing follow-up MT approximately 3" below start of bottom bend.

The top transverse indication runs approximately 2" axially.

The bottom transverse indication runs approximately 4" axially.

Photo 12:

Cabin # 21, Arm serial # N/A.

Indications 5.

Length approximately 2".

Located on the outside of the arm approximately 1" below the start of the lower bend.

Photo 13:

Cabin # 21, Arm serial # N/A.

Indications 5.

After grinding indication out with stone.

Photo 14:

Cabin # 21, Arm serial # N/A.

Indications 5.

After confirming indication was removed with MTOK.

Photo 15:

Cabin # 22, serial # 024400.

Overview photo as accessible.

Photo 16:

Cabin # 22, serial # 024400.

Typical mechanical marks due to U-bolt clamps at two sections.

Photo 17:

Cabin # 22, serial # 024400.

Typical section with galvanized coating removed.

Photo 18:

Cabin # 22, serial # 024400.

MTOK, no relevant indications were found. No buffing/grinding was performed on this arm.

Photo 19:

Cabin # 23, serial # 026800.

Overview photo as accessible.

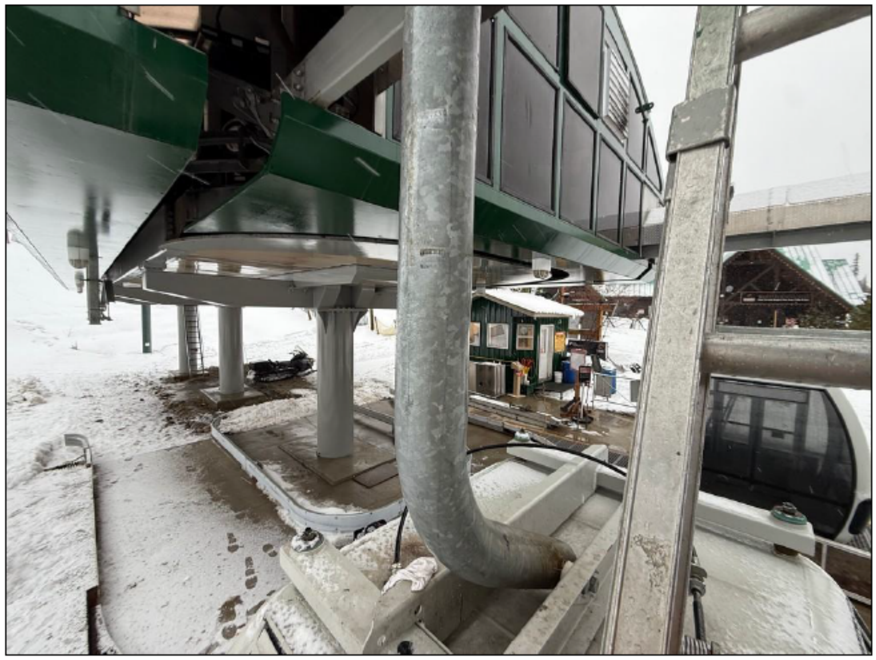

Photo 20:

Cabin # 23, serial # 026800.

Indication 6.

Length approximately 4”

Found on the inside section, approximately 2” below start of bottom bend

Photo 21:

Cabin # 23, serial # 026800.

Indication 6.

Length approximately 4”.

Found on the inside section, approximately 2” below start of bottom bend.

Indication was removed by grinding stone.

The approximate thickness in the area is between 0.400” – 0.420” and the indication and galvanized coating was removed for remaining 0.380”.

Photo 22:

Cabin # 23, serial # 026800.

Indication 7.

Length approximately 2”.

Found on the inside section, approximately 4” below start of bottom bend.

Photo 23:

Cabin # 23, serial # 026800.

Indication 7.

Length approximately 2”.

Found on the inside section, approximately 4” below start of bottom bend.

Indication was removed by grinding stone.

Photo 24:

Cabin # 23, serial # 026800.

Indications 6 & 7.

Both locations were MTOK after grinding the indications out.

TEST DETAILS: MAGNETIC PARTICLE

ACCEPTANCE STANDARD: CSA Z98:19 — REVISION: 2024
PROCEDURE/TECHNIQUE: CAN-MT-14P001 — REVISION: 19

TYPE: Wet Visible	METHOD: Yoke
PARTICLE BRAND: Magnaflux PRODUCT NO.: 7HF	CURRENT: AC MT INSTRUMENT: Parker B-300
PARTICLE COLOUR: Black	MT INSTRUMENT S/N: 3748 CAL DUE: May 08, 2025
SUSPENSION: Oil	LIFT CHECK BEFORE USE: Yes LIFT WEIGHT S/N: P16.807
CONTRAST PAINT: Magnaflux PRODUCT NO.: WCP2	LIGHTING EQUIPMENT: Flashlight
MAG TIME (SECONDS): 5 DEMAG REQUIRED?: Yes	BLACKLIGHT MAKE: N/A S/N: N/A
TECHNIQUE DEMONSTRATED OVER A PAINTED SURFACE?: Yes	LIGHT METER S/N: 11010298 CAL DUE: Sep 22, 2025
	LIGHT INTENSITY: > 100 fc (1076 lx)

BATCH NOS. (WHEN REQUIRED): PARTICLES: SUSPENSION: CONTRAST PAINT:

TEST SURFACE CONDITION: As Coated (Galvanized), as grinded in suspect areas — TEST SURFACE TEMPERATURE: 0°C to 5°C

TEST DETAILS: VISUAL

ACCEPTANCE STANDARD: CSA Z98:19 — REVISION: 2024
PROCEDURE/TECHNIQUE: CAN-VT-14P001 — REVISION: 09

METHOD: Direct

EQUIPMENT TYPE: N/A MANUFACTURER: N/A MODEL: N/A S/N: N/A

LIGHT SOURCE: Natural light — ILLUMINATION INTENSITY: > 100 fc (1076 lx)
LIGHT METER S/N: 11010298 CAL. DUE: Sep 22, 2025

ADDITIONAL EQUIPMENT: N/A — MAGNIFICATION POWER: N/A

SUPPLEMENTAL NDT REPORT ATTACHED?: No — PROCEDURE DEMONSTRATION REQUIRED?: No

TEST SURFACE CONDITION: As Coated (Galvanized), as grinded in suspect areas

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NONDESTRUCTIVE EXAMINATION

CLIENT: TECHNICAL SAFETY BC
2889 E 12th Ave suite 600,
VANCOUVER, BC
V5M 4T5

DATE: March 18, 2025
ACUREN JOB #: 605-J215610
REPORT #: 03
CONTRACT/PO: N/A WO: TBD
WORK LOCATION: Guildford & Pipeline Road, Coquitlam

ATTENTION: **RYAN HAZLETT**
ryan.hazlett@technicalsafetybc.com

PROJECT: Gondola Arm Failure

ITEM(S) EXAMINED: Gondola Arm (16)

PART #: See Below MATERIAL: Carbon steel THICKNESS: Various

SCOPE: As directed by the client, perform dry visible magnetic particle inspection of the requested area.

TYPE OF INSPECTION: Magnetic Particle

RESULT:

As directed by the client, dry visible magnetic particle inspection was performed on Gondola Arm-16 on the selected area. No relevant indications were found, the welds were acceptable at the time of inspection. See the table and photos below.

WELD ID	LENTGH (INCH)	NDE REQUIRED	ITEM(S) EXAMINED	RESULTS
Gondola Arm-016	14	MT	Base Metal	✓

CLIENT: [redacted]
CLIENT SIGNATURE ACCEPTED & ACKNOWLEDGED BY

ACUREN TECHNICIAN: [redacted]
2nd Technician

REVIEWER: Bob Milne, P.Eng

TOTAL HOURS S.T. O.T. SHIFT
1ST TECHNICIAN: See DTR Day ☒
2ND TECHNICIAN: PM ☐
KILOMETRES: OTHER CHARGES: YES ☐ NO ☐
(IF YES, SEE DAILY OR PROJECT TIME REPORT)

Photo 1:

Overview of the Inspected item

Photo 2:

Overview of the MT Inspection area.

Photo 3:

Overview of the MT inspection area.

Photo 4:

Overview of the 8" and 6" length MT area

MT OK

TEST DETAILS:			
ACCEPTANCE STANDARD: Client Information		REVISION: -	
PROCEDURE/TECHNIQUE: CAN-MT-14P001		REVISION: 19	
TYPE: Dry Visible		METHOD: Yoke	
PARTICLE BRAND: Magnaflux	PRODUCT NO.: 8A	CURRENT: AC	MT INSTRUMENT: Parker B-300
PARTICLE COLOUR: Red		MT INSTRUMENT S/N: 8085	CAL DUE: June 19, 2025
SUSPENSION: N/A		LIFT CHECK BEFORE USE: Yes	LIFT WEIGHT S/N: P16089
CONTRAST PAINT: N/A	PRODUCT NO.: N/A	LIGHTING EQUIPMENT: Flashlight	
MAG TIME (SECONDS): >5	DEMAG REQUIRED?: No	BLACKLIGHT MAKE: N/A	S/N: N/A
TECHNIQUE DEMONSTRATED OVER A PAINTED SURFACE?: N/A		LIGHT METER S/N: 11010074	CAL DUE: May 15, 2025
		LIGHT INTENSITY: > 100 fc (1076 lx)	
BATCH NOS. (WHEN REQUIRED): PARTICLES: -		SUSPENSION: -	CONTRAST PAINT: -
TEST SURFACE CONDITION: Base Material		TEST SURFACE TEMPERATURE: 10°C to 15°C	