



## THOR MOTOR COACH TEST SUMMARY

**DATE:** 5/9/2022  
**BY:** GLS  
**PROJECT:** TAE22-0029 Hitch Review

### SCOPE:

Scope of this report is to verify steel properties in fabrication of a failed hitch from a Outlaw motorhome. Fracture analysis was also performed to determine mode of failure.

### SUMMARY OF RESULTS

Review of Lab Report 7190 from QA Metallurgical Services reveal that the steel used to fabricate the hitch in question was ASTM A1011, Grade S Type B steel as specified on the LCI prints. Breakage of the end plates originated in bending fatigue in the formed corner which was caused by side to side motion. In addition the report states that breakage is attributed to overloading.

At the time of the incident the vehicle being flat towed was a 2017 Chevy Equinox and is rated as a good vehicle to tow. During an on ramp entrance the hitch broke from it's steel flanges and separated from the motor home. Flat towing a Chevy Equinox does not constitute a "overload". Over time this bending fatigue has weakened the hitch till this final failure occurred.

This lateral loading on the hitch is created by turning and in some cases a flat towed vehicle can have a wobble in it. Another means of getting a wobble in the towed vehicle is not using a level tow bar. In such cases when the motorhome accelerates weight can be removed from the towed vehicle front end not allowing the front tires to self align.

### Recommendation

A hitch fail such as this should not occur. The hitch needs to be strengthened in this lateral direction to prevent this failure. Cyclic testing may also need to be addressed in this hitch design. The SAE standard for this hitch is SAE J684 it does not require cyclic testing but SAE J2638 for 5th wheel and gooseneck hitches does. Guidance for cyclic testing could be taken from this latter SAE standard and applied to this design.

TAE 22-0029  
OL Hitch  
Chemical Report  
2020 OL 38MB  
Chevy Equinox  
#11 (3)

# Quality Associates – Metallurgical Services

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QA Lab Report No. 7190

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**TO:** Gary Stilwell  
Thor Motor Coach  
701 C.R. 15  
Elkhart, IN 46516

26 April 2022

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**SUBJECT:** Hitch  
Part Number: Not Provided  
Specification: ASTM A1011, Grade CS Type B  
Supplier: Lippert Components

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**OBJECT:** Determine the mode of breakage. Determine if the base material complies with product specifications and if there was a metallurgical cause for breakage.

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**RECEIVED:** One broken hitch was submitted for analysis. No information was provided with respect to the circumstances surrounding its breakage.

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**CONCLUSION:** Breakage of the end plates originated in bending fatigue caused by side to side loading. Primary fracture origins coincided with the inside bend radii, in an area close to the rear mounting holes. Additional bending fatigue fracture origins were found near the front mounting holes. No material flaws or defects were found in association with the fracture origins.

The plates were made from two different melt batches of steel. Both complied with the compositional requirements for CS Type B. They exhibited strength, ductility and hardness at or above the typical levels for this steel.

No metallurgical cause for breakage was found. Breakage is attributed to overloading.

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**TEST DATA:** Visual Examination

Both end plates broke along the bend radius adjacent to the mounting face (Figure 1). The left plate remained essentially straight (Figure 2), but the right was bent inward on the front (Figure 3) as if the hitch had been pushed forward after the left broke.

The safety decal (Figure 4) identified the hitch as a Class IV per SAE J684 5 4 35893 made by LCI. It specified a maximum gross trailer weight of 8000 pounds and a maximum gross tongue weight of 500 pounds. A paper sticker on the right end bore the identification "360231" and "#2014-1175 03/11/19"

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**TEST DATA:** (Continued)

Fracture features included beach marks that show crack propagation in fatigue and ratchet marks indicating multiple fatigue origins. Primary cracks formed in bending fatigue off the inside radii of the end plates. These origins were towards the rear, just past the rear mounting hole on both the left and right. Fracture origins were also found on the front, especially on the left, also off the inside radius of the end plate (Figures 5 to 8). No material flaws or defects were found in association with the origins.

Metallographic Examination per ASTM Methods

Longitudinal and transverse cross sections were cut from the mounting faces of both end plates (Figures 9 and 10). Microstructures consisted of fine grains of ferrite with scattered pearlite islands and carbide particles (Figures 11 to 14). This microstructure reveals the plates were made from low carbon steels. No objectionable features were detected.

Cleanliness of both plates, based on the size and distribution of the nonmetallic inclusions, was good.

Hardness per ASTM E10

Surface hardness of the left plate was 143 HBW; the right plate was 116 HBW (Table I). While there is no specified hardness for this steel grade, the typical maximum hardness is 75 HRB, which is equivalent to 137 HBW maximum.

Mechanical Properties of ASTM E8

Sheet metal specimens were cut from the end plates to determine the mechanical properties. Test results (Table II) show these parts were made from steels that exhibit acceptable strength and ductility.

Chemical Analysis per ASTM E415

Compositions (Table III) complied with the requirements for CS Type B. These results also show the plates came from two different melt batches of steel. No objectionable features of the compositions were found.



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**ATTACHMENTS:** Figures 1 to 14  
Tables I to III

Table I. Hardness, HBW (Brinell)		
Left	Right	Nonmandatory
143	116	137 Max.

Table II. Mechanical Properties			
Characteristic	Left	Right	Typical (Nonmandatory)
Cross Section, Inches	0.239 x 0.503	0.126 x 0.503	--
Gauge Length, Inches	2.00	2.00	--
Yield (0.2% Offset) Strength, ksi	53.5	43.1	30-50
Ultimate Tensile Strength, ksi	67.5	57.0	--
Elongation, percent	30	36	25 Min.

Table III. Composition, Weight Percent			
Element	Left	Right	CS Type B
Carbon (C)	0.12	0.08	0.02-0.15
Manganese (Mn)	0.37	0.49	0.60 Max.
Phosphorus (P)	0.010	0.004	0.030 Max.
Sulfur (S)	0.010	<0.002	0.035 Max.
Silicon (Si)	0.01	0.01	--
Nickel (Ni)	0.06	0.01	0.20 Max.
Chromium (Cr)	0.10	0.03	0.15 Max.
Molybdenum (Mo)	0.02	0.01	0.06 Max.
Copper (Cu)	0.08	<0.01	0.20 Max.
Aluminum (Al)	0.030	0.053	--
Vanadium (V)	<0.005	<0.005	0.008 Max.
Columbium (Cb)	<0.002	<0.002	0.008 Max.
Titanium (Ti)	<0.002	<0.002	0.025 Max.
Boron (B)	<0.0002	<0.0002	
Calcium (Ca)	0.0010	0.0001	
Lead (Pb)	<0.005	<0.005	

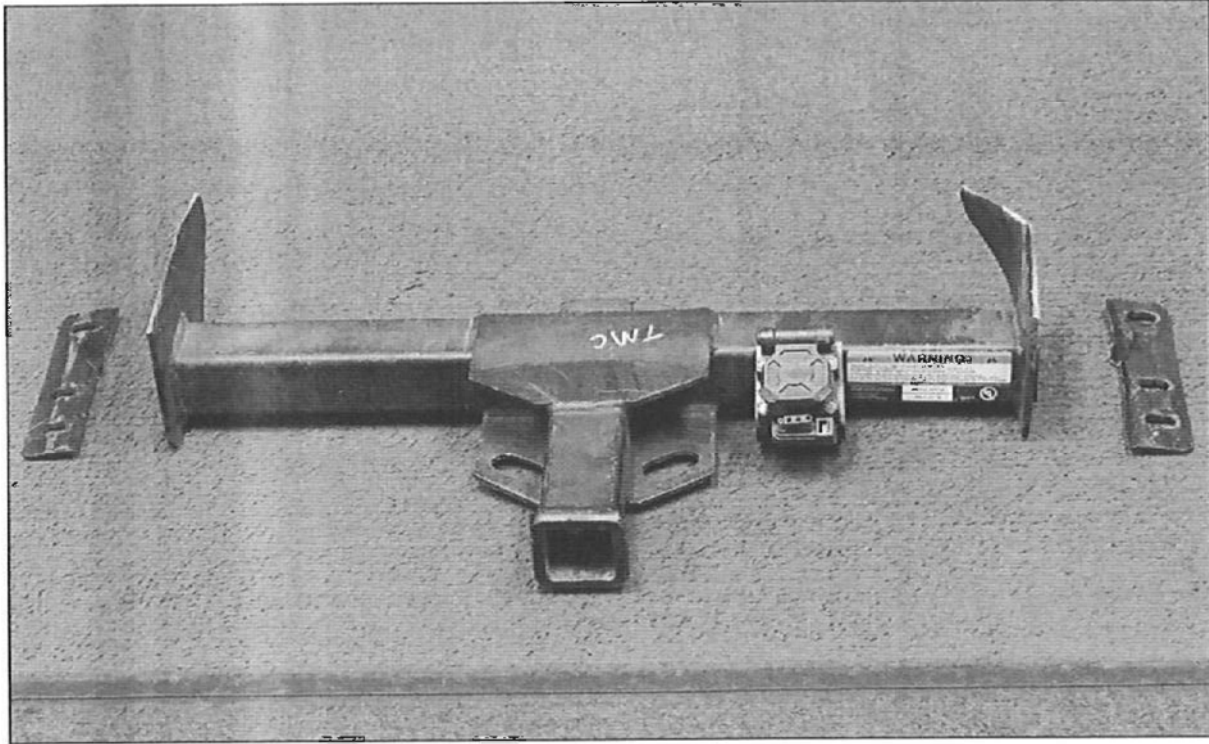


Figure 1. Both ends broke along the radius to the mounting face – the front side of the end plate on the right side bent inward, presumably because the left side broke free and the hitch was pushed forward

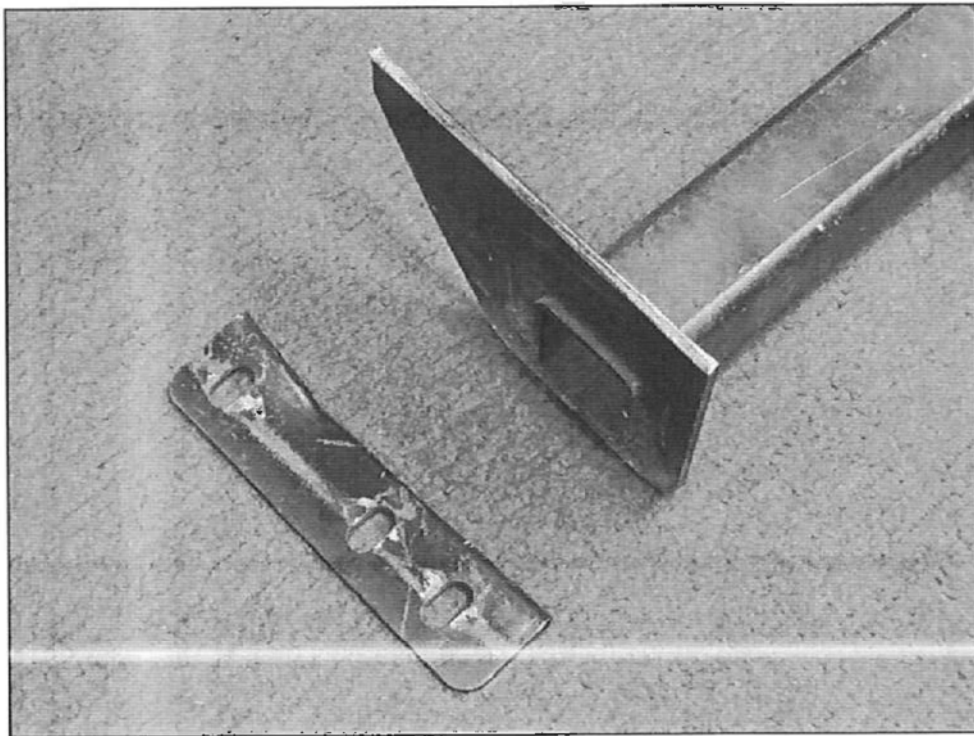


Figure 2. Left Side – breakage followed the radius to the mounting – the fractured end was relatively straight

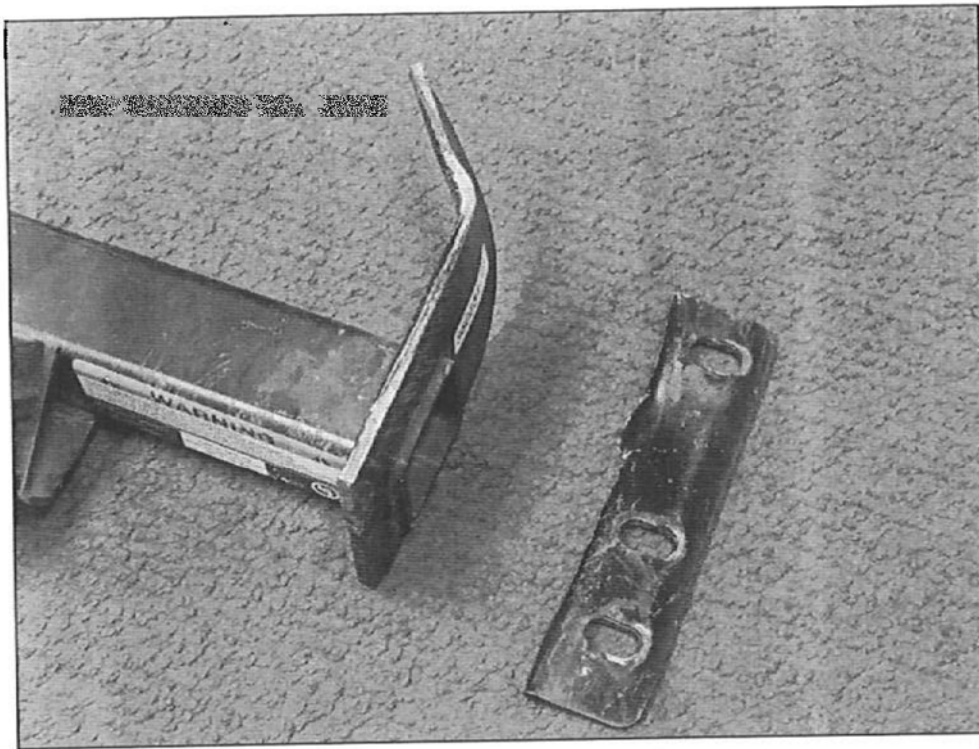


Figure 3. Right Side – breakage followed the radius to the mounting – the fractured end plate bent inward, apparently because the hitch had been pushed forward

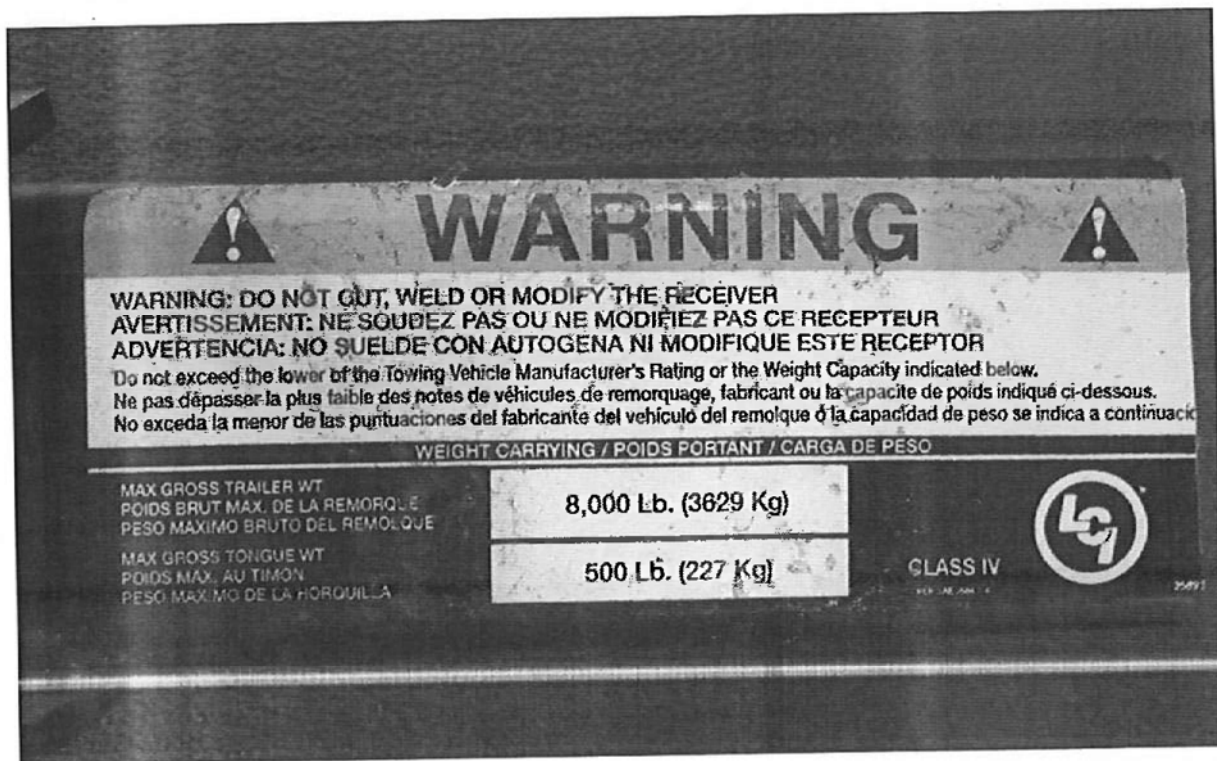
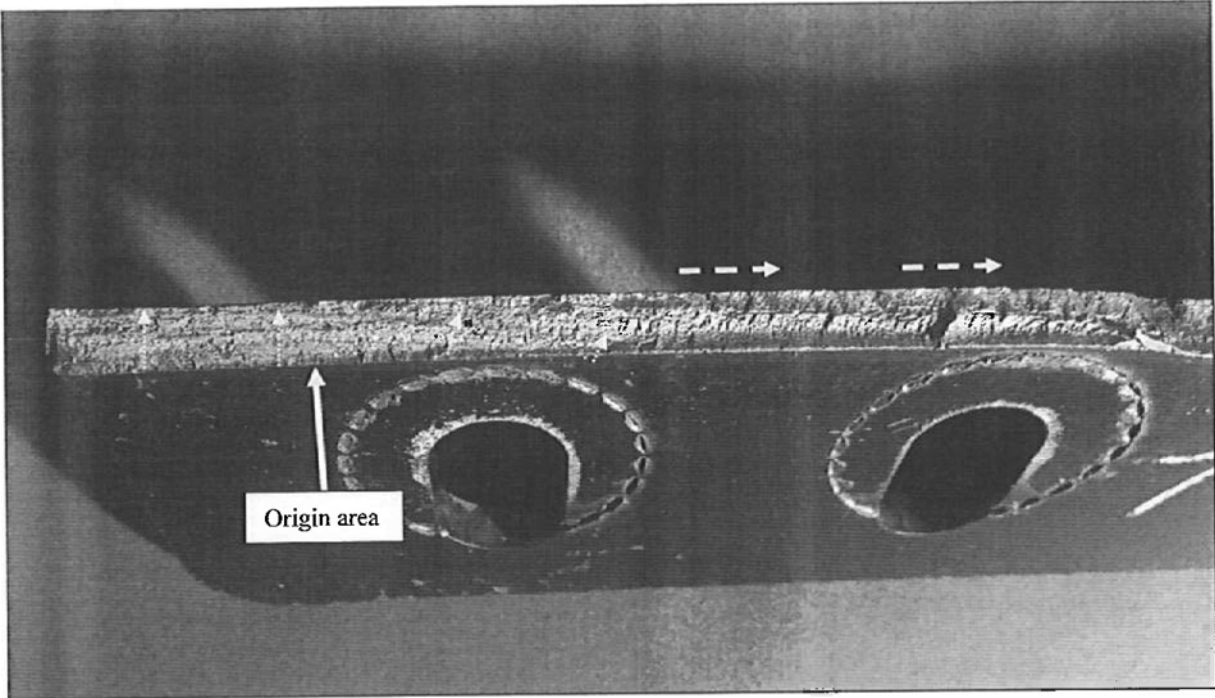
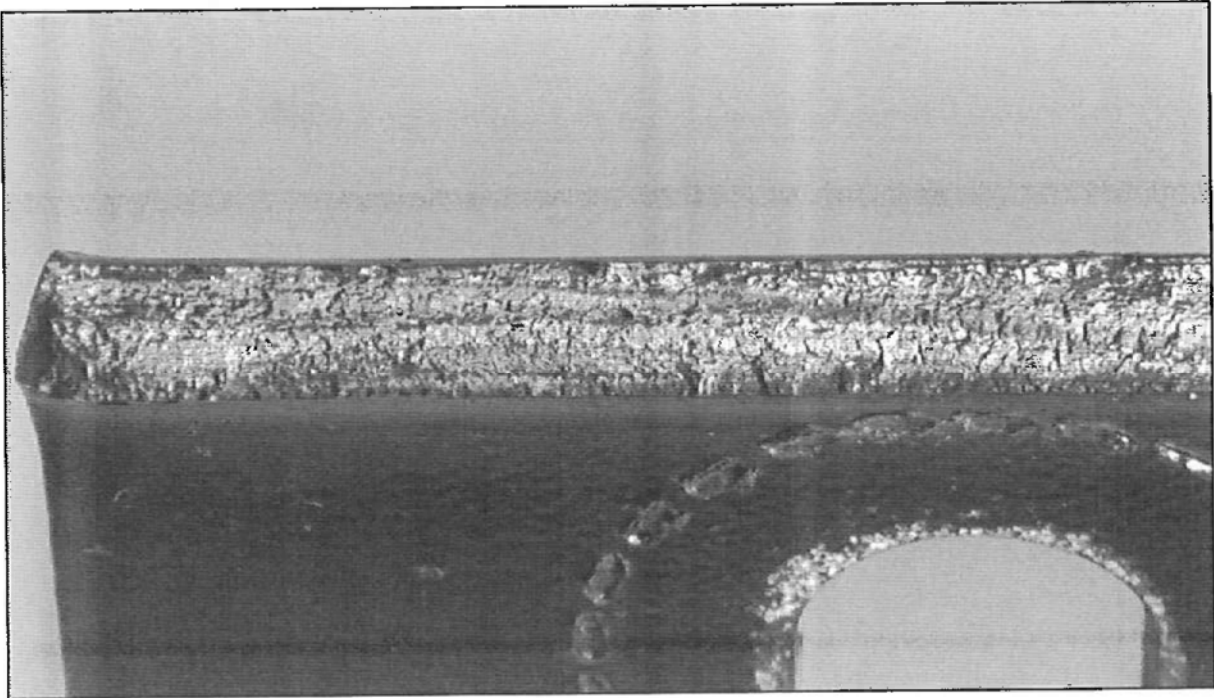


Figure 4. The safety decal identified the manufacturer, hitch type and load capacity ratings

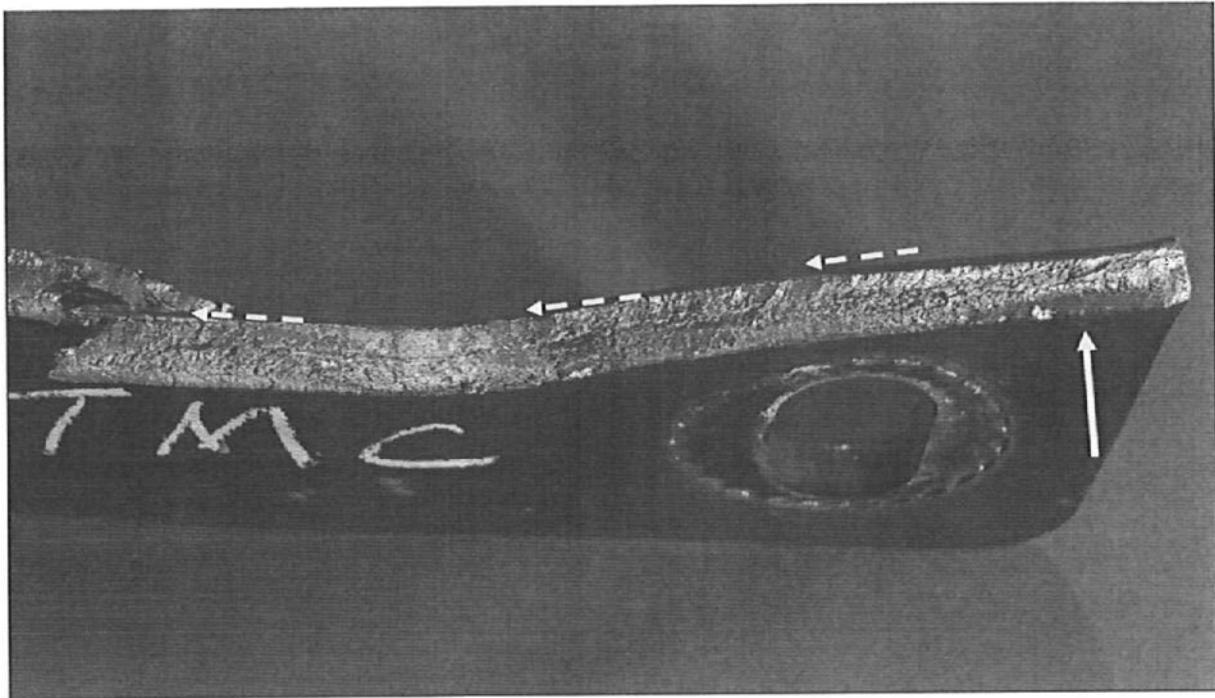


a)

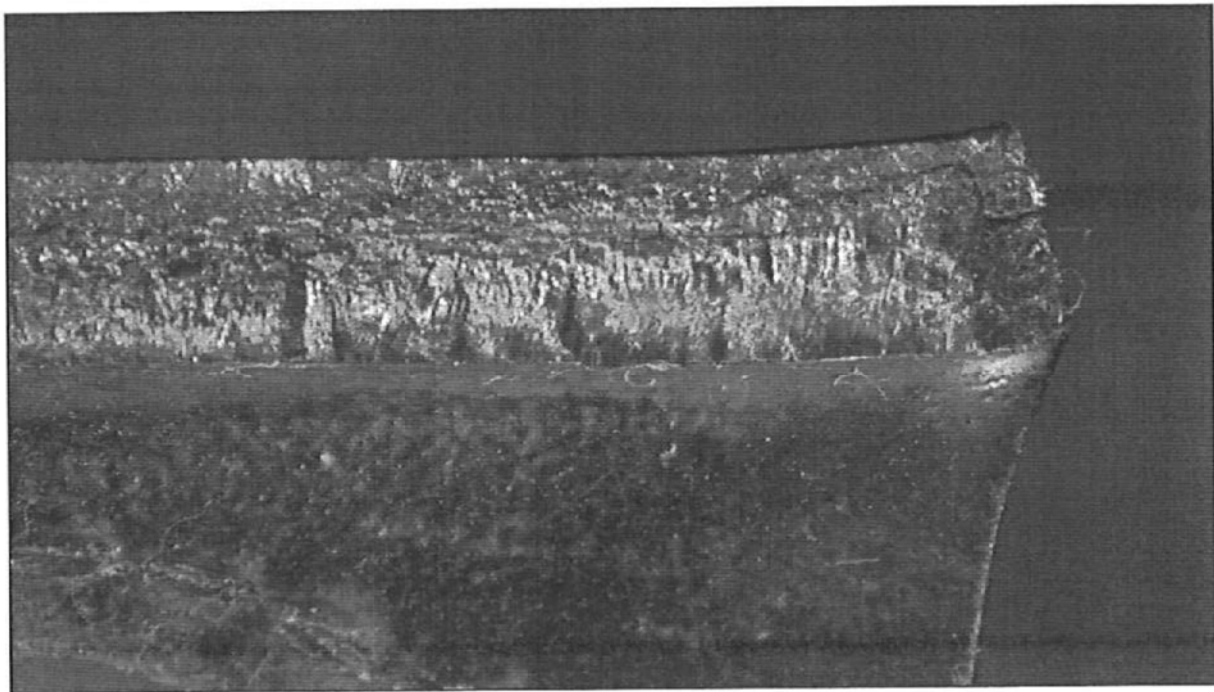


b)

Figure 5. Left, Rear – beach marks point to bending fatigue origins off the inside bend radius, centered behind the rear mounting bolt hole – ratchet marks or steps reveal multiple fatigue origins – no material flaws or defects were found in association with the origin area – ductile tearing extended from the fatigue zone to the mid length of the mounting

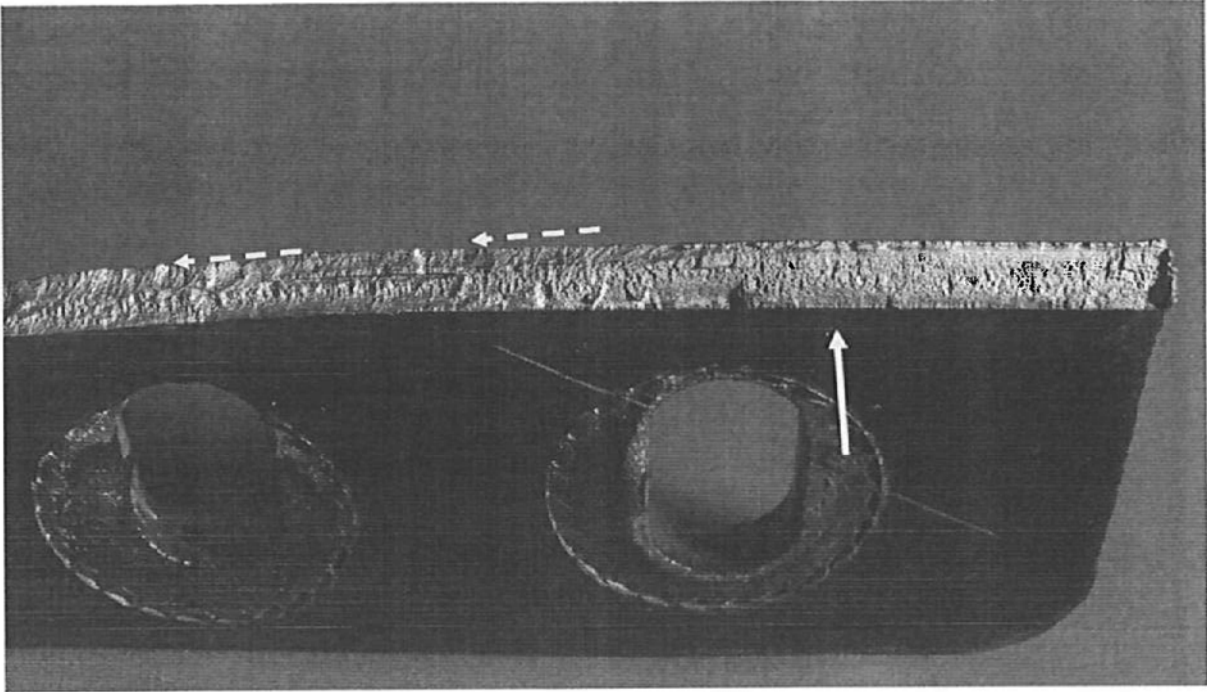


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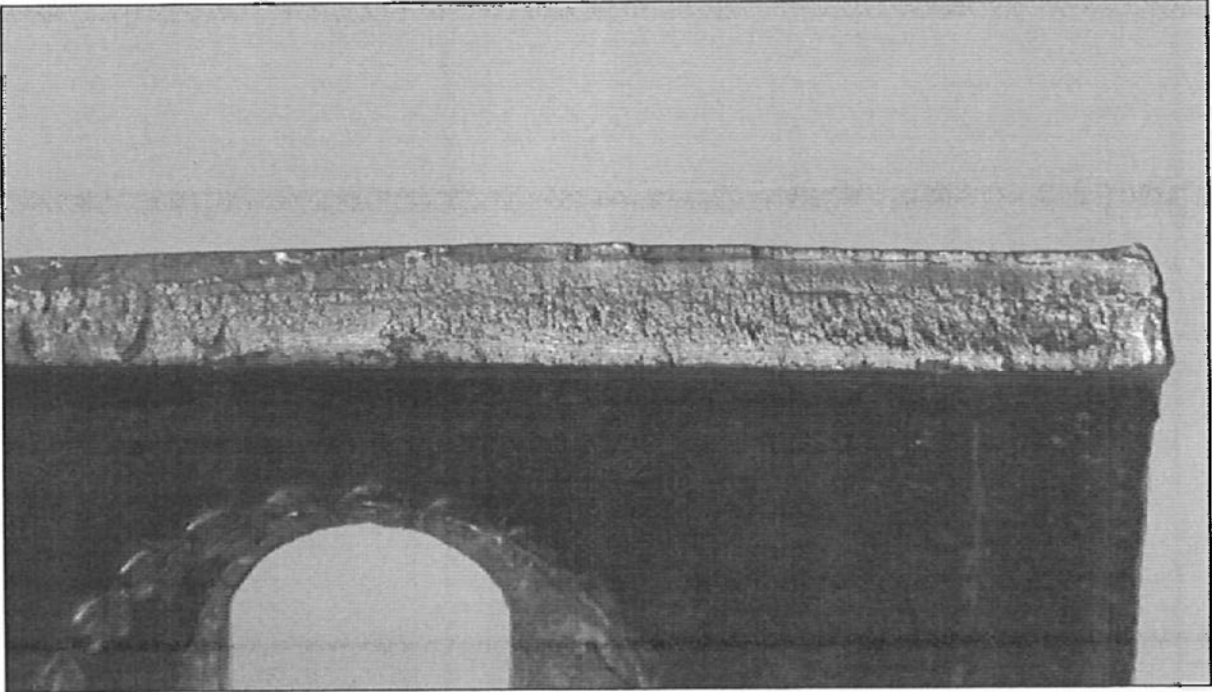


b)

Figure 6. Left, Front – beach marks were not as well defined, but ratchet marks show the fracture at this end originated in bending fatigue off the inside radius, ahead of the front mounting bolt hole – no material flaws or defects were found in association with the origin area – ductile tearing extended from the fatigue zone to the mid length of the mounting where final fracture occurred in a ductile manner

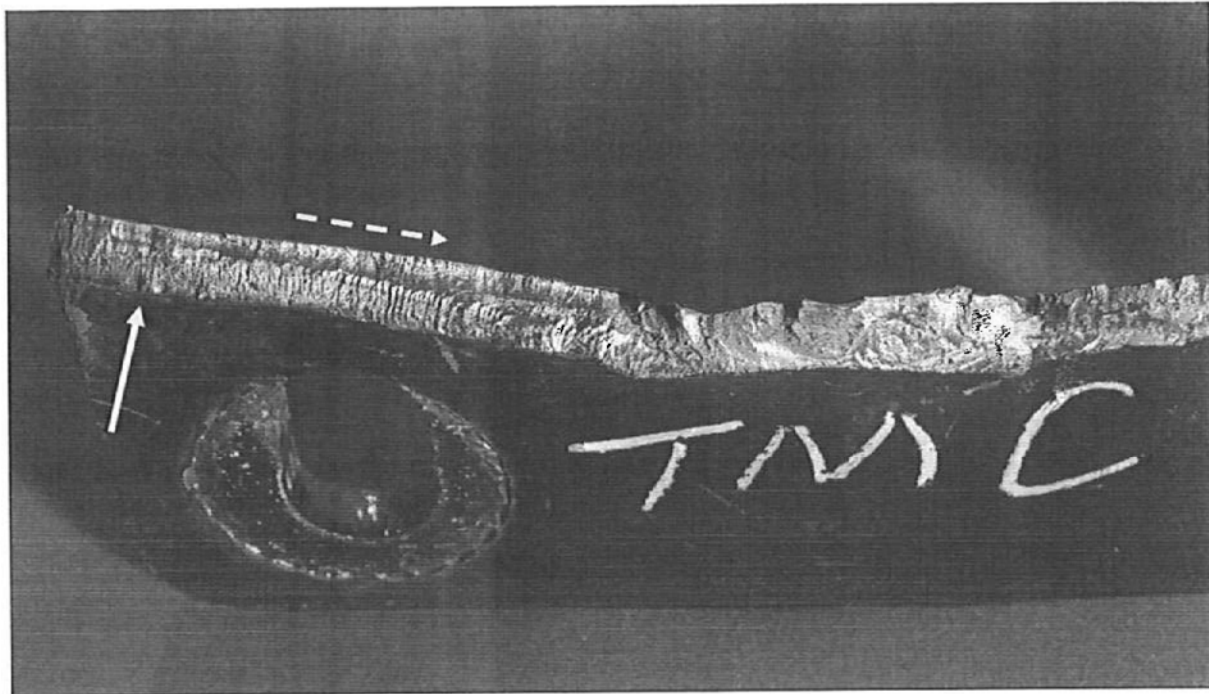


a)

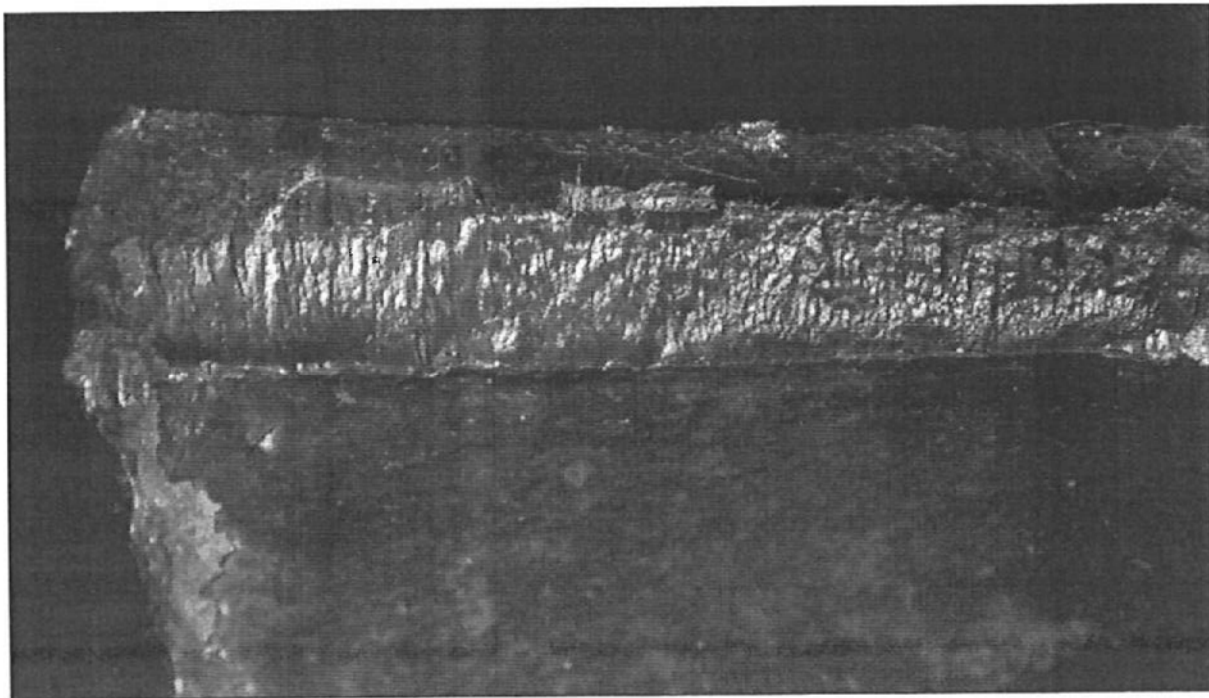


b)

Figure 7. Right, Rear – beach marks point to bending fatigue origins off the inside bend radius, centered near the rear mounting bolt hole – ratchet marks or steps reveal multiple fatigue origins – no material flaws or defects were found in association with the origin area – ductile tearing extended from the fatigue zone to the mid length of the mounting



a)



b)

Figure 8. Right, Front – fracture features did not include beach marks – some traces of ratchet mark steps were found on the inside radius, but no significant propagation in fatigue – a majority of the fracture appears to be the result of ductile overloading – no materials flaws or defects were found in association with this fracture

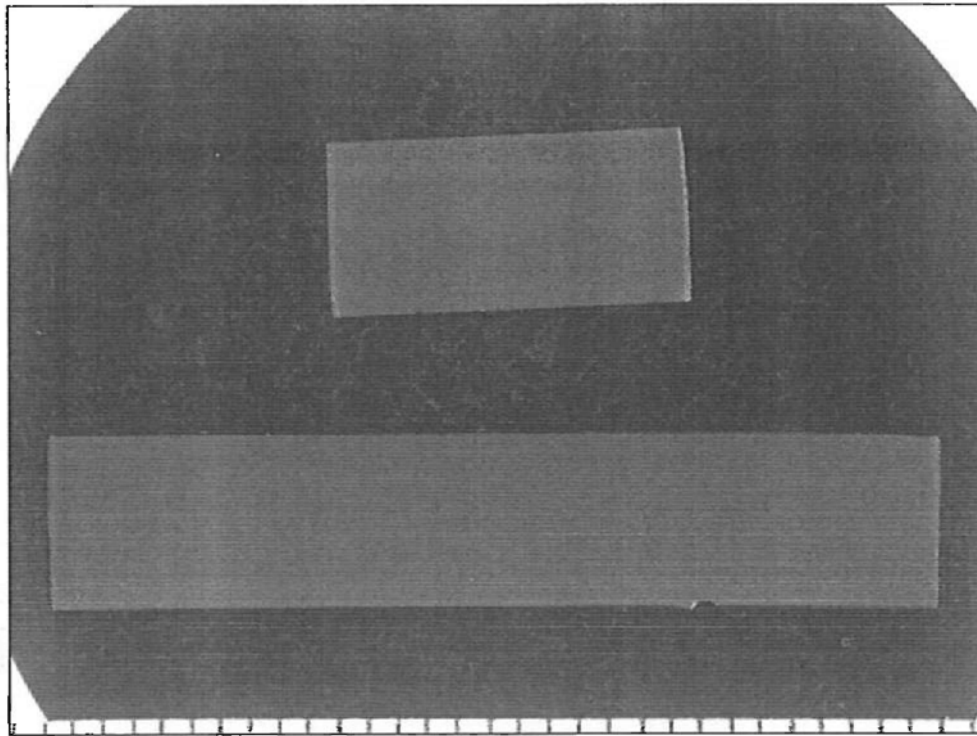


Figure 9. Left – metallographic cross sections cut from the mounting face in the longitudinal and transverse directions – indents are from the bolts – Nital Etchant, mm Scale

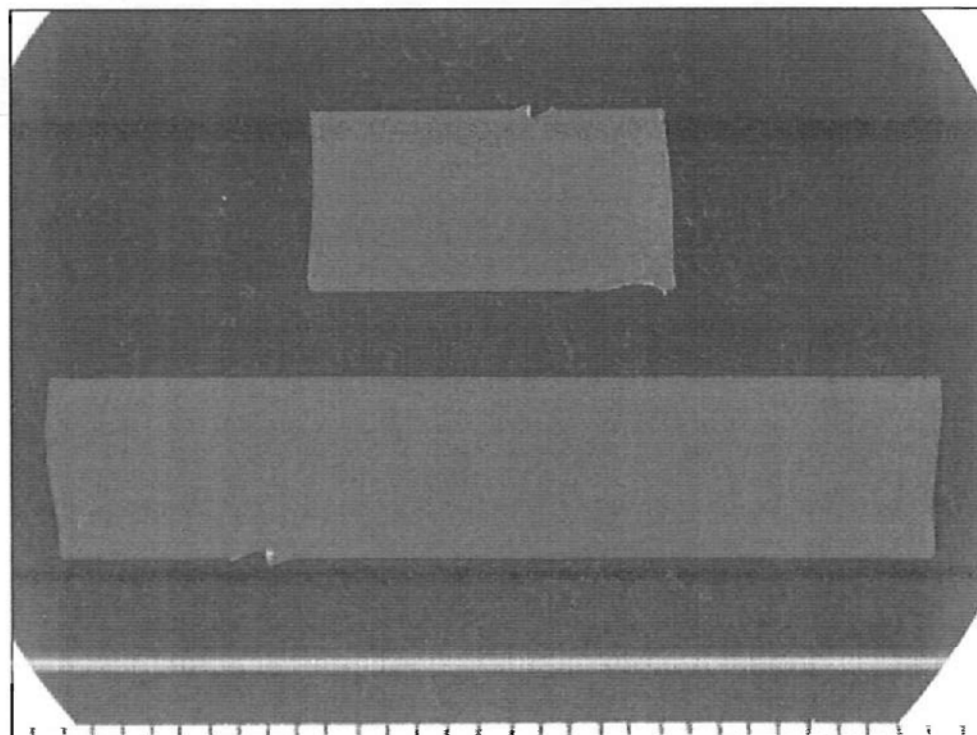
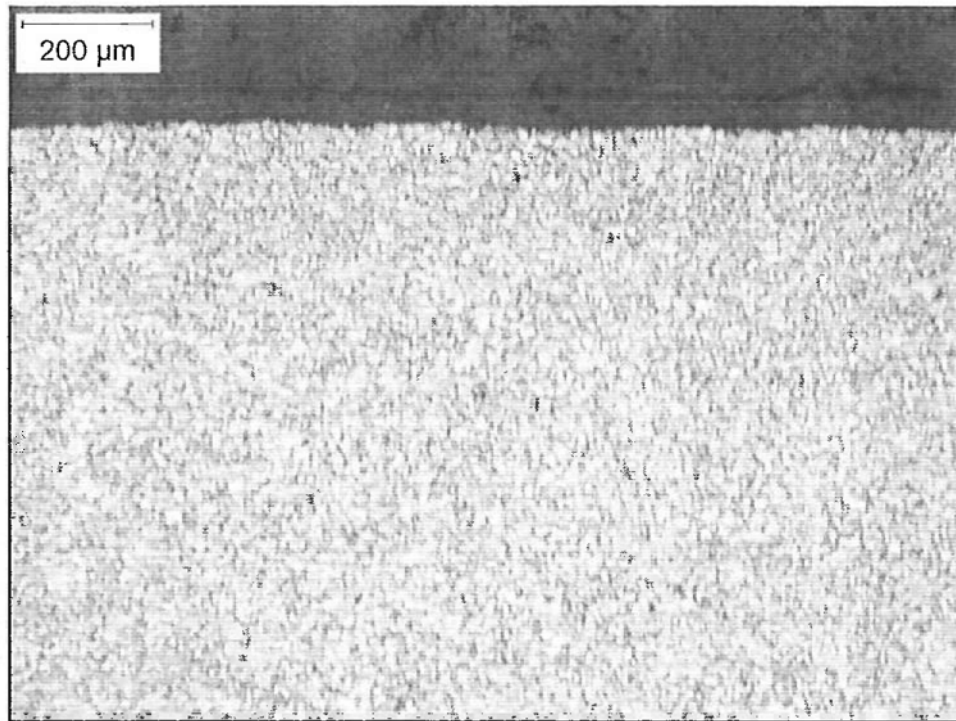
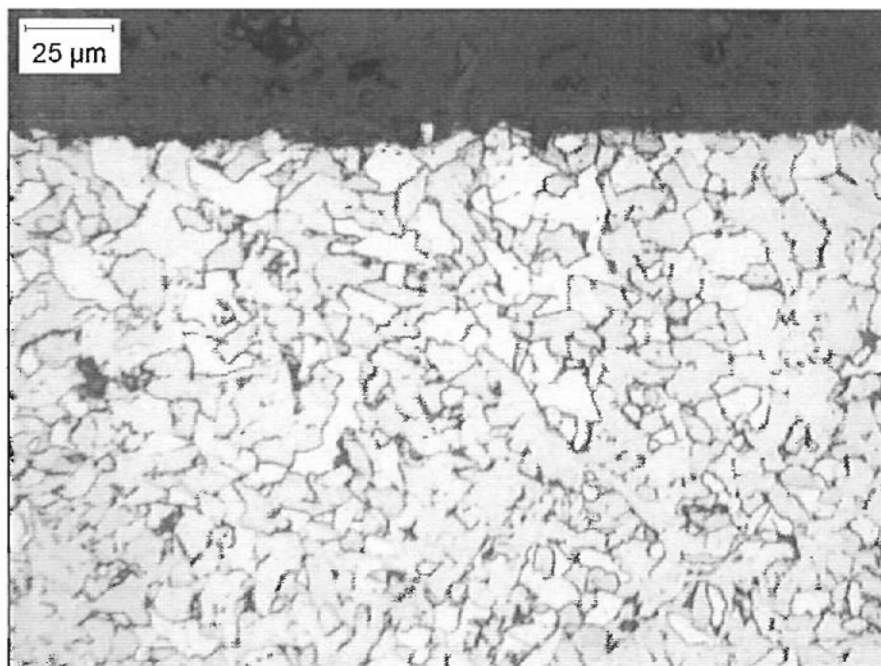


Figure 10. Right – metallographic cross sections cut from the mounting face in the longitudinal and transverse directions – indents are from the bolts – Nital Etchant, mm Scale

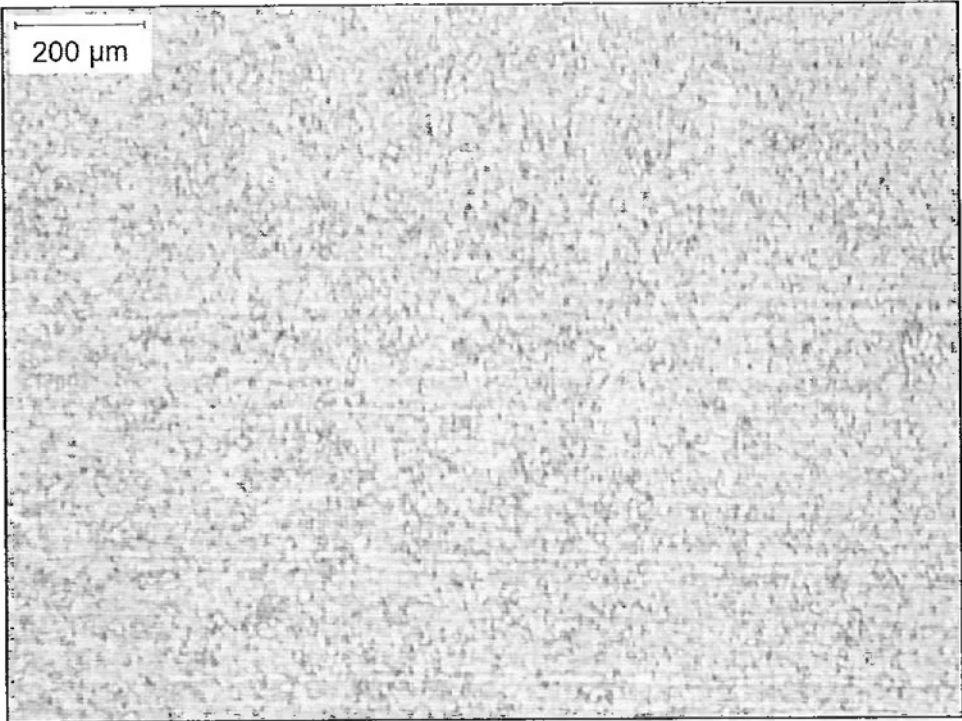


a) Nital Etchant, 90X

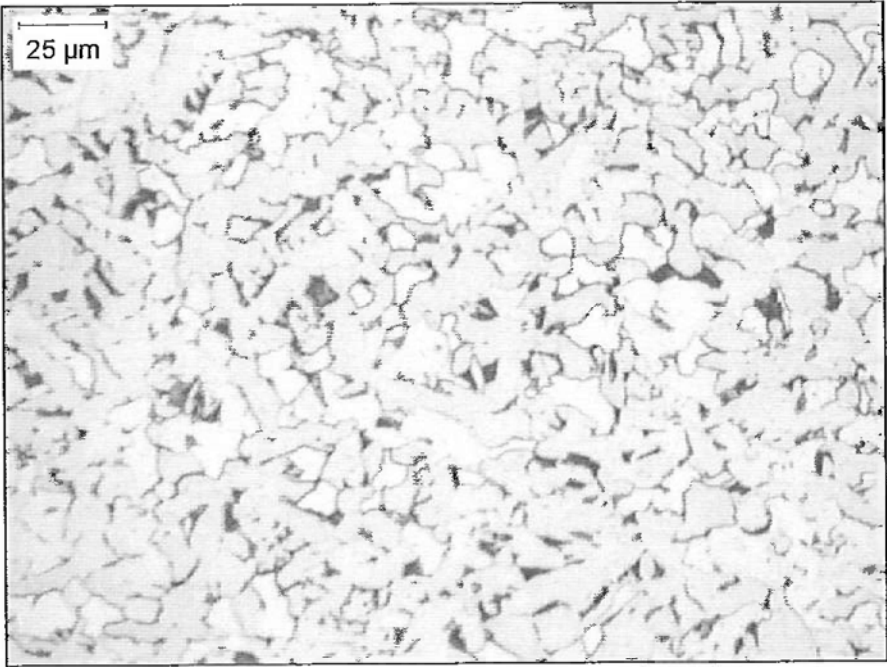


b) Nital Etchant, 500X

Figure 11. Left, Surface – the microstructure consists of fine ferrite grains (white) with scattered islands of pearlite (dark) – no objectionable features of the microstructure were found – this microstructure is consistent with expectations for the specified low carbon steel

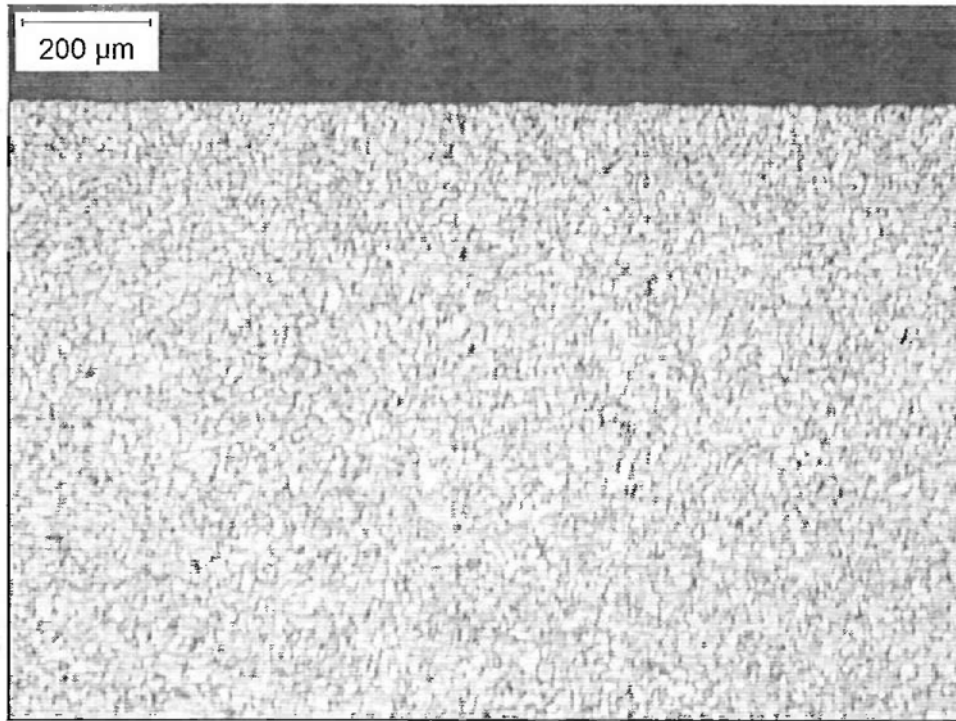


a) Nital Etchant, 90X

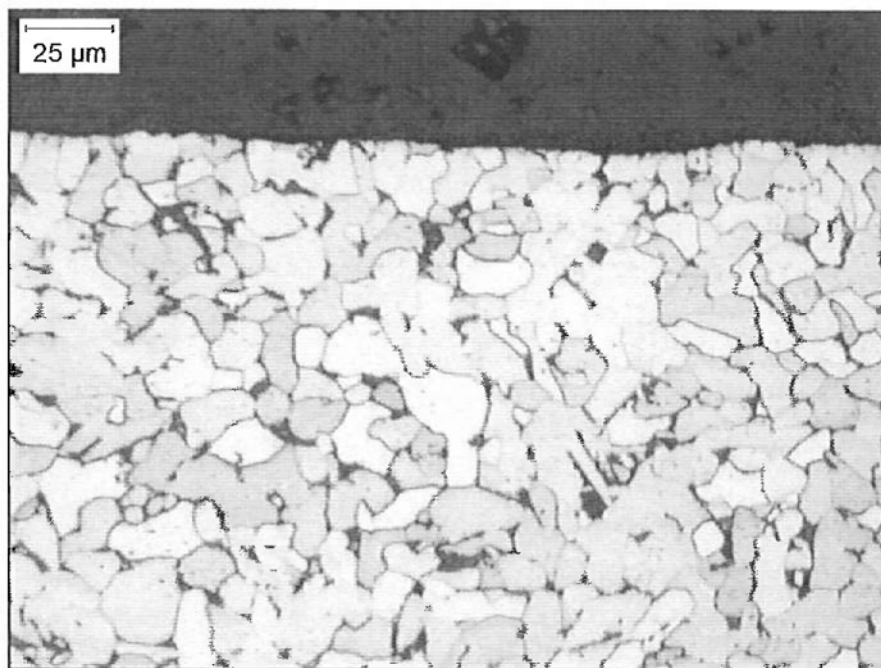


b) Nital Etchant, 500X

Figure 12. Left, Core – the microstructure consists of fine ferrite grains (white) with scattered islands of pearlite (dark) – no objectionable features of the microstructure were found – this microstructure is consistent with expectations for the specified low carbon steel

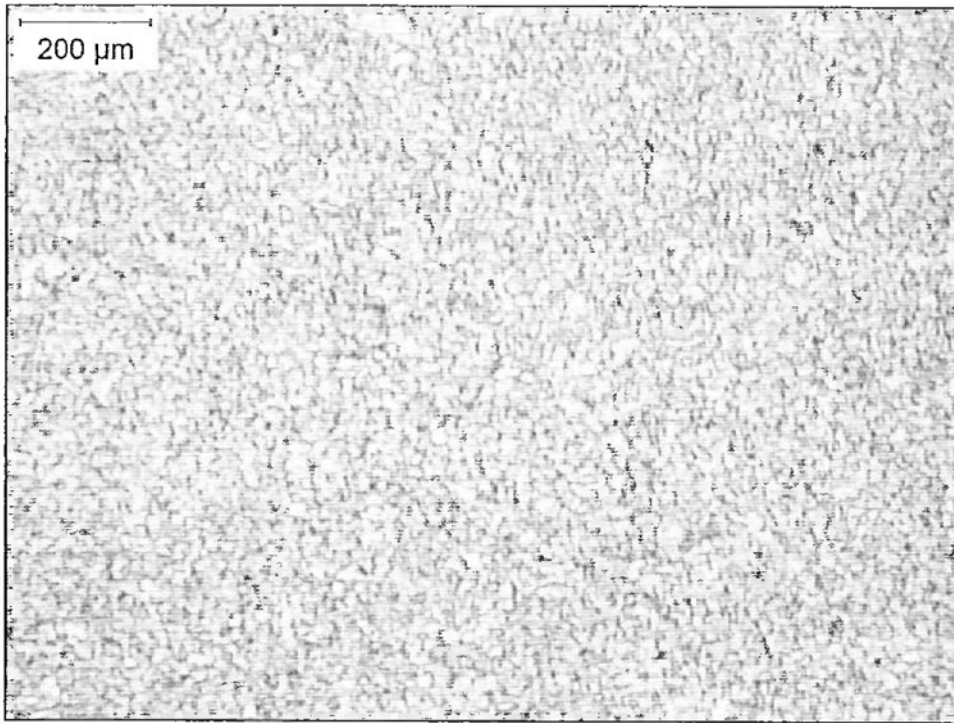


a) Nital Etchant, 90X

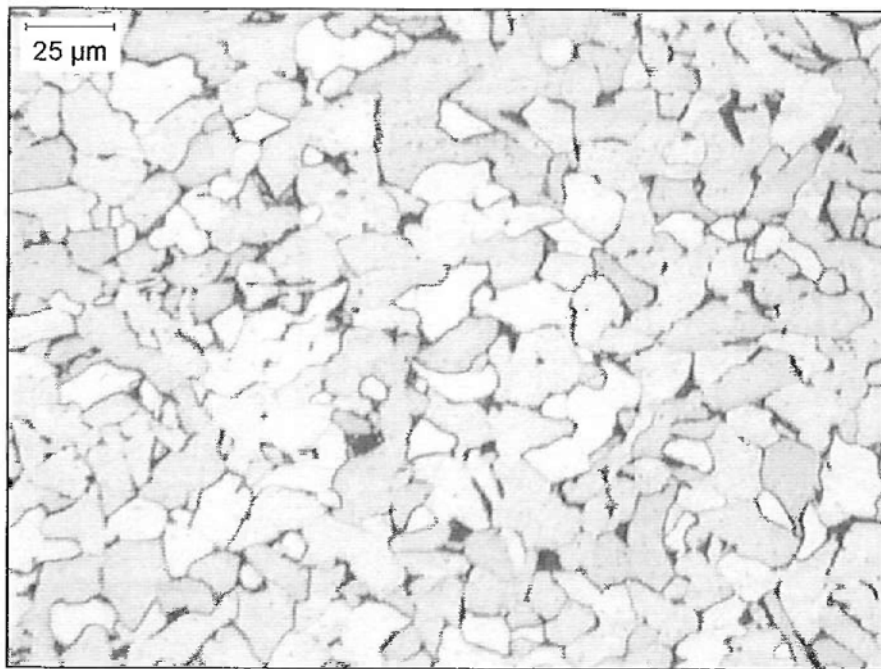


b) Nital Etchant, 500X

Figure 13. Right, Surface – the microstructure consists of fine ferrite grains (white) with scattered islands of pearlite (dark) – no objectionable features of the microstructure were found – this microstructure is consistent with expectations for the specified low carbon steel



a) Nital Etchant, 90X



b) Nital Etchant, 500X

Figure 14. Right, Core – the microstructure consists of fine ferrite grains (white) with scattered islands of pearlite (dark) – no objectionable features of the microstructure were found – this microstructure is consistent with expectations for the specified low carbon steel