Investigation of wireline failure

Reference: Dimension Bid – CWR-1280

For

Danum Well Services Ltd

Testing and reporting by:

S. Lee
Metallurgist

Signed for and on behalf of
Doncaster Analytical Services Ltd

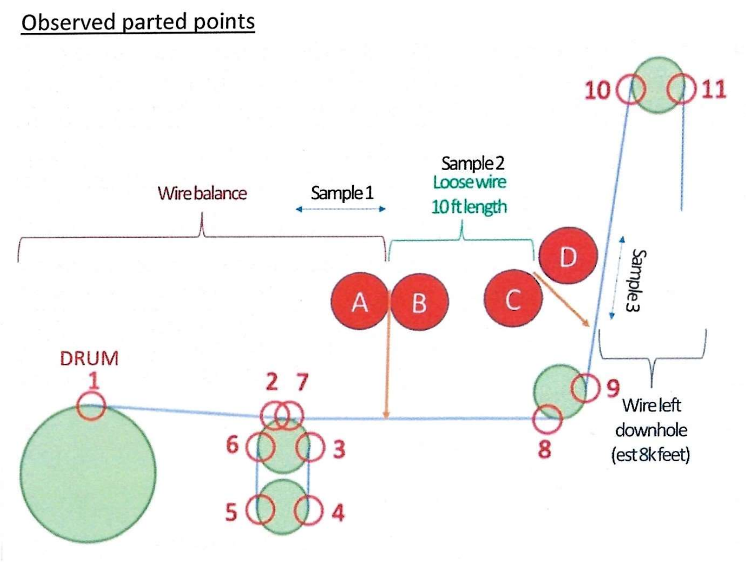
1.0 Introduction

The Laboratory was commissioned by Danum Well Services to assess wireline break that occurred during operational use by Dimension Bid.

The following was reported:

Well : LARUT A-27L

"Crew offshore (night shift) reported that during WOL, while tension to firing spring jar @ 2641m-RKB, wire parted in between counter wheel assembly and hay pulley (2 parted points A-B and C-D)." Below image provided by customer.



1. A,B,C,D, are based on images of fractured end of parted wire.
2. Wire parted at 2 points; A-B and C-D.
3. Parted point A-B is between mp16 (7) and Hay Pulley (8)
4. Parted point C-D is between Hay Pulley (9) and Stuffing box (10).

2.0 Sample provided

Three samples were provided for the investigation and identified as CWR-1280, a 6Mo super-austenitic stainless steel used extensively around the globe in challenging conditions.

Sample A: end of wire parted @ MP16
Sample B-C:
Sample D: end parted from well

A copy of the test certificate is presented in Appendix 1.

3.0 Scope of work

The following was performed on the samples provided:

- Visual inspection of the fractures at Locations A, B, C and D.
- High resolution SEM images to confirm the mode of failure
- EDS analysis for material verification and possible corrosion or contamination
- Wrap ductility testing
- Breaking load/Pull testing
- Metallurgical assessment

4.0 Results

4.1 Visual inspection

- Sample A is the sample that parted at MP16, the wire forms a coil and is only bend close to the fracture, Figure 1.
- Sample B-C has undergone kinking and loss of circular cast, typical for wire jumping out of the sheave/pulleys, Figure 2.
- Sample D kinked and damaged opposite to location C, Figure 3.

All the fracture ends were cut and then ultrasonically cleaned in petroleum spirit to remove general contamination and debris followed by inspection using a low magnification stereomicroscope. Images were taken of each fracture at 90 degrees to show the general mode of failure and key locations of interest.

Location A, the wire has locally necked down, indicating a good level of ductility, and then parted in a semi-shear nature, Figure 4. Associated with the fracture is an indentation mark, possibly from cross cutting or lapping with the line itself at MP16.

On the opposite side, Location B, there is more post failure mechanical damage due to the wire being free to contact the deck floor and ancillary equipment, Figure 5. Even though Location B was damaged, the Laboratory was still able to match the two ends to confirm that A-B parted via tensile overload with localised necking down, Figure 6.

Locations C-D were matched and appear to be shear in nature with no necking down, Figure 7. Higher magnification images of the top of the fracture found an indentation than spanned both sides of the fracture, Figure 8. The bottom image provided further confirmation that the fractures were a pair with the continuation of a chatter mark from the D side of the break to C.

Higher magnification images of the fractures at Location C and D are presented in Figures 9 and 10. The shear nature of the break is clearly evident on both sides.

4.2 SEM imaging of fractures A and C

At Location A, it is evident that even though the region had necked down, due to high applied load, the final shear fracture was initiated by the indentation on the side of the wire, Figure 11.

A comparison of the typical wire surface and indented surface is presented in Figure 12. On the indented surface the grain boundaries are still present but flattened. EDS analysis of the wire surface confirmed the line to be manufactured from SUPA75, a corrosion resistant super austenitic stainless steel used in medium to sour well conditions around the globe, Figure 13. EDS analysis of the indentation again found it to be SUPA75, no other foreign material was present, Figure 14. It can therefore be concluded that the indentation was formed by cross cutting with the line itself.

Norm. mass percent (%)

Spectrum	Al	Si	Cr	Mn	Fe	Ni	Cu	Mo
CWR-1280	0.11	0.37	20.59	0.64	46.78	24.22	0.75	6.54
CWR-1280 indent	0.09	0.47	20.49	0.57	46.42	24.30	0.78	6.86

At Location C, analysis of the fracture face confirmed the shear nature of the fracture initiated from the top, Figure 15.

4.3 Wrap ductility testing

For reference the original test wrap performed by the Laboratory during initial certification is presented in Figure 16. The sample revealed a typical surface without cracks or ruptures present.

Wrap ductility testing was performed adjacent to the fractures at Locations A, B and C, Figure 17. Higher magnification images of the test pieces are presented in Figure 18. All passed without cracks or ruptures present.

4.4 Breaking load evaluation

Pull tests were performed on the line adjacent to the fractures at Locations A, B and C, Figure 19

The diameter was measured using a set of Mitutoyo digital hand micrometer and found Samples A and B to be considerably undersize compared to the standard 0.125” +/-0.001” from the mill.

Sample A: 0.1225” Sample B: 0.1216” Sample C: 0.1235”

The knock on effect of the reduction in diameter is the loss of breaking load, for reference the test certificate 2103-067 achieved 2,950 lbf.

Sample A: 2,799 lbf Sample B: 2,763 lbf Sample C: 2,915 lbf

Photographs of the test pieces are presented in Figure 20, the fractures are similar to that found at location A-B with localised necking down before parting. Without further samples from the drum, the loss in diameter and breaking load is most likely due to the line being trapped and stretched down resulting from the failure.

4.5 Metallurgical assessment

Fractures at Locations A and C were metallurgically prepared using standard techniques and to reveal the structure the samples were electrolytically etched in oxalic acid.

The fracture at Location A is presented in Figure 21. The region at the fracture has necked down causing the elongated grains to converge towards the middle from both sides. Final failure is semi-shear in nature.

In contrast, Location C, Figure 22, there is no necking down at the fracture just a slight bend and shear failure cutting across the elongated grains.

5.0 Discussion/Conclusions

The line was confirmed to be SUPA 75 and super austenitic stainless steel used in medium to sour wells around the globe.

Wrap ductility was acceptable without anu ruptures or cracks.

There is a reduction in diameter and subsequent breaking load at Locations A and B with less reduction at Location C. This is most likely due to the stretching of the line associated with the failure or repeated heavy jarring.

The fractures marked as Locations A and B were successfully matched and analysis confirmed that with the localised necking down, final failure occurred via tensile overload. However, a contributing factor is the indentation at the side of the line resulting from either cross cutting typically on the drum when loose wraps were present or trapped in a sheave if the line has jumped. The indentation becomes a stress raiser which can effectively reduce the applied load to failure.

The fracture at C and D is the result of contact damage causing the line to shear. This may have been the result of the line jumping out of the sheave which then came into contact with a deflection point.

It is not clear which break occurred first; corrosion was not a factor in the failures.

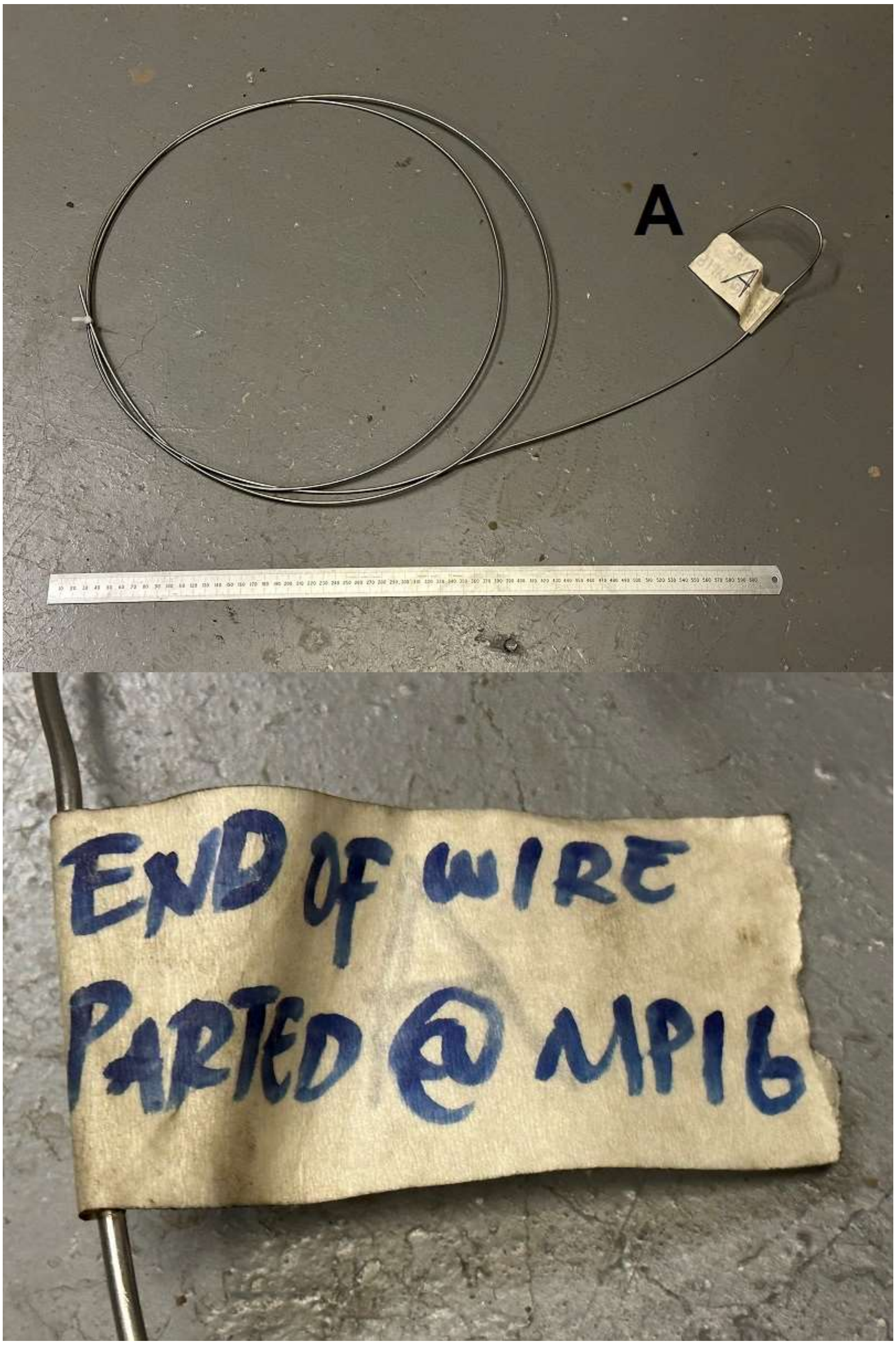


Figure 1, As received Sample A

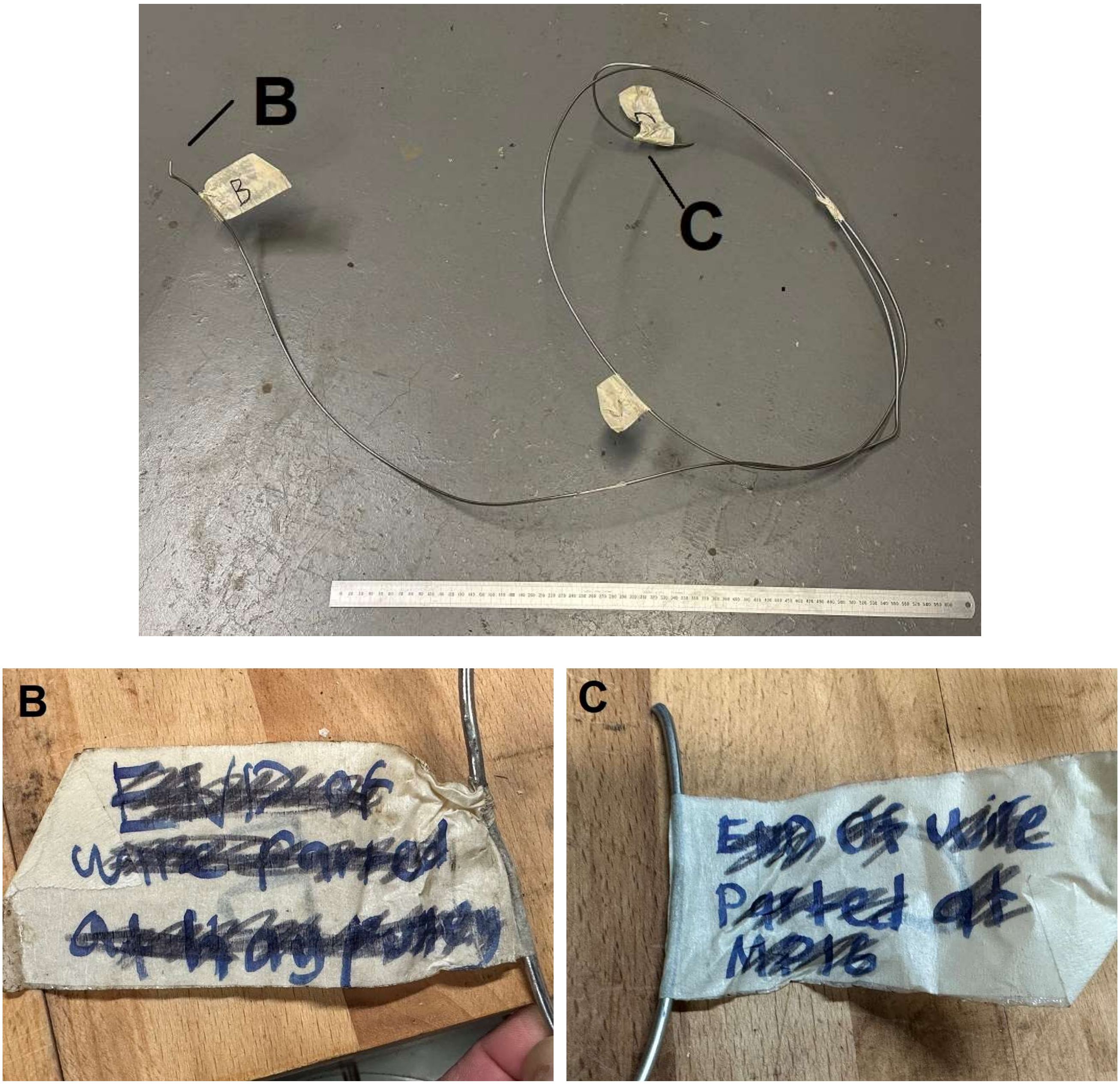


Figure 2, As received Sample B-C

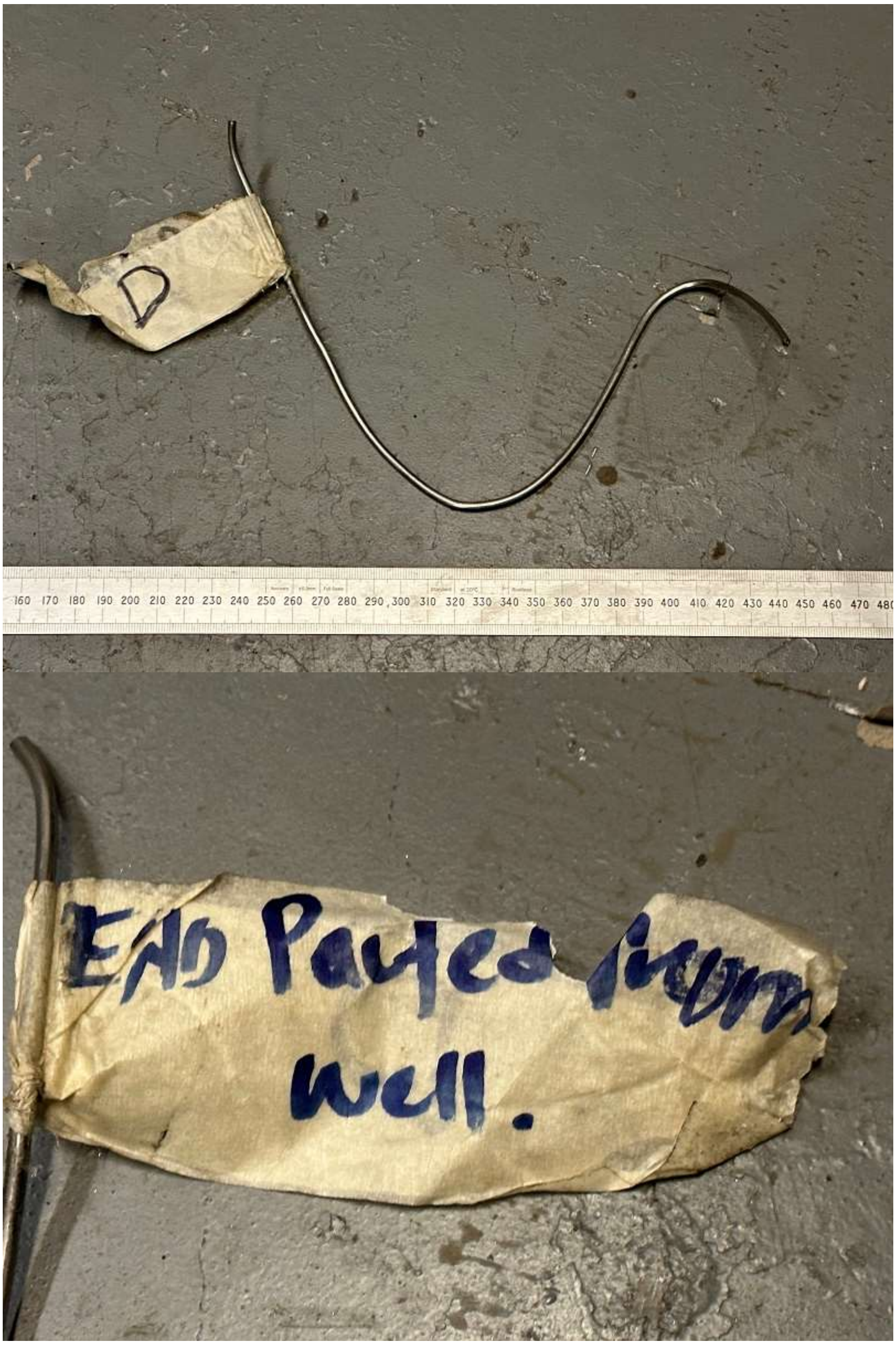


Figure 3, As received sample D

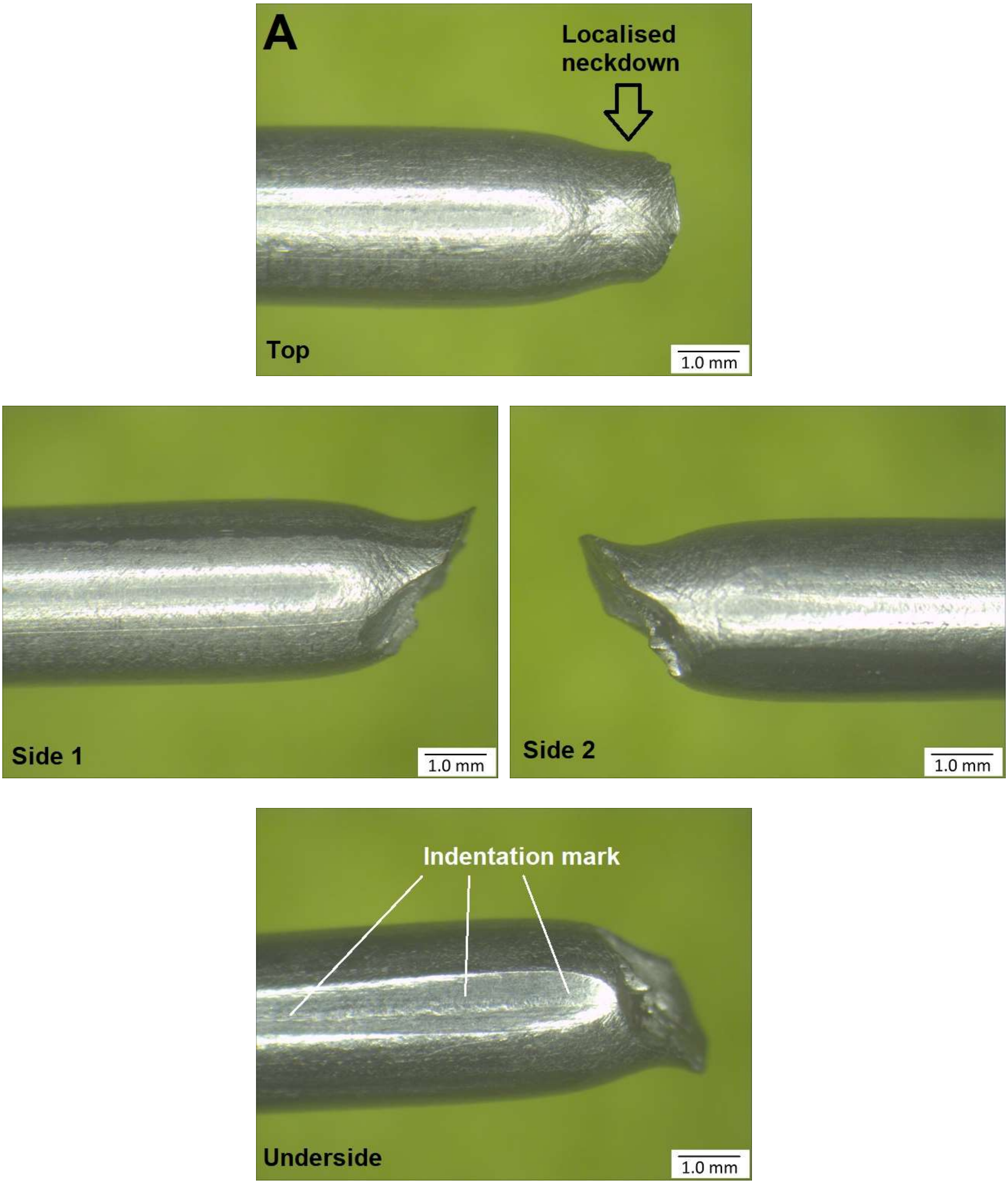


Figure 4, Images taken of the fracture at Location A

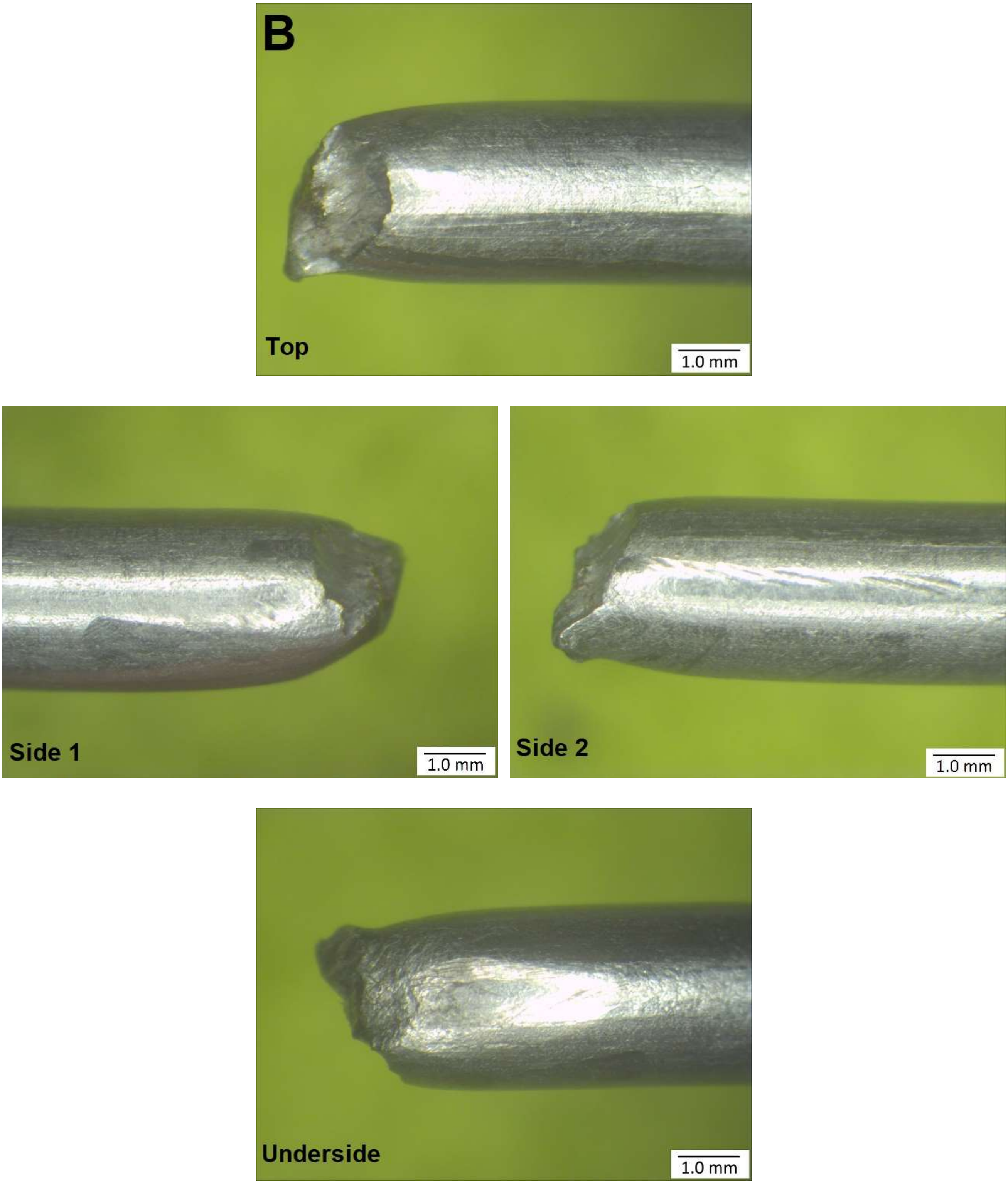


Figure 5, Images taken of the fracture at Location B

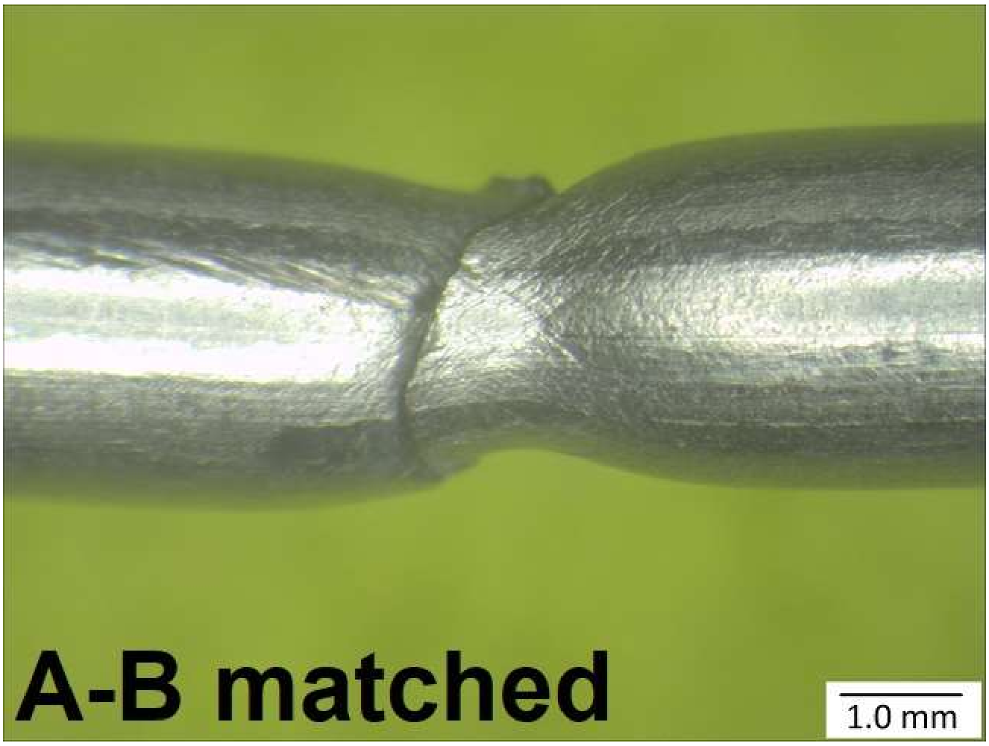


Figure 6, Locations A and B matched, neck down tensile overload

Figure 7, Locations C and D seems to have sheared

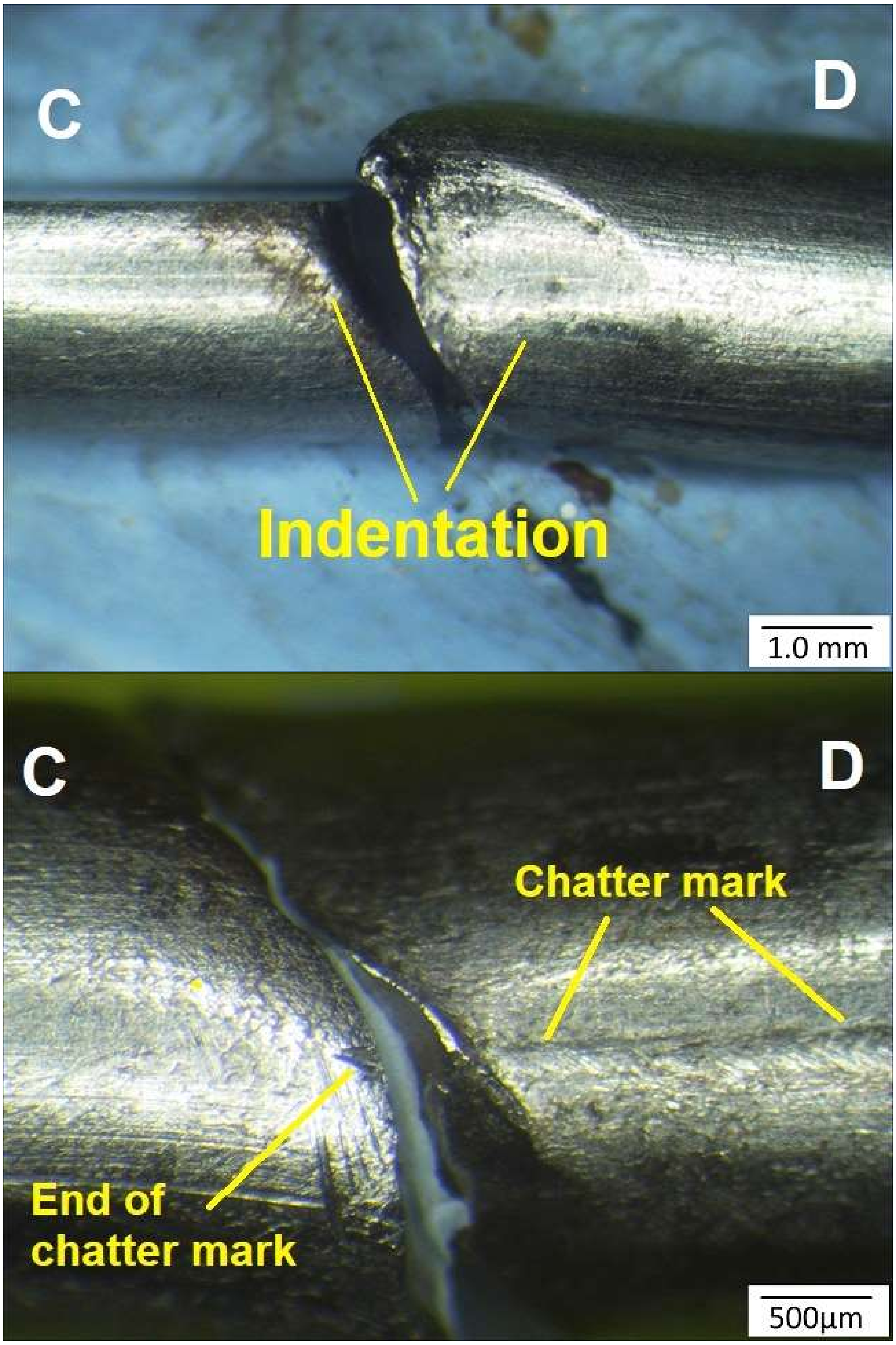


Figure 8, higher magnification images of the C-D fracture confirmed the shear break is concentrated from a surface indentation, further confirmation of the match is the chatter mark

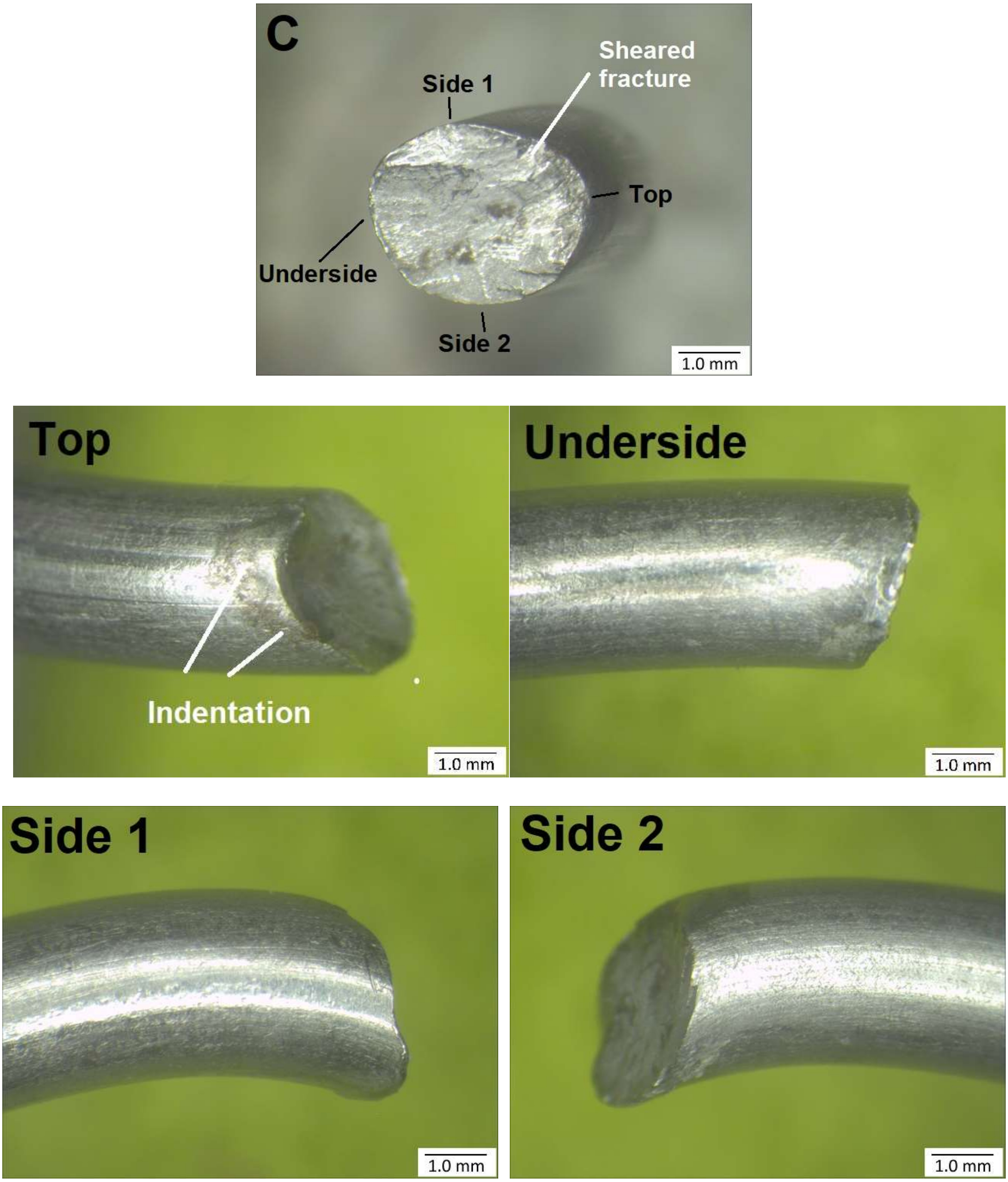


Figure 9, fracture has initiation from the top side and parted resulting from shearing action towards the underside

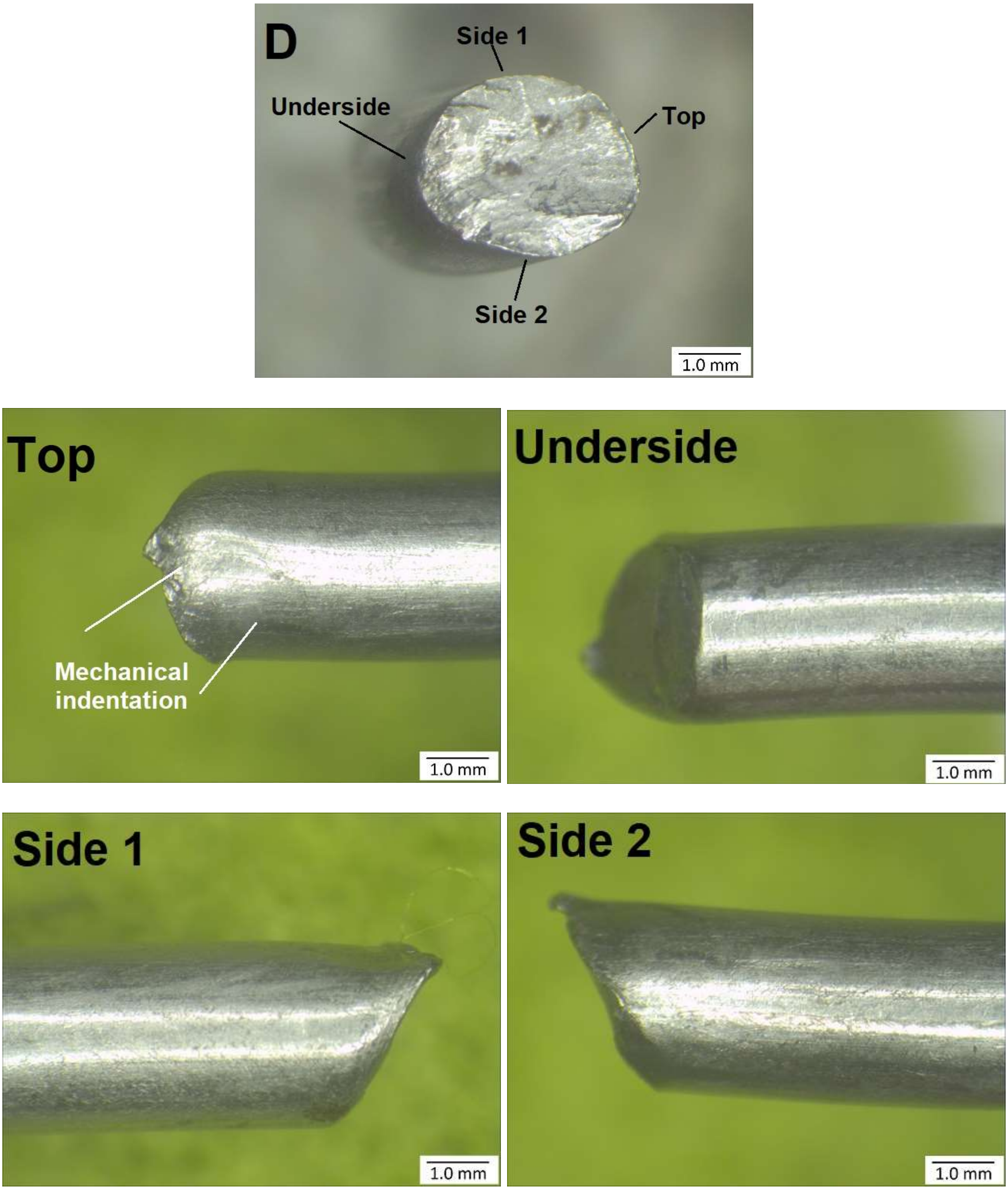
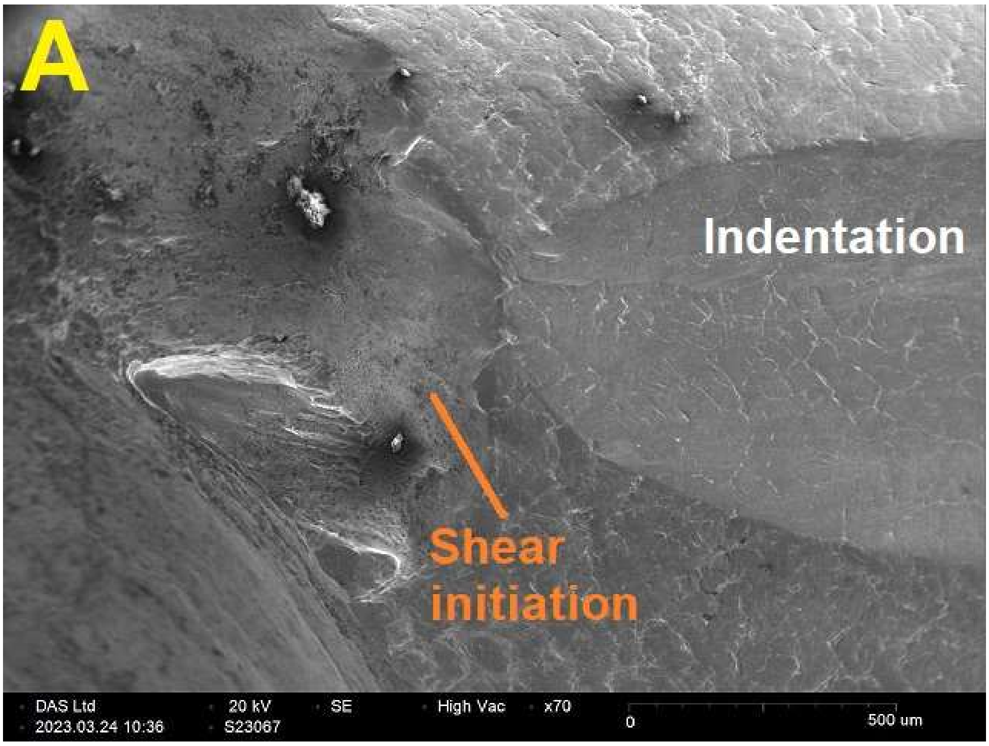


Figure 10, fracture has initiation from the top side and parted resulting from shearing action towards the underside



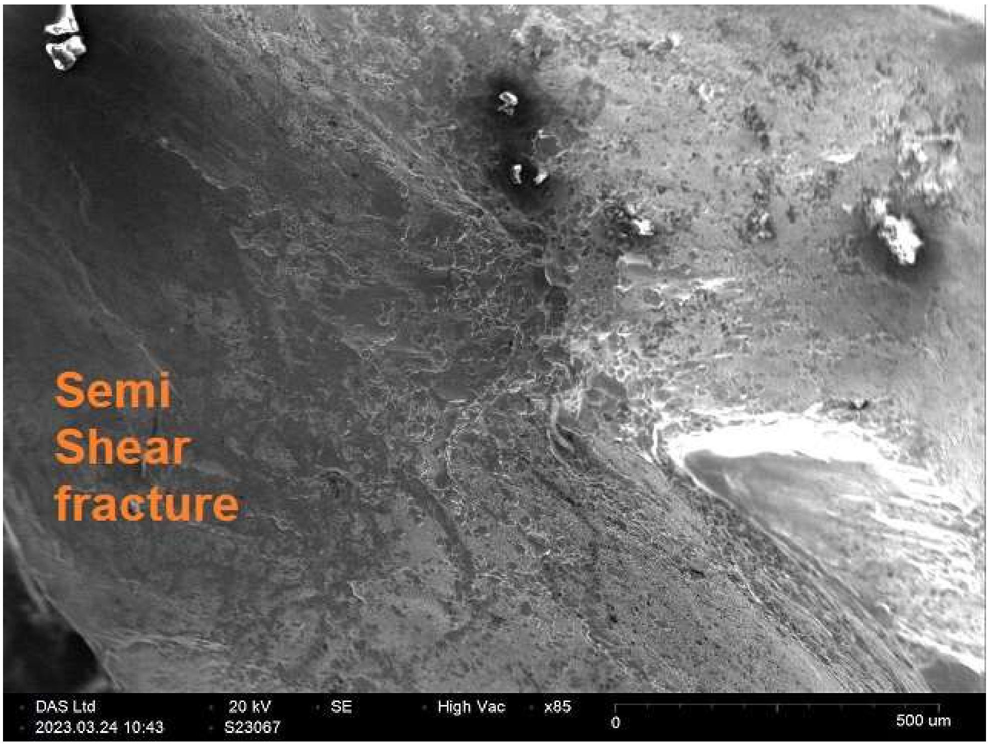
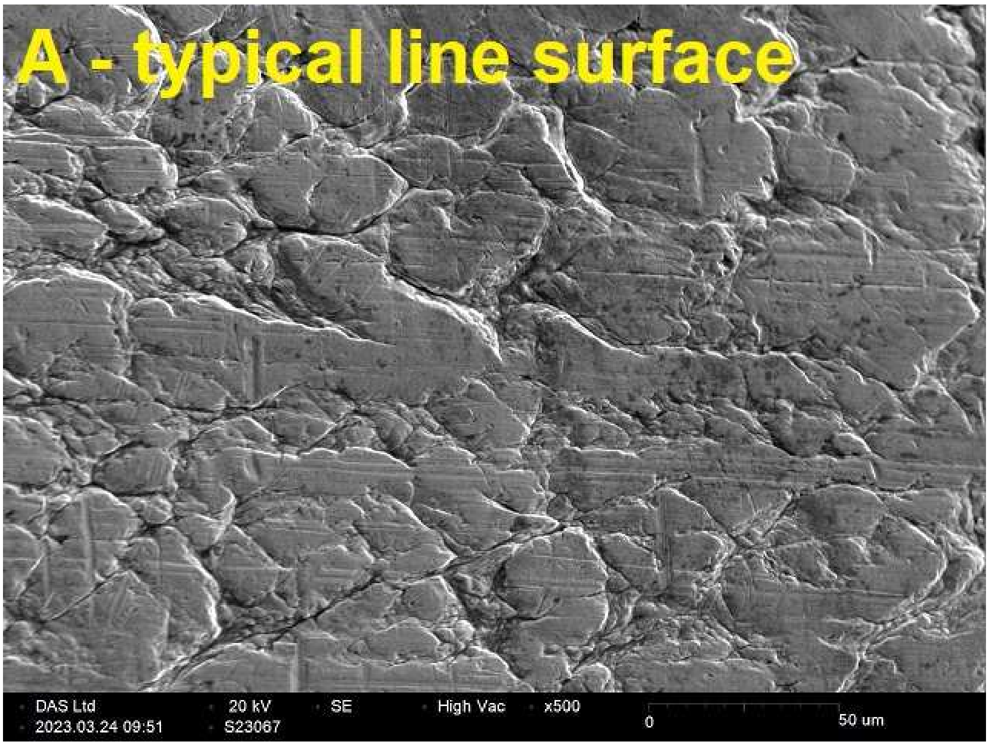


Figure 11, although the fracture region has necked down, the final fracture is shear in nature due to the applied stress from the indentation.



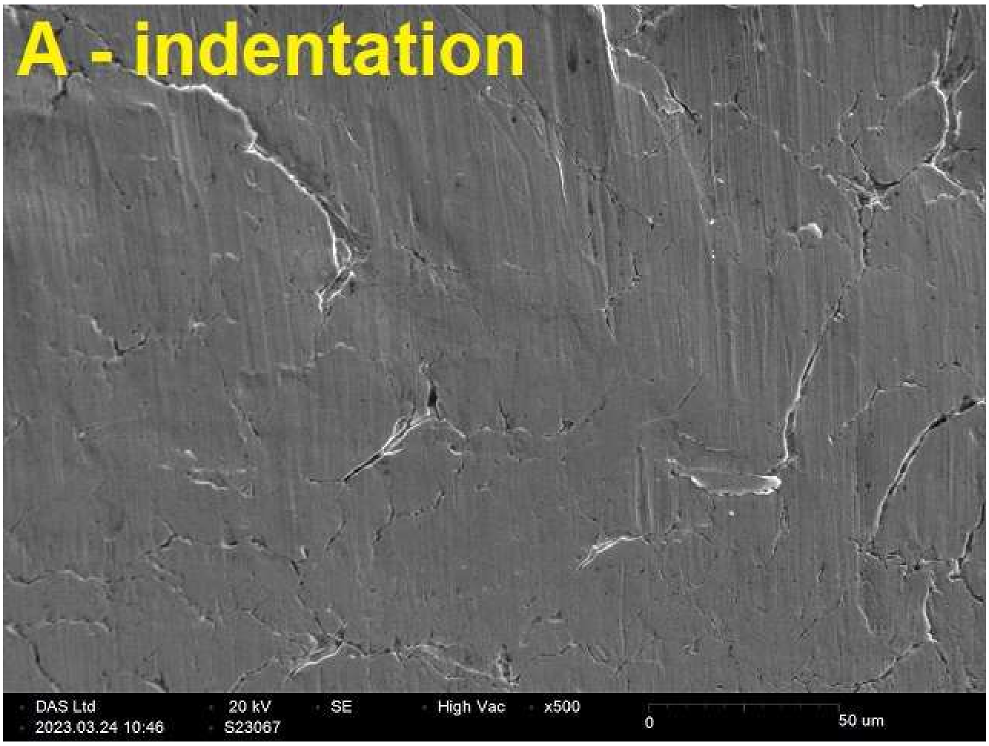
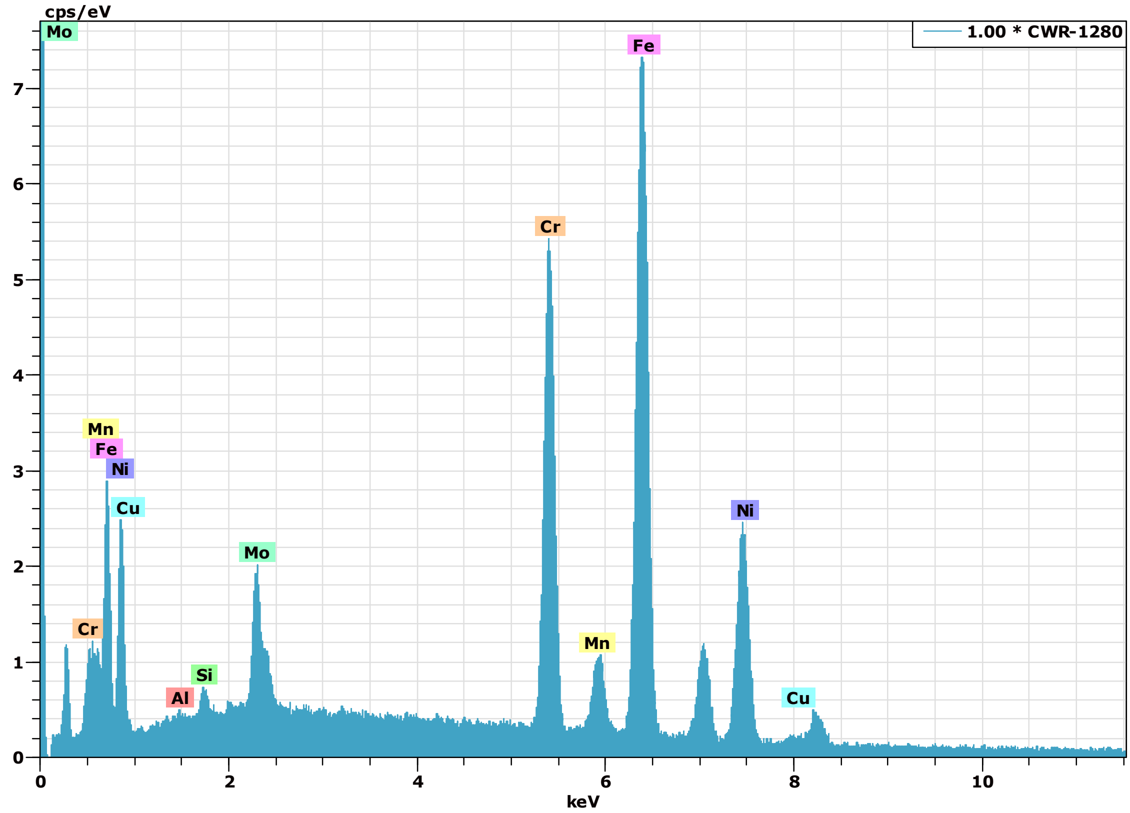
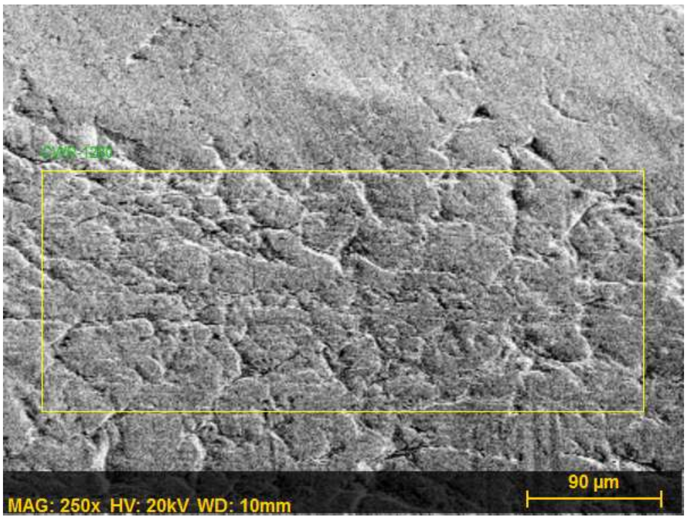


Figure 12, comparison of the typical wire surface showing elongated grains and the smooth indented surface

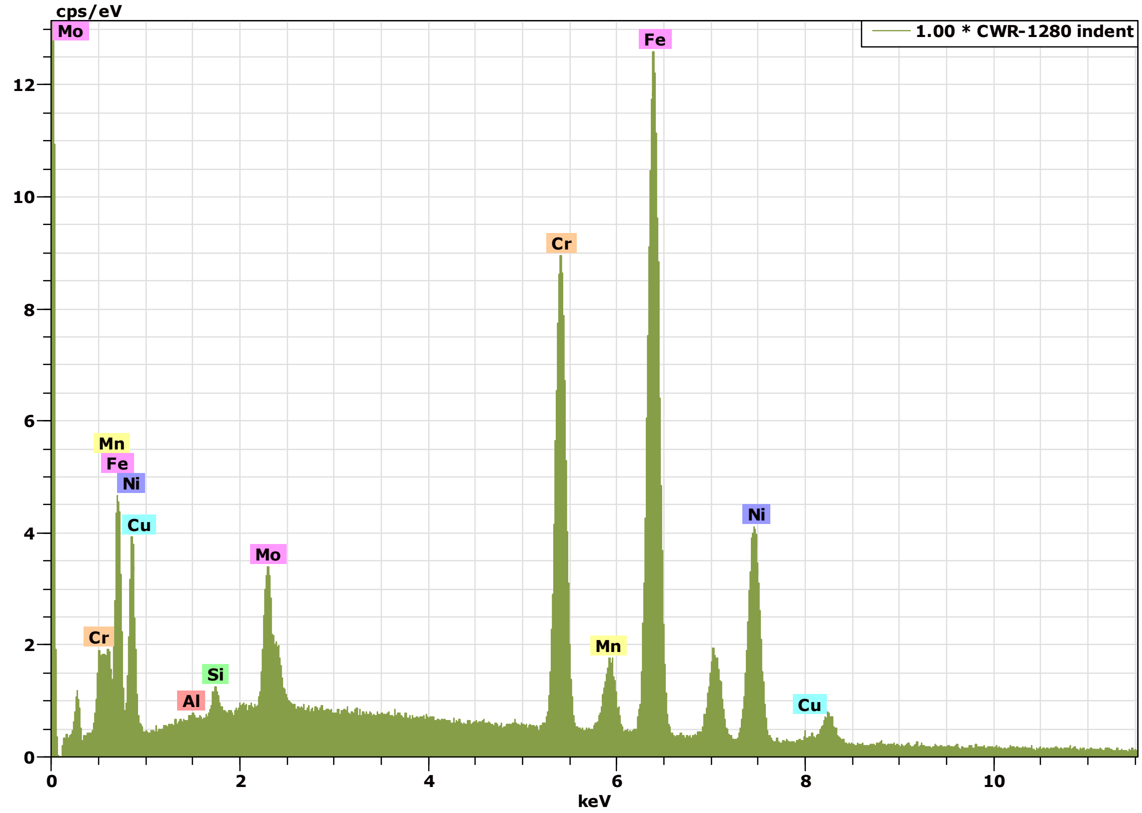


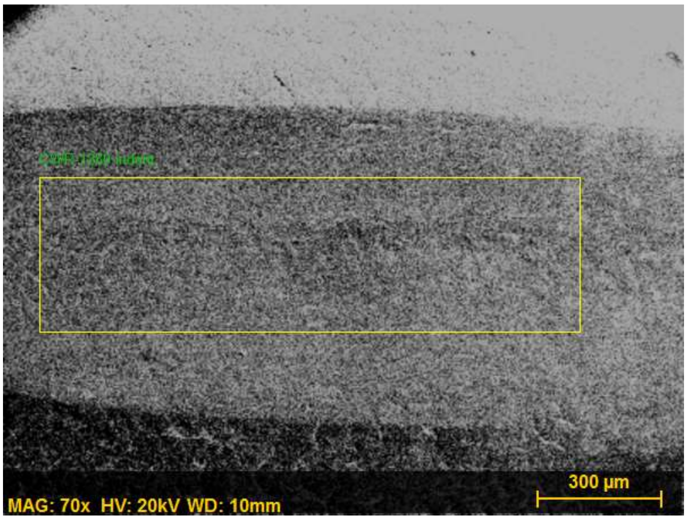


Spectrum: CWR-1280

Element	Series	norm. C [wt.%]
Aluminium	K-series	0.11
Silicon	K-series	0.37
Nickel	K-series	24.22
Copper	K-series	0.75
Iron	K-series	46.78
Manganese	K-series	0.64
Chromium	K-series	20.59
Molybdenum	L-series	6.54
Total:		100.00

Figure 13, EDS analysis of the line surface confirmed the material to be GD31Mo





Spectrum: CWR-1280 indent

Element	Series	norm. C [wt.%]
Aluminium	K-series	0.09
Silicon	K-series	0.47
Nickel	K-series	24.30
Copper	K-series	0.78
Iron	K-series	46.42
Manganese	K-series	0.57
Chromium	K-series	20.49
Molybdenum	L-series	6.86

Total: 100.00

Figure 14, EDS analysis of the indentation did not find foreign material present, just the original wire surface

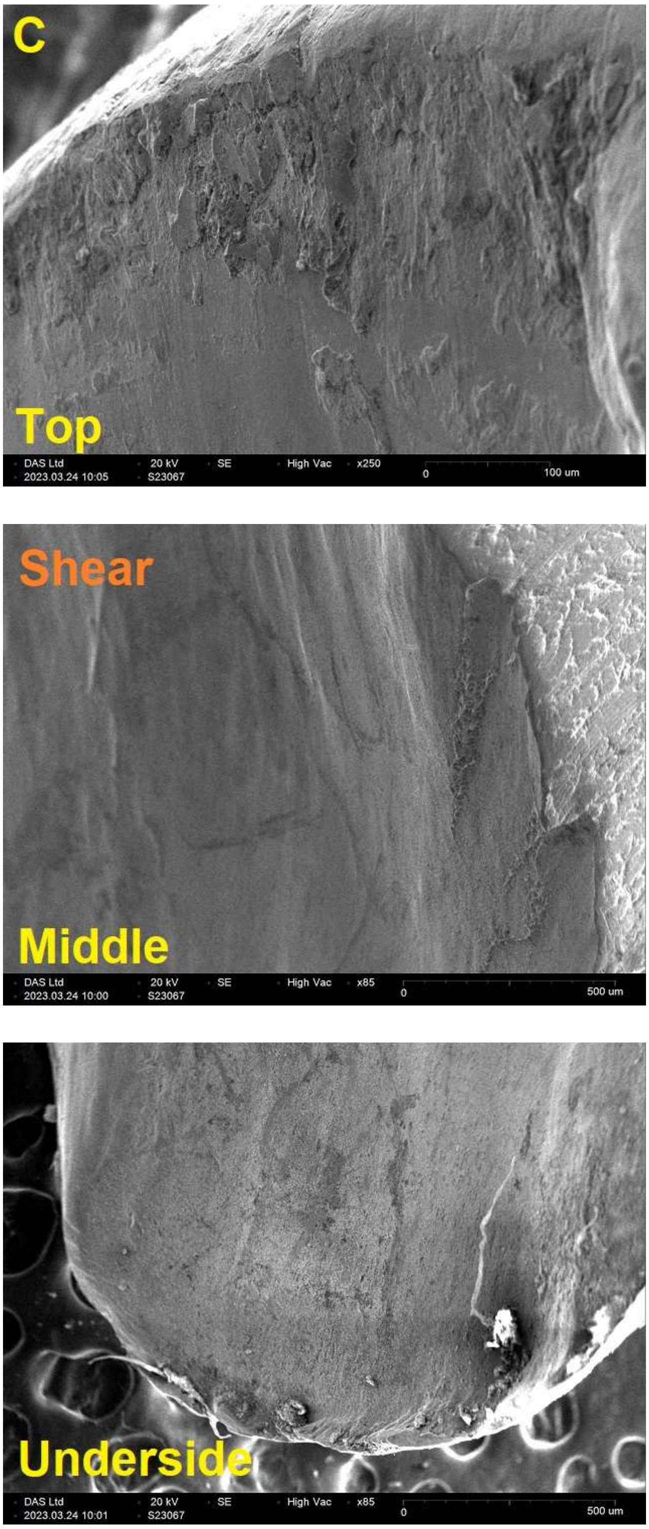


Figure 15, high resolution SEM images of the fracture face taken at Location C, the line parted in shear

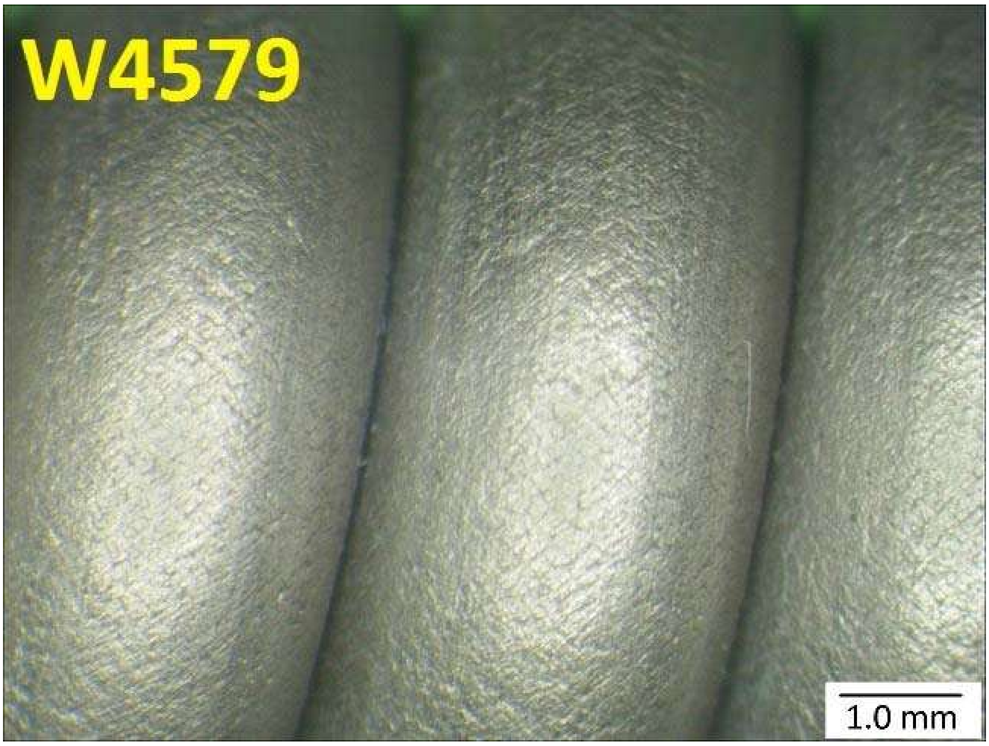


Figure 16, archived wrap sample of CWR-1280

Figure 17, wrap test samples performed at Locations A, B and C

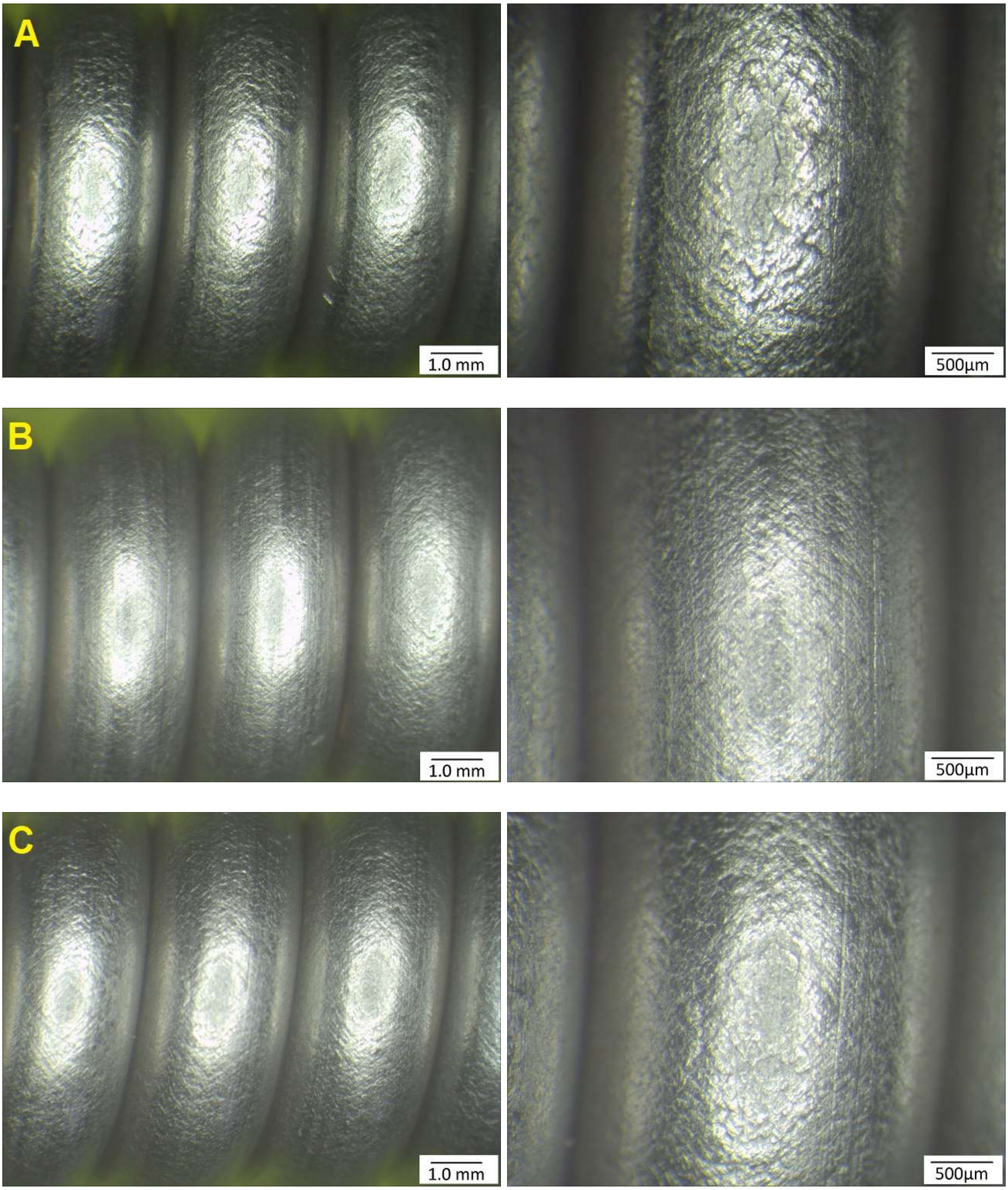


Figure 18, macro images of the wrap test samples, all passed without cracking or rupturing.

Doncaster Analytical Scotland Ltd 20.03.23

Parameter table:

Customer	:	DWS
Job no.	:	S23067
Test standard	:	ANSI/API 9A, ISO 10425:2003, ASTM A370
Tester	:	SL

Results table:

No.	REEL No.	Diameter in	0.2% P.S. psi	UTS psi	Max Load lbf
1	CWR-1280 Sample A	0.1225	237000	237661	2799
2	CWR-1280 Sample B	0.1218	235000	237332	2763
3	CWR-1280 Sample C	0.1235	240000	243346	2915

No.	Elongation %	Wrap Test
1	4.0	PASS
2	4.4	PASS
3	4.5	PASS

Curve graph:

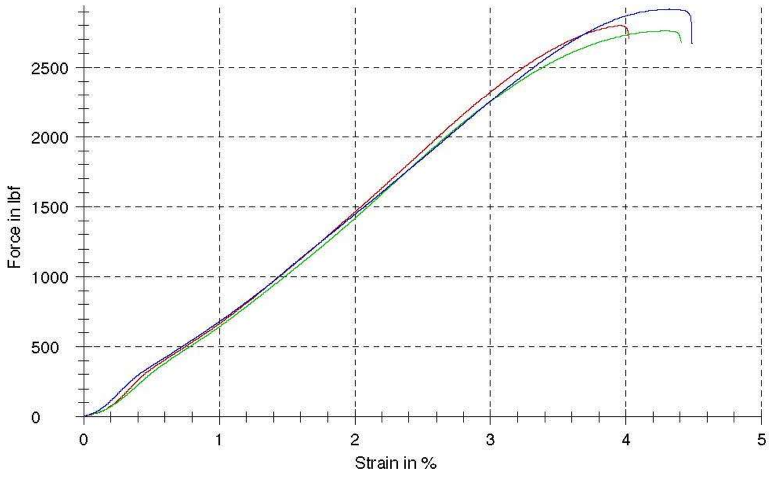


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Figure 19, breaking load evaluation of the as received sample locations

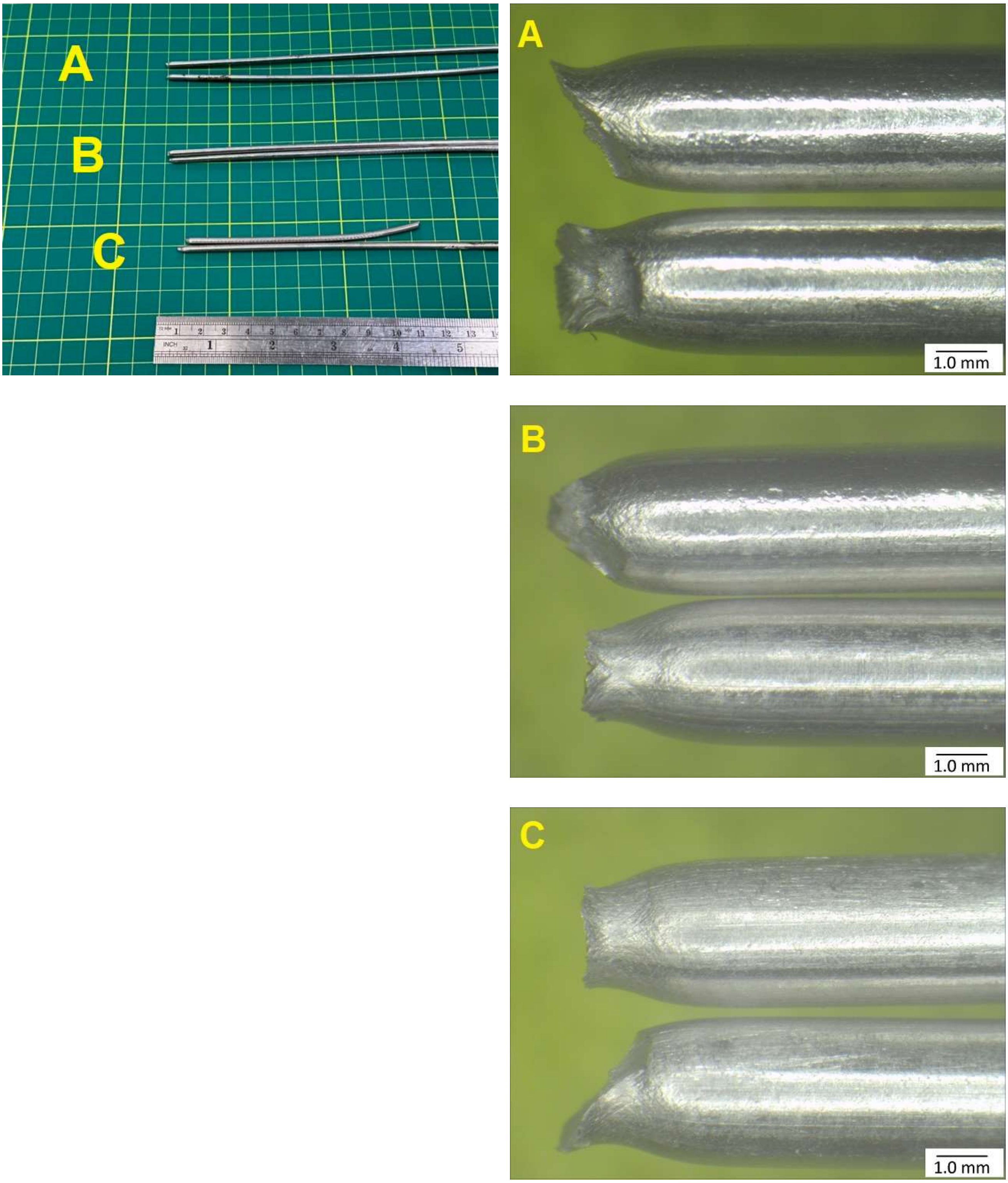

Figure 20, breaking load test pieces all revealed typical ductility with localised necking down

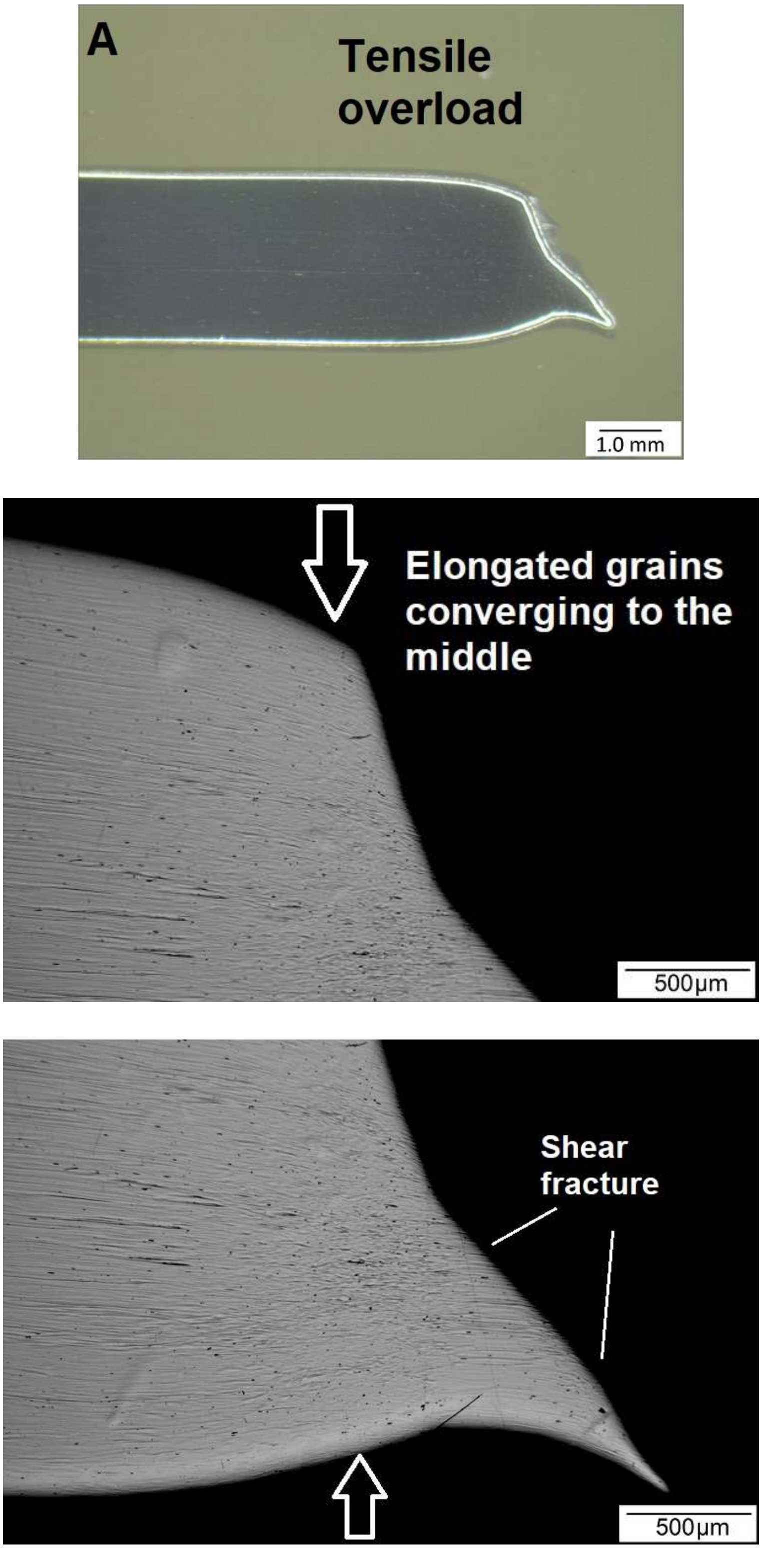

Figure 21, metallurgical section of fracture at Location A, elongated grains converging towards the centre due to necking down and final failure via shear

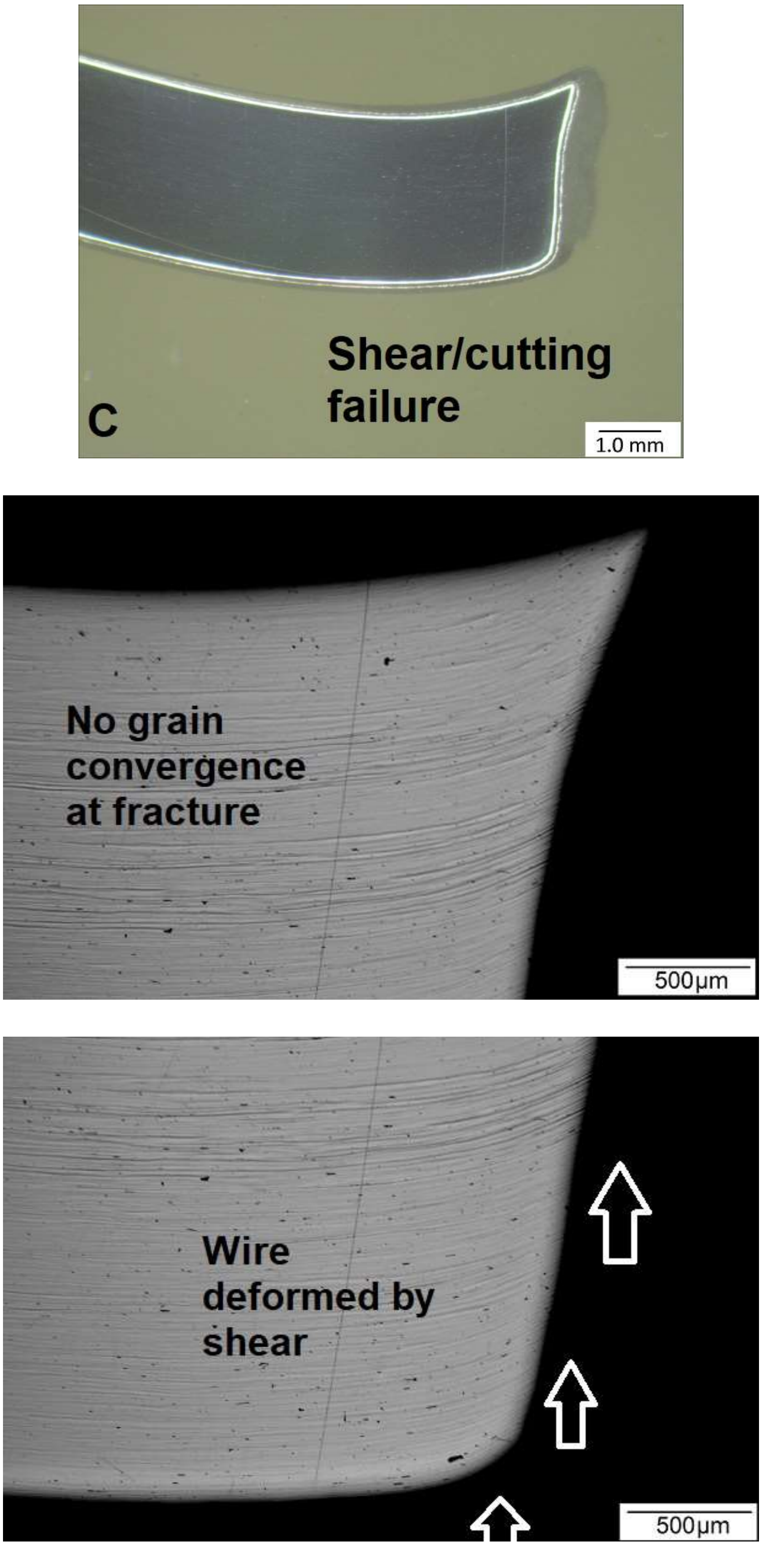

Figure 22, metallurgical section through fracture C, no converging of grains towards the middle, wire slightly bent in the shearing direction

Appendix 1

DONCASTER ANALYTICAL SERVICES LTD

INSPECTION CERTIFICATE 3.2

EN 10204: 2004

Certificate Number: **2103-067**

CUSTOMER: **Danum Well Services Ltd.**
Unit 12,
Bullrush Business Park
Bullrush Grove,
Doncaster,
DN4 8SL

PO No.: **DWS 2110**

DAS No.: **20308**

MANUFACTURER TEST CERT:
5305

PRODUCT:
0.125" diameter SUPA75 Measuring Line - 25,000ft

SPECIFICATION:
DWS/SUPA/05/15

Reel Number: **CWR-1280**

Manufacturer's Chemical Analysis (wt.%)

Heat / Cast No.	C	Si	Mn	P	S
433793	**0.013**	**0.480**	**0.870**	**0.024**	**0.001**
	Cr	Mo	Ni	Cu	N2
	20.100	**6.080**	**24.850**	**0.890**	**0.150**

Manufacturer's Results:

Diameter (inches)	U.T.S. (psi)	Breaking Load (lbf)	WRAPS
0.1250	**240,713**	**2,954**	**Pass**

D.A.S. Ltd. Results:

Diameter (inches)	U.T.S. (psi)	Breaking Load (lbf)	WRAPS
0.1250	**240,387**	**2,950**	**Pass**

We hereby certify that the material described above has been tested and complies with the terms of the order contract/specification.

M. Howells

S. Lee

24th Mar '21
Date

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Doncaster, South Yorkshire
DN4 8SL

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Company Registration: SC705392