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SEAL LABORATORIES

May 28, 2002

Mr. Jeff Rich
N.T.S.B.
1515 West 190th Street, Suite 555
Gardena, California 90248

RE: Examination of Failed Aluminum Spars From a Cessna Aircraft
N444JV LAX02FA101; SEAL Job No. 9034

Dear Mr. Rich:

Four (4) aluminum spars from a Cessna aircraft were submitted to SEAL Laboratories for examination. The spars were reportedly manufactured from a type 7075 aluminum alloy and heat treated to a T-76511 condition.

It was requested to perform visual examination of the fracture surfaces and perform chemical analysis, hardness testing, and electrical conductivity measurements. The hardness and electrical conductivity of the spars were reportedly per AMS 2658 specification.

RESULTS

The failed spars were identified as follows:

1) Front Bottom Spar (Cap Fractured)

2) Front Top Spar

3) Rear Top Spar

4) Rear Bottom Spar

VISUAL EXAMINATION: Figure 1 shows the failed aluminum spars received for examination. The fracture surface of the spars was examined using a stereo light microscope. Then, specimens for chemical analysis, hardness testing, and electrical conductivity measurements were removed.

Figures 2(a) through 3(a) show the Front Bottom Spar with a fractured cap. The fracture surface was non-planar and relatively rough; Figure 3(b). The fracture surface features indicate that the failure of the cap was caused by an overload fracture; Figures 3(b) through 4(b).

Figure 5(a) shows the Front Top Spar. The fracture surface was non-planar and relatively rough; Figure 5(b). The fracture surface features indicate that the failure of the spar was caused by an overload fracture; Figures 5(b) through 6(b).

Figure 5(a) shows the Rear Top Spar. The fracture surface was non-planar and relatively rough; Figure 5(b). Faint Chevron marks were observed on the fracture surface; Figures 8(a) and 8(b). The fracture surface features indicate that the failure of the spar was caused by an overload fracture; Figures 8(b) and 6(b).

Figure 9(a) shows the Rear Bottom Spar. The fracture surface was non-planar and relatively rough; Figure 9(b). Examination of the fracture surface revealed faint Chevron marks and features of an overload fracture; Figures 10(a) through 12(b).

Figures 13(a) through 14(b) show the locations of specimens for chemical analysis, hardness testing and electrical conductivity. A secondary crack was revealed during cutting the specimen from "Front Bottom Spar" fractured cap; Figures 15(a) through 16(b). Examination of the fracture surface revealed an elliptical crack arrest line; Figures 17(a) and 17(b). It was requested to perform fractographic examination of the fracture surface of the secondary crack using a Scanning Electron Microscope (SEM).

SEM FRACTOGRAPHY: Figure 22 was obtained from an area marked "A" in Figure 17(b). Examination of various areas of the fracture surface revealed the presence of dimples indicative of an overload fracture; Figures 23(a) through 26(a). Figure 27 shows the edge of the fracture surface. Examination of an area marked "E" in Figure 27 revealed the presence of dimples indicative of an overload fracture; Figures 28(a) and 28(b). The results of SEM fractographic examination indicate that the secondary crack of the "Front Bottom Spar" with elliptical crack arrest lines was also due to an overload fracture.

CHEMICAL ANALYSIS: The results of chemical analysis are presented in Tables I through IV, which indicate that all of the samples were manufactured from a type 7075 aluminum alloy.

HARDNESS TESTING: The results of Rockwell "B" hardness testing are presented in Table V through VIII. The average hardness of the samples was higher than the minimum specified 82 HRB per AMS 2658 specification for a Type 7075-T76 aluminum alloy.

ELECTRICAL CONDUCTIVITY: The results of electrical conductivity measurement are presented in Tables IX through XII. The electrical conductivity of a Type 7075-T76 aluminum alloy per AMS 2658 is 38.0 to 42.0 %IACS. Except for the "front Bottom Spar" cap, the electrical conductivity of the other samples were below 38%IACS.

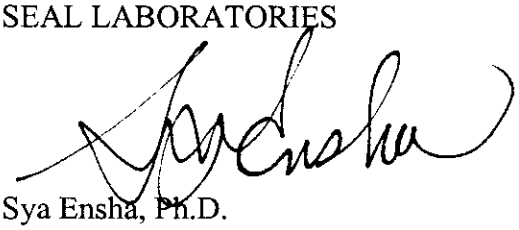
SUMMARY & CONCLUSIONS

Based on the results of this examination, it is concluded that the failure of the spars was due to an overload fracture. The chemical composition and hardness values of the spars were in agreement with AMS 2658 specification for a Type 7075-T76 aluminum alloy. However, the electrical conductivity values for the "Front Top Spar", "Rear Top Spar" and the "rear Bottom Spar" were lower than the specified values per AMS 2658.

Please do not hesitate to contact me if you have any further questions regarding this analysis.

Sincerely,

SEAL LABORATORIES



Sya Ensha, Ph.D.
Senior Member Technical Staff
Metallurgy & Materials Science

Enclosures

TABLE I

CHEMICAL ANALYSIS OF FRONT BOTTOM SPAR (CAP)
(wt.%)

ELEMENT	ANALYSIS	7075 Specified
Silicon (Si)	0.131	0.40 max.
Copper (Cu)	1.498	1.20-2.00
Manganese (Mn)	0.052	0.30 max.
Magnesium (Mg)	2.346	2.10-2.90
Zinc (Zn)	5.479	5.10-6.10
Titanium (Ti)	0.033	0.20 max.
Iron (Fe)	0.177	0.50 max.
Chromium (Cr)	0.214	0.18-0.28
Nickel (Ni)	0.003	---------
Others (Each)	<0.05	<0.05 (each)
Others (Total)	<0.150	<0.150 (Total)
Aluminum (Al)	Rem.	Rem.

TABLE II

CHEMICAL ANALYSIS OF FRONT TOP SPAR
(wt.%)

ELEMENT	ANALYSIS	7075 Specified
Silicon (Si)	0.131	0.40 max.
Copper (Cu)	1.463	1.20-2.00
Manganese (Mn)	0.056	0.30 max.
etc		
Magnesium (Mg)	2.346	2.10-2.90
Zinc (Zn)	5.479	5.10-6.10
Titanium (Ti)	0.033	0.20 max.
Iron (Fe)	0.177	0.50 max.
Chromium (Cr)	0.214	0.18-0.28
Nickel (Ni)	0.003	---------
Others (Each)	<0.05	<0.05 (each)
Others (Total)	<0.150	<0.150 (Total)
Aluminum (Al)	Rem.	Rem.

TABLE III

CHEMICAL ANALYSIS OF REAR TOP SPAR
(wt.%)

ELEMENT	ANALYSIS	7075 Specified
Silicon (Si)	0.124	0.40 max.
Copper (Cu)	1.516	1.20-2.00
Manganese (Mn)	0.056	0.30 max.
Magnesium (Mg)	2.435	2.10-2.90
Zinc (Zn)	5.820	5.10-6.10
Titanium (Ti)	0.034	0.20 max.
Iron (Fe)	0.220	0.50 max.
Chromium (Cr)	0.203	0.18-0.28
Nickel (Ni)	0.003	---------
Others (Each)	<0.05	<0.05 (each)
Others (Total)	<0.150	<0.150 (Total)
Aluminum (Al)	Rem.	Rem.

TABLE IV

CHEMICAL ANALYSIS OF REAR BOTTOM SPAR
(wt.%)

ELEMENT	ANALYSIS	7075 Specified
Silicon (Si)	0.136	0.40 max.
Copper (Cu)	1.472	1.20-2.00
Manganese (Mn)	0.060	0.30 max.
Magnesium (Mg)	2.312	2.10-2.90
Zinc (Zn)	5.638	5.10-6.10
Titanium (Ti)	0.037	0.20 max.
Iron (Fe)	0.234	0.50 max.
Chromium (Cr)	0.198	0.18-0.28
Nickel (Ni)	0.003	---------
Others (Each)	<0.05	<0.05 (each)
Others (Total)	<0.150	<0.150 (Total)
Aluminum (Al)	Rem.	Rem.

TABLE V

ROCKWELL HARDNESS TEST

Customer: NTSB

Sample Identification: Front Bottom Spar (Cap)

Location	Scale HRC	Cnvrtd to	Location	Scale	Cnvrtd to
1	86				
2	85				
3	84.5				
4	85.9				
5	84.9				
AVERAGE	85				

CALIBRATION CHECK

Test Block: 97R2957

Actual Results: 85.7

Date: 05/06/02 Operator: J. Hollman

TABLE VI

ROCKWELL HARDNESS TEST

Customer: NTSB

Sample Identification: Front Top Spar

Location	Scale HRC	Cnvrtd to	Location	Scale	Cnvrtd to
1	91.5				
2	91.5				
3	91.8				
4	92				
5	92				
AVERAGE	92				

CALIBRATION CHECK

Test Block: 97R2957

Actual Results: 85.7

Date: 05/06/02 Operator: J. Hollman

TABLE VII

ROCKWELL HARDNESS TEST

Customer: NTSB

Sample Identification: Rear Top Spar

Location	Scale HRC	Cnvrtd to	Location	Scale	Cnvrtd to
1	92.1				
2	92				
3	92.5				
4	91.9				
5	93				
AVERAGE	92				

CALIBRATION CHECK

Test Block: 97R2957

Actual Results: 85.7

Date: 05/06/02 Operator: J. Hollman

TABLE VIII

ROCKWELL HARDNESS TEST

Customer: NTSB

Sample Identification: Rear Bottom Spar

Location	Scale HRC	Cnvrtd to	Location	Scale	Cnvrtd to
1	91				
2	91.2				
3	91.8				
4	91.5				
5	92				
AVERAGE	92				

CALIBRATION CHECK

Test Block: 97R2957

Actual Results: 85.7

Date: 05/06/02 Operator: J. Hollman

TABLE IX

ELECTRICAL CONDUCTIVITY TEST

(MIZ-6 Conductivity Meter Serial No. 455)

Customer: NTSB

Sample Identification: Front Bottom Spar (Cap)

Location	% IACS	Location	% IACS
Reading #1	39		
Reading #2	40		
Reading #3	39		

Calibration Check

Standard	Actual	Standard	Actual
9.662% ± 1%		29.61% ± 1%	29.5%
101.03% ± 1%		46.43% ± 1%	46.5%

Date: 05/06/2002 **Operator:** C. Driesler

TABLE X

ELECTRICAL CONDUCTIVITY TEST
(MIZ-6 Conductivity Meter Serial No. 455)

Customer: NTSB

Sample Identification: Front Top Spar

Location	% IACS	Location	% IACS
Reading #1	32		
Reading #2	32		
Reading #3	32		

Calibration Check

Standard	Actual	Standard	Actual
9.662% ± 1%		29.61% ± 1%	29.5%
101.03% ± 1%		46.43% ± 1%	46.5%

Date: 05/06/2002 **Operator:** C. Driesler

TABLE XI

ELECTRICAL CONDUCTIVITY TEST

(MIZ-6 Conductivity Meter Serial No. 455)

Customer: NTSB

Sample Identification: Rear Top Spar

Location	% IACS	Location	% IACS
Reading #1	31.5		
Reading #2	31.5		
Reading #3	31.5		

Calibration Check

Standard	Actual	Standard	Actual
9.662% ± 1%		29.61% ± 1%	29.5%
101.03% ± 1%		46.43% ± 1%	46.5%

Date: 05/06/2002 **Operator:** C. Driesler

TABLE XII

ELECTRICAL CONDUCTIVITY TEST

(MIZ-6 Conductivity Meter Serial No. 455)

Customer: NTSB

Sample Identification: Rear Bottom Spar

Location	% IACS	Location	% IACS
Reading #1	32.5		
Reading #2	32.5		
Reading #3	32.5		

Calibration Check

Standard	Actual	Standard	Actual
9.662% ± 1%		29.61% ± 1%	29.5%
101.03% ± 1%		46.43% ± 1%	46.5%

Date: 05/06/2002 **Operator:** C. Driesler

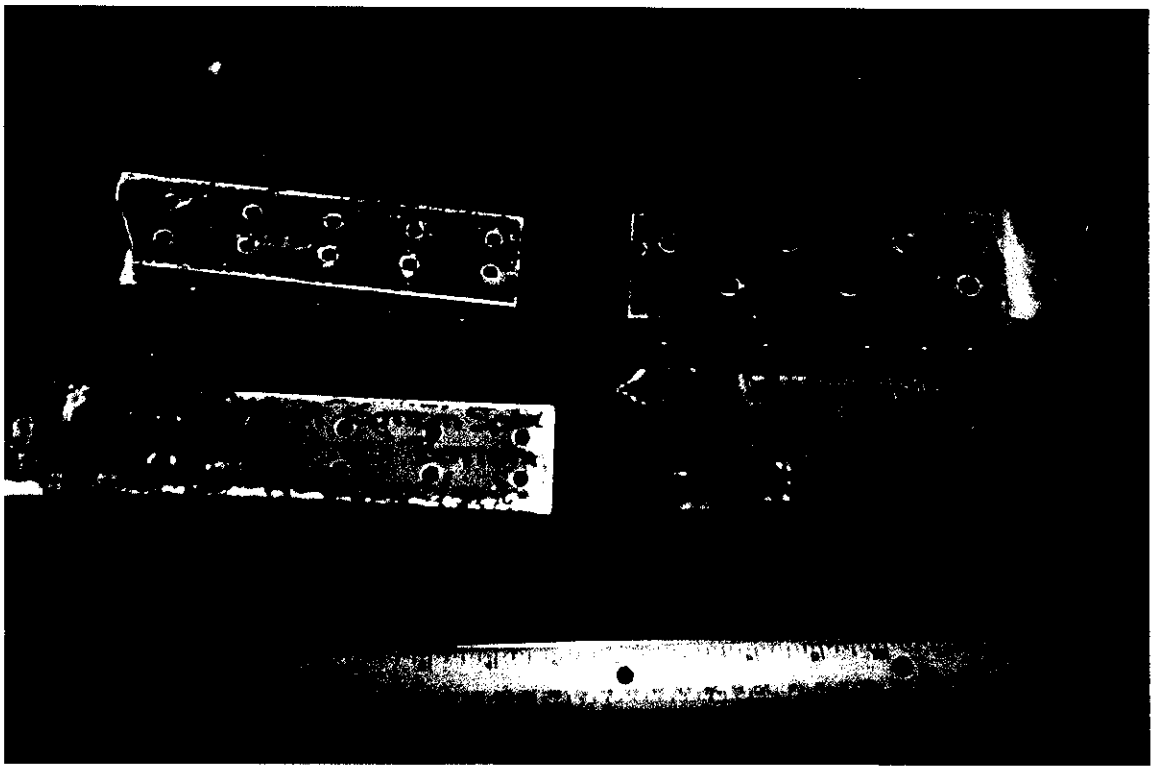
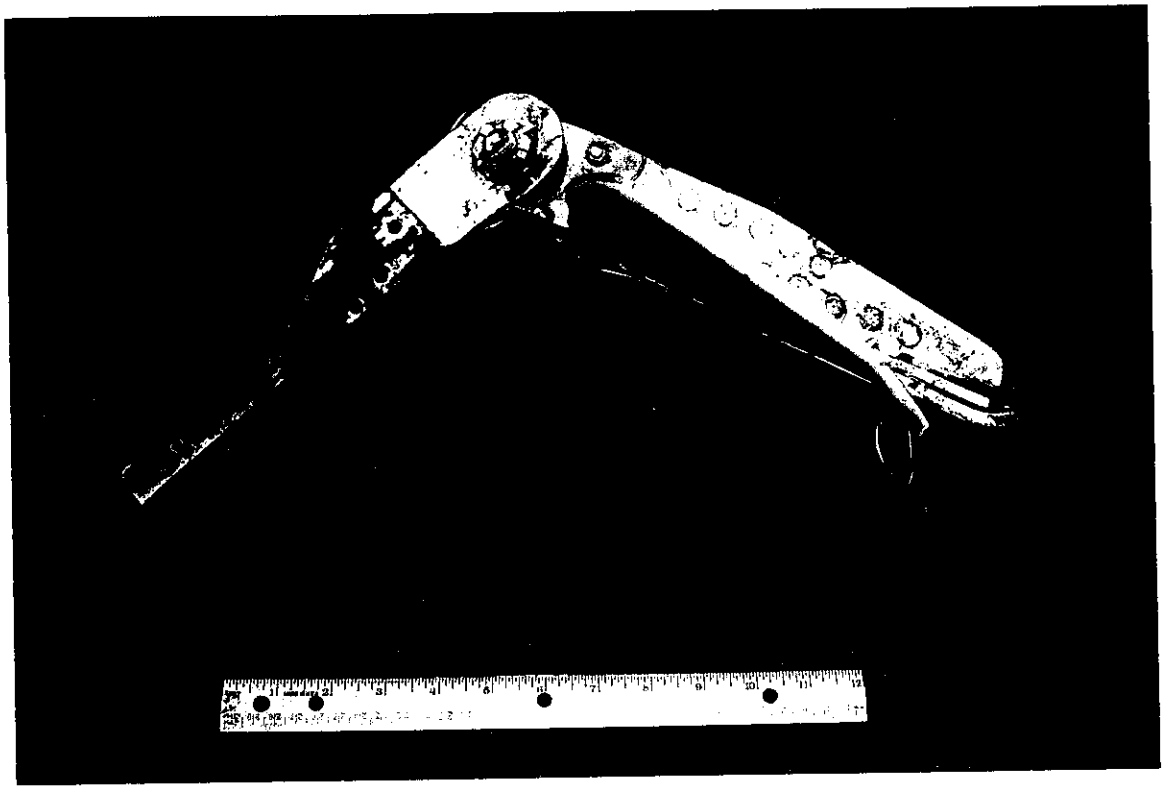


Figure 1. A color photograph showing the failed aluminum spars received for examination.



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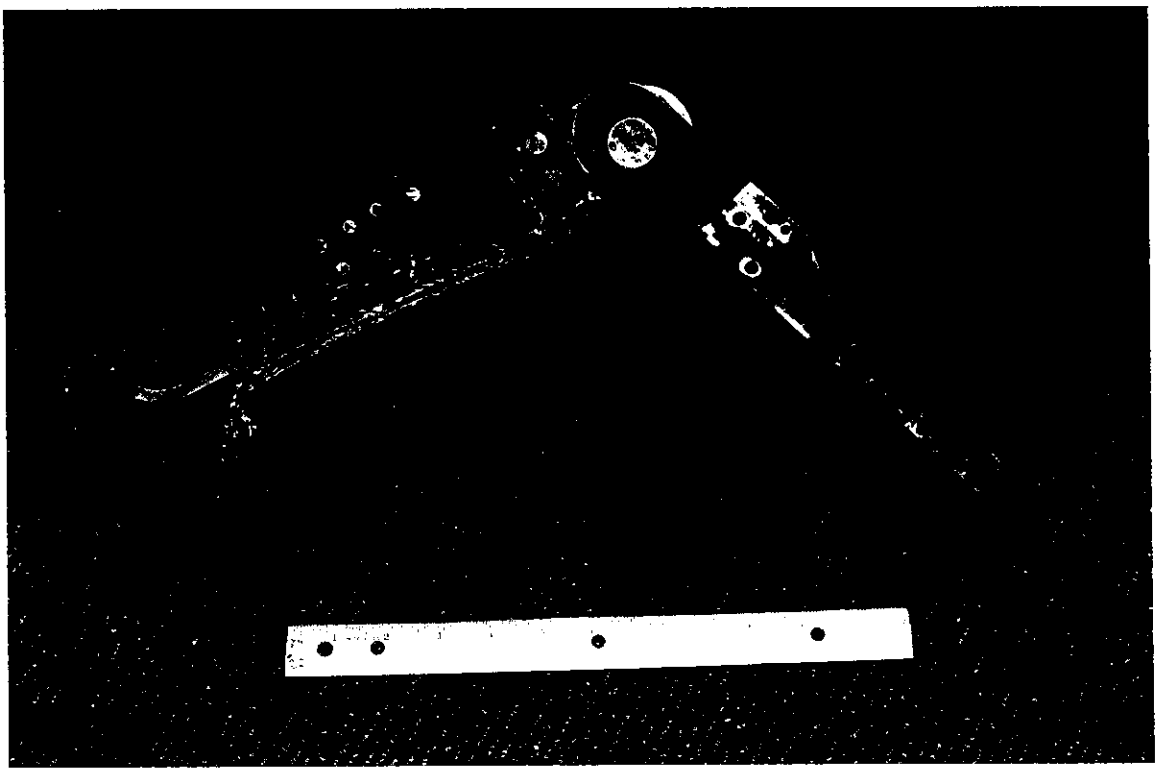
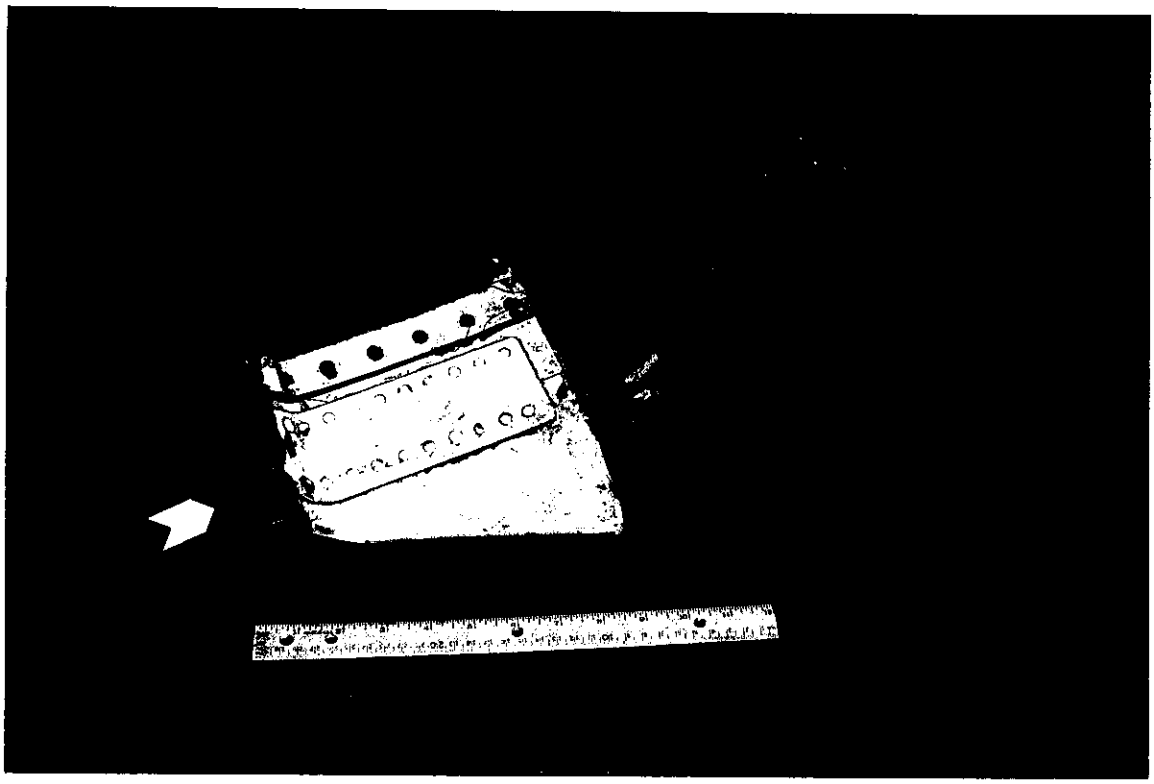


(b)

Figure 2. Color photographs of the failed "Front Bottom Spar" with fractured cap. (a) View 1. (b) View 2.

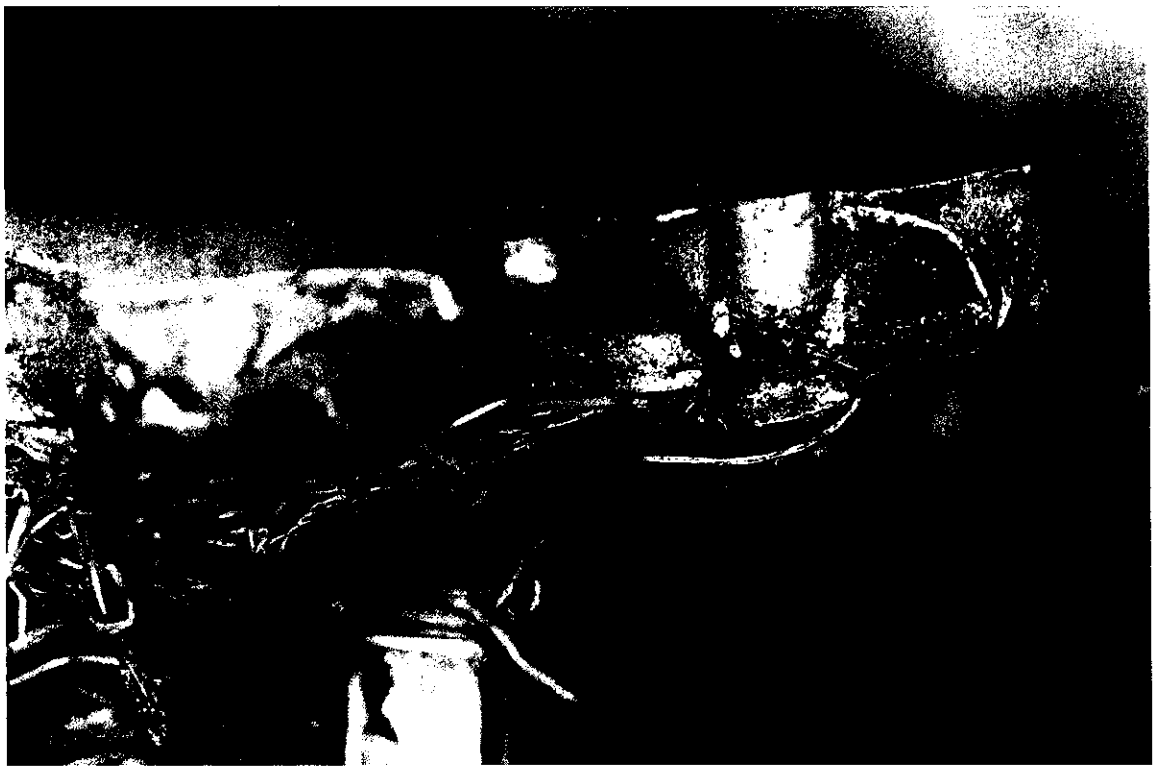


(a)

(b)

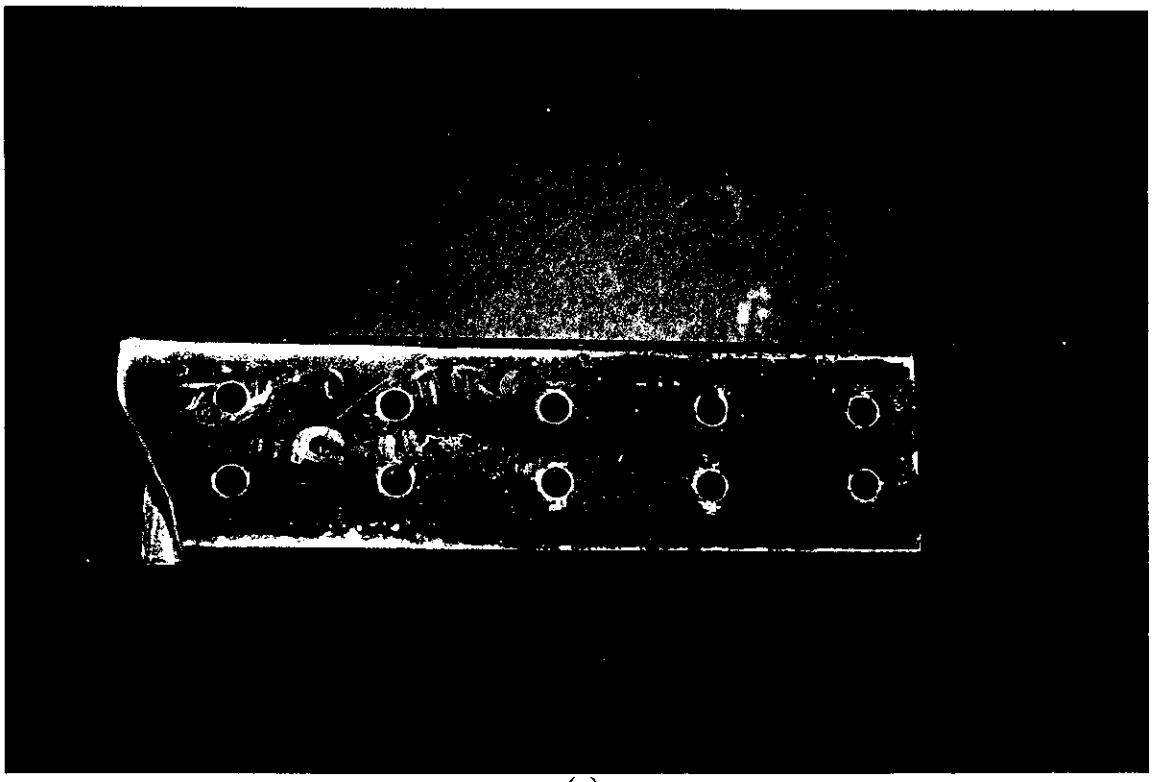
Figure 3. Color photographs of the failed "Front Bottom Spar" with fractured cap. (a) Overall view. (b) From an area indicated by the arrow in Figure 3(a), showing the fracture surface.

(a)



(b)

Figure 4. Color photographs of the failed "Front Bottom Spar", showing close-up views of the fracture surface. (a) View 1. (b) View 2.



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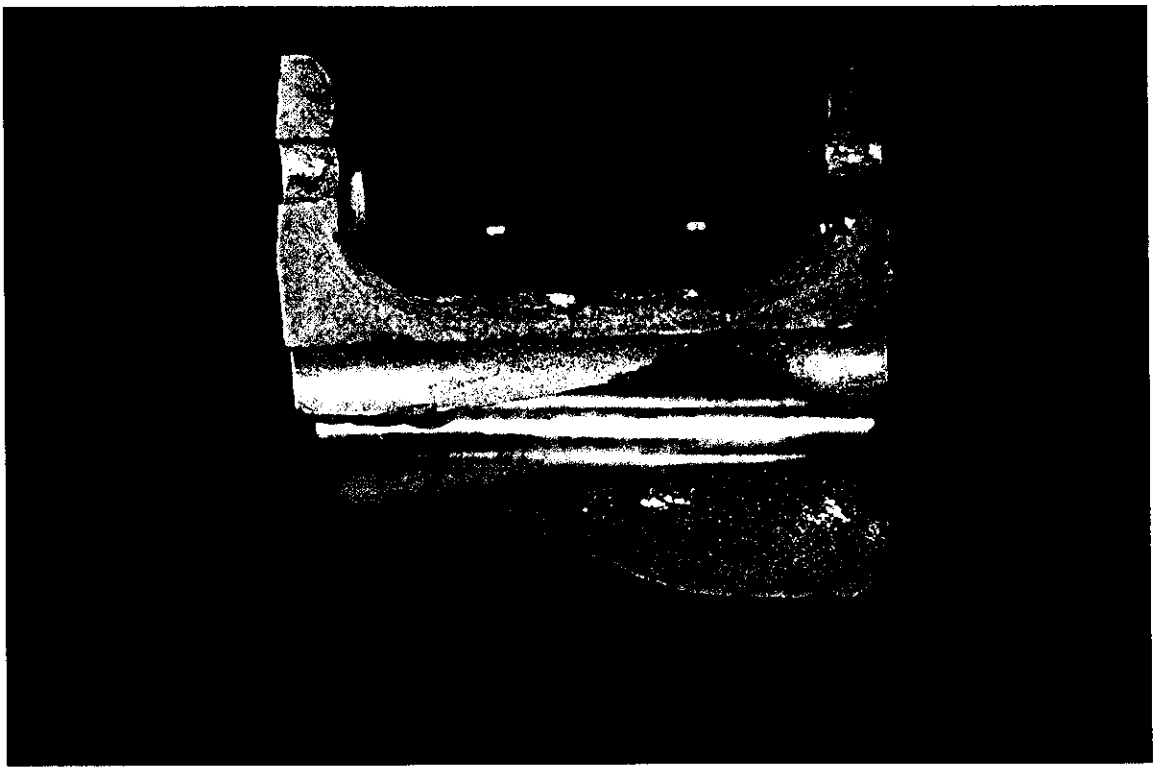
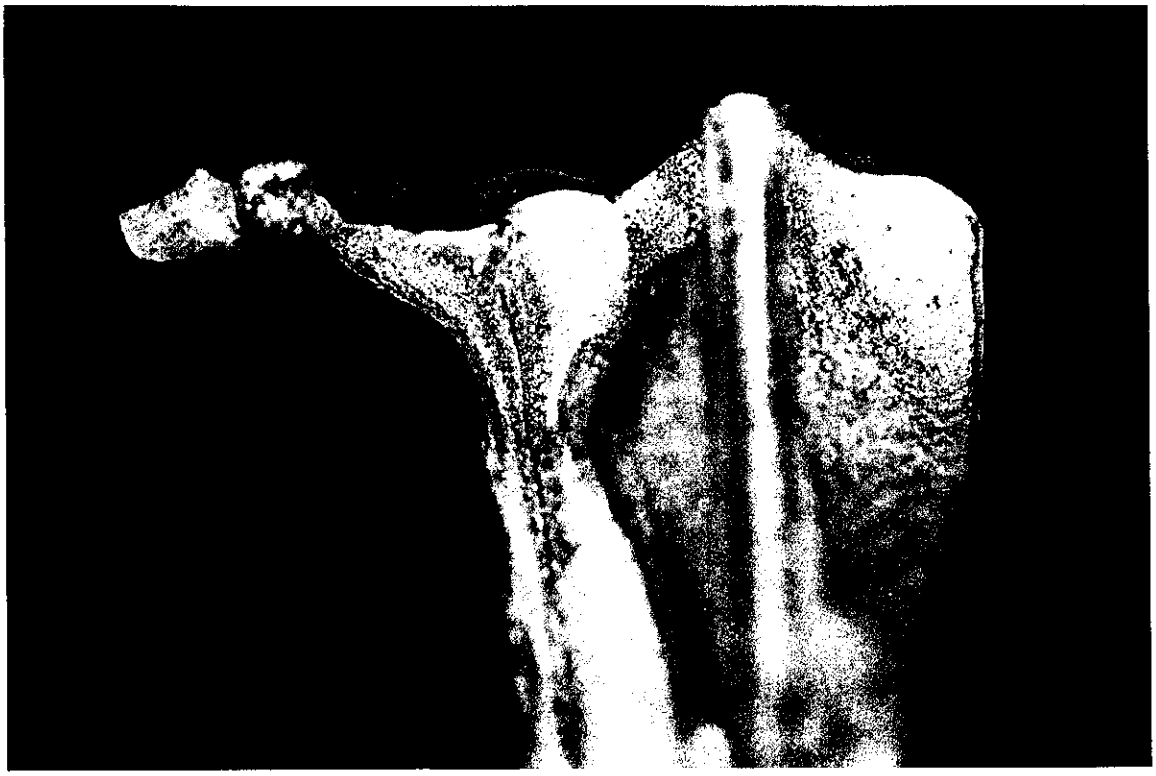
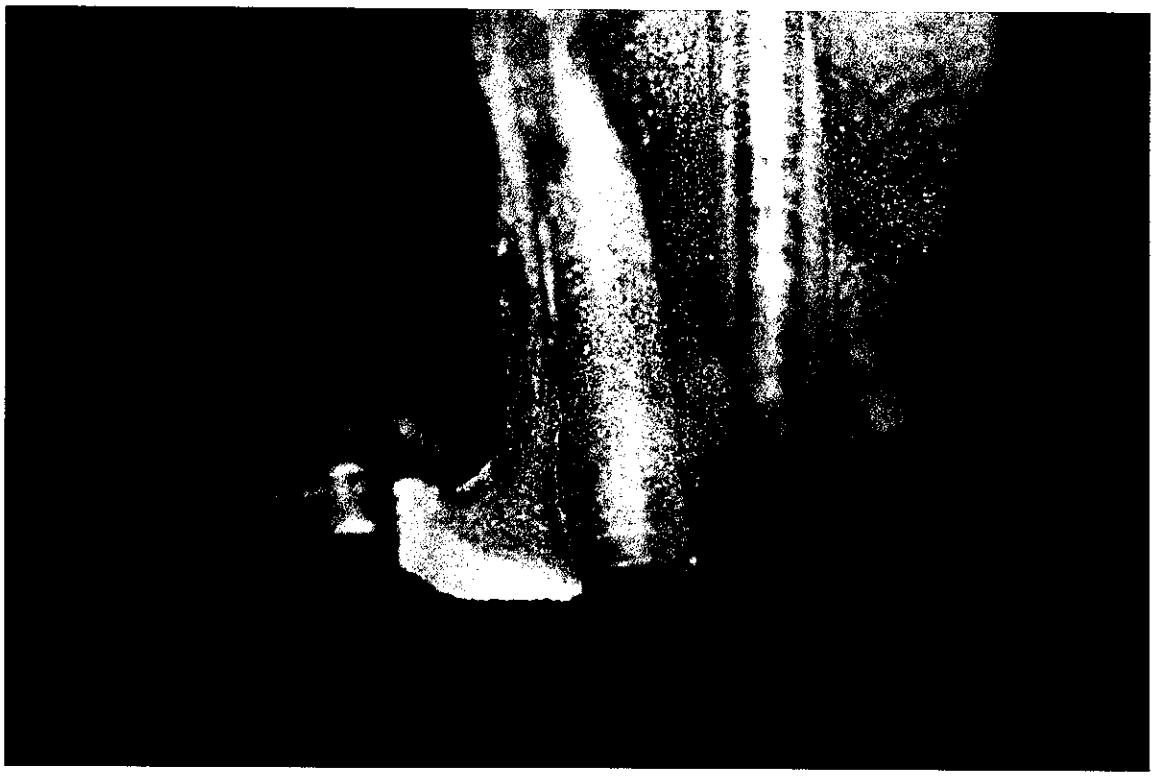


(b)

Figure 5. Color photographs of the failed "Front Top Spar". (a) Overall view. (b) Fracture surface.



(a)



(b)

Figure 6. Color photographs of the failed "Front Top Spar", showing close-up views of the fracture surface. (a) View 1. (b) View 2.

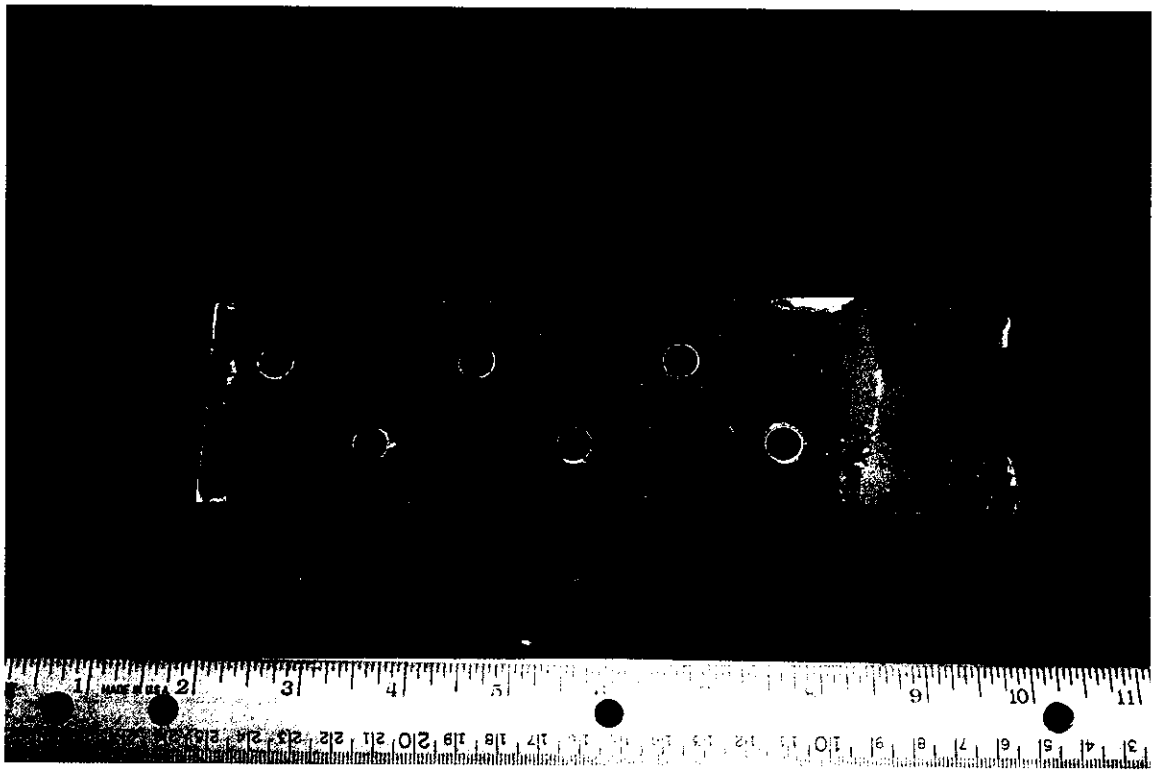
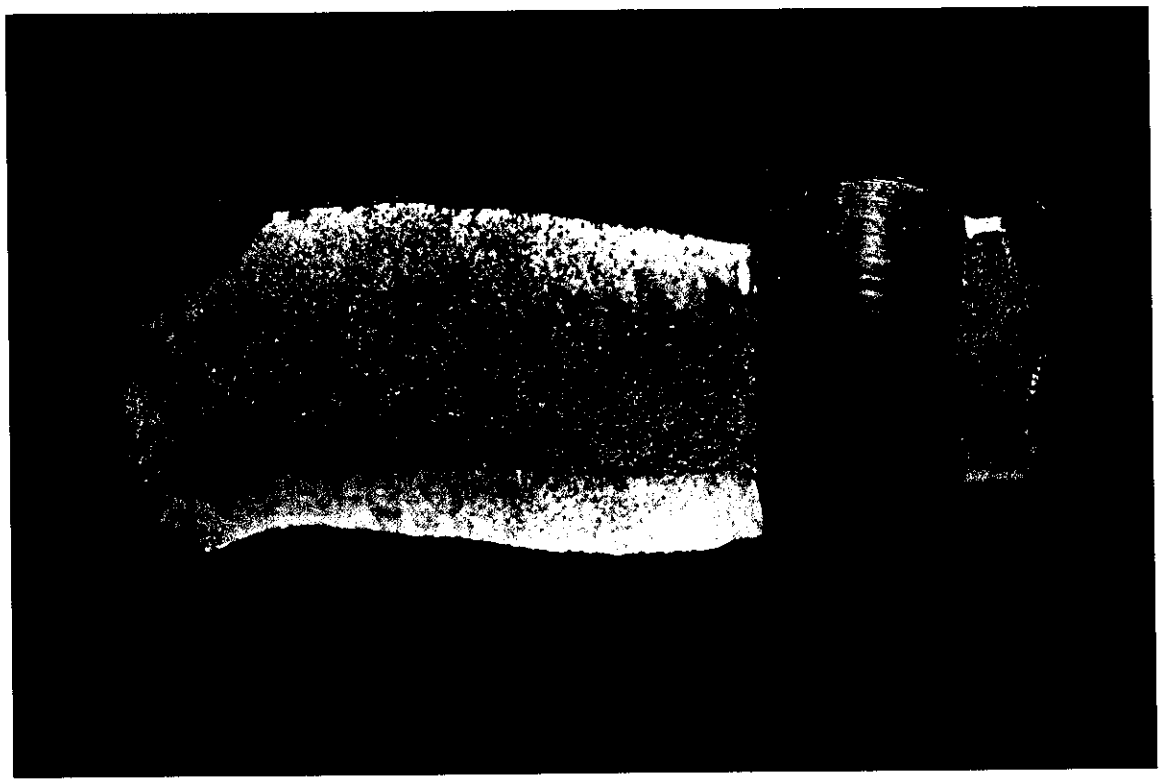


Figure 7. A color photograph of the failed "Rear Top Spar".



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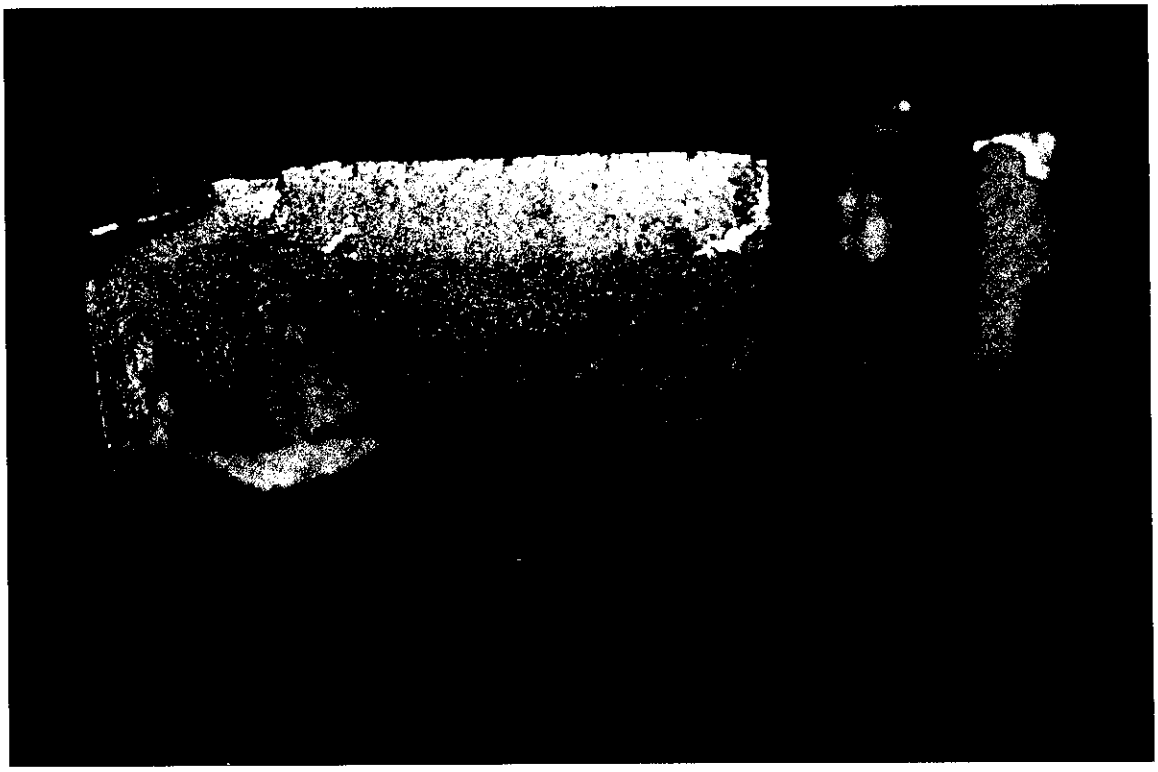
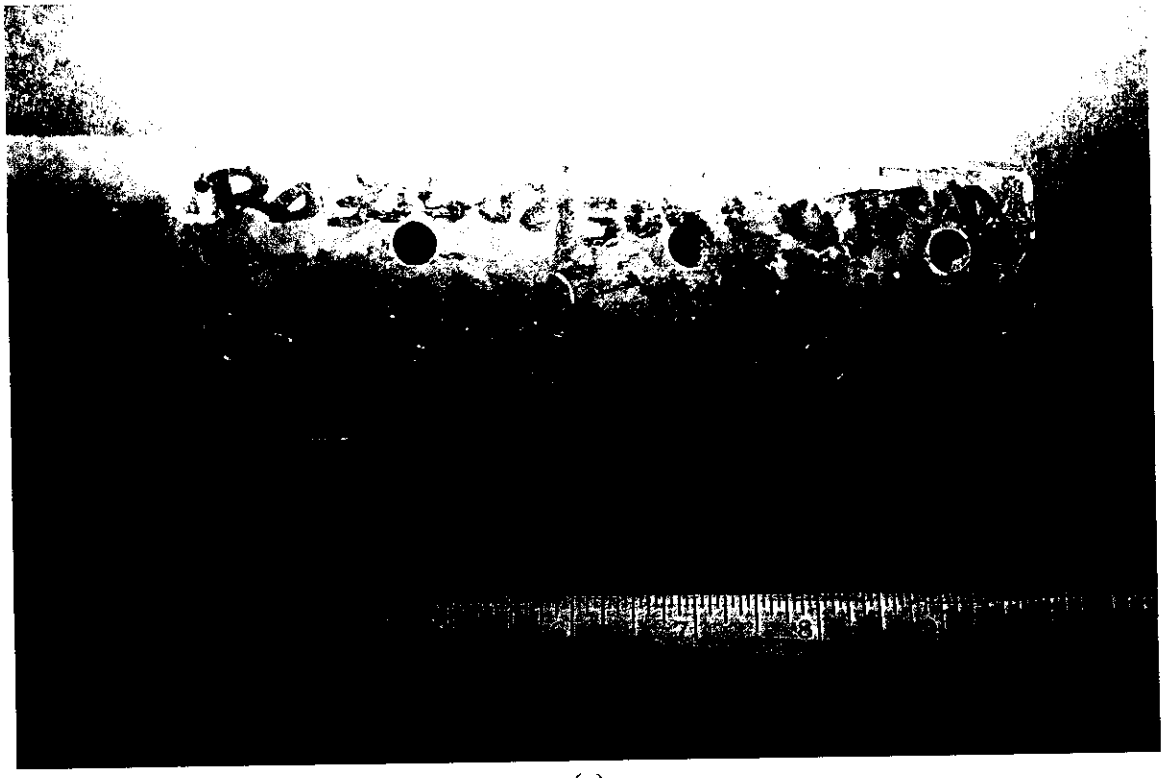


(b)

Figure 8. Color photographs of the failed "Rear Top Spar", showing close-up views of the fracture surface. (a) View 1. (b) View 2.



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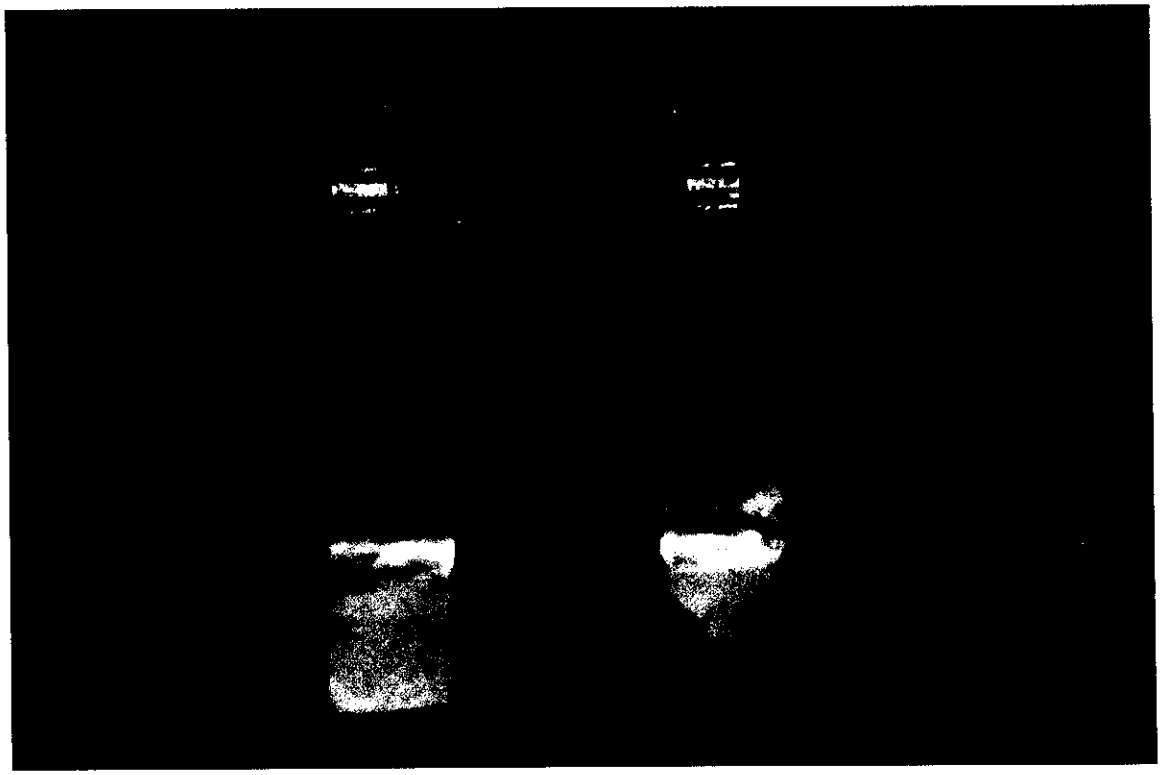


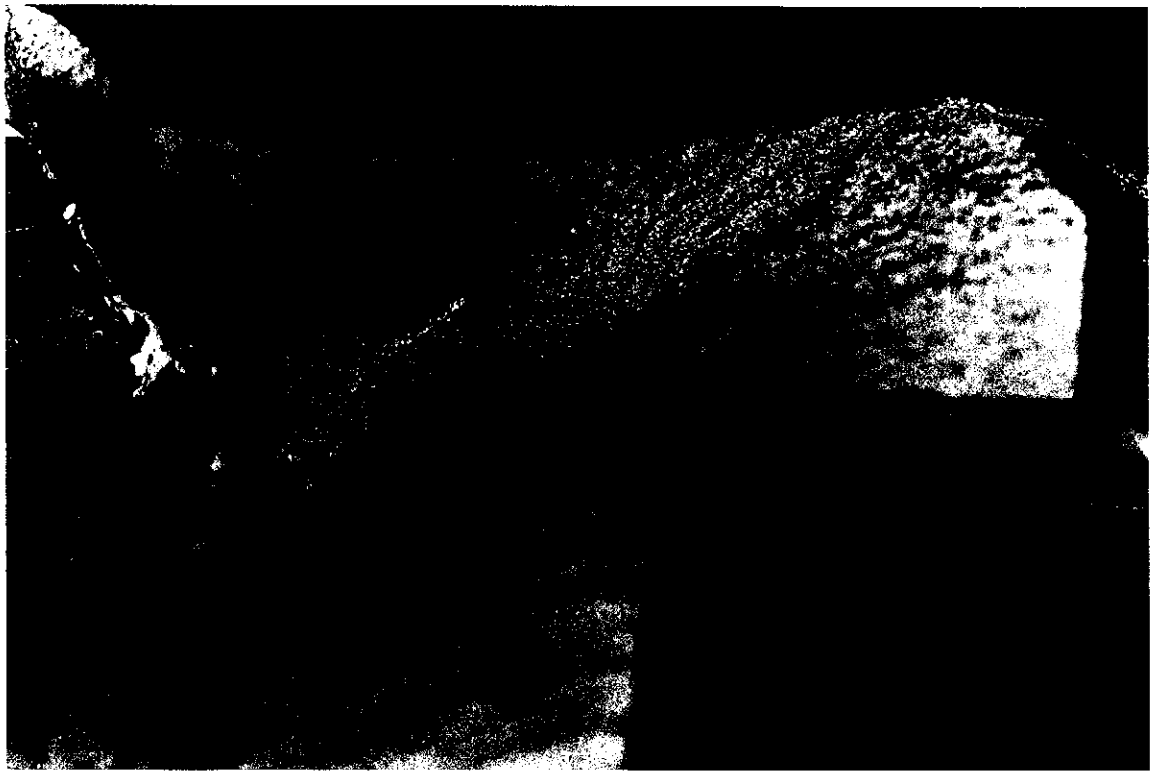
(b)

Figure 9. Color photographs of the failed "Rear Bottom Spar". (a) Overall view. (b) Fracture surface.

(a)

(b)

Figure 10. Color photographs of the failed "Rear Bottom Spar", showing close-up views of the fracture surface. (a) View 1. (b) View 2.



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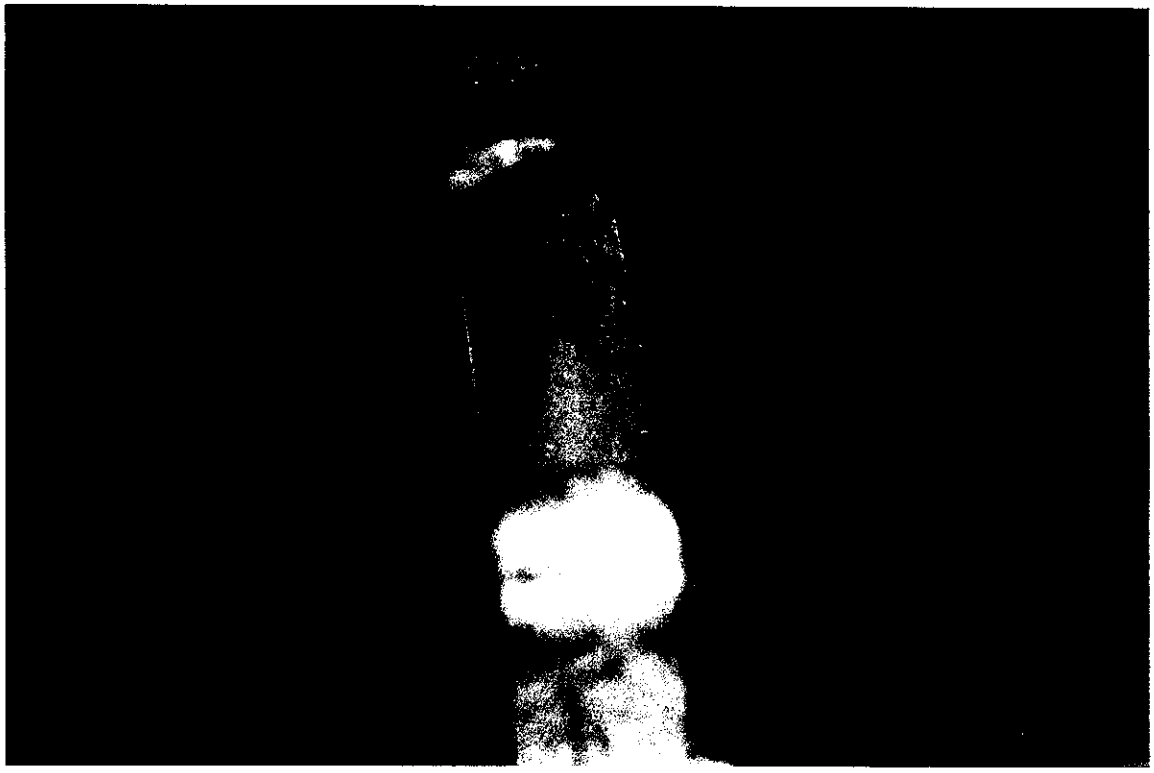
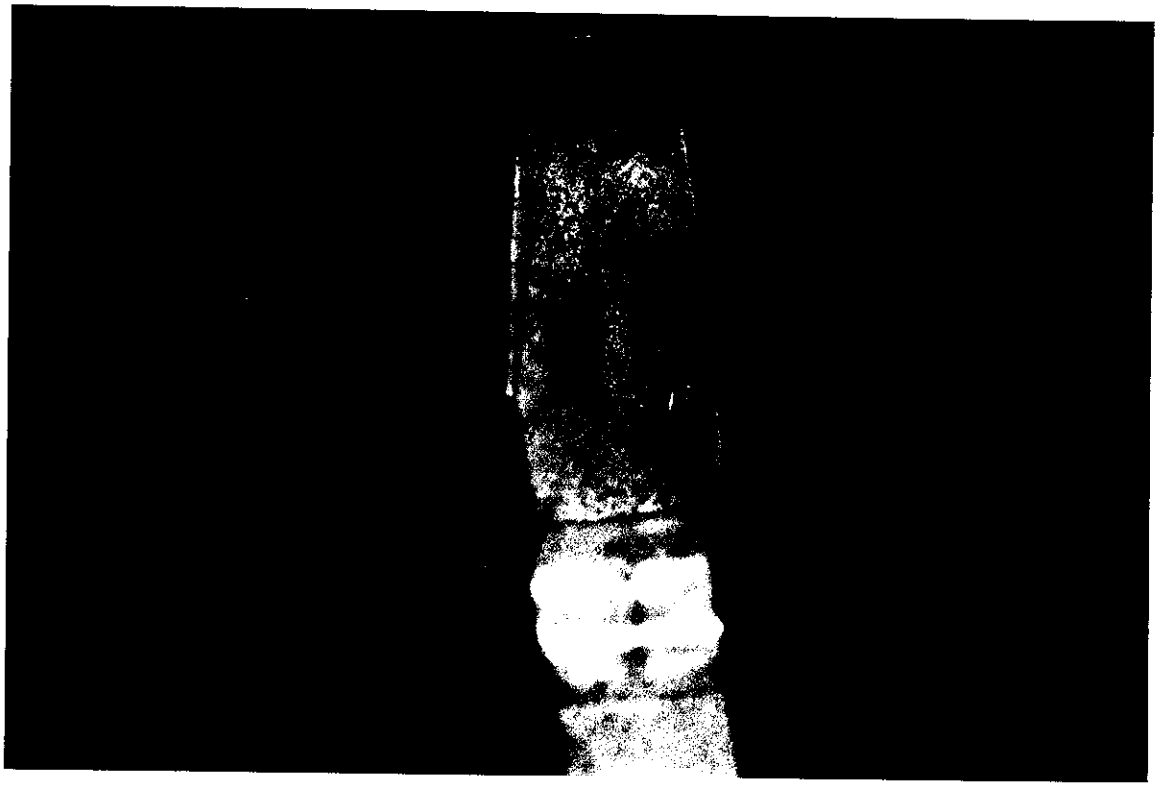
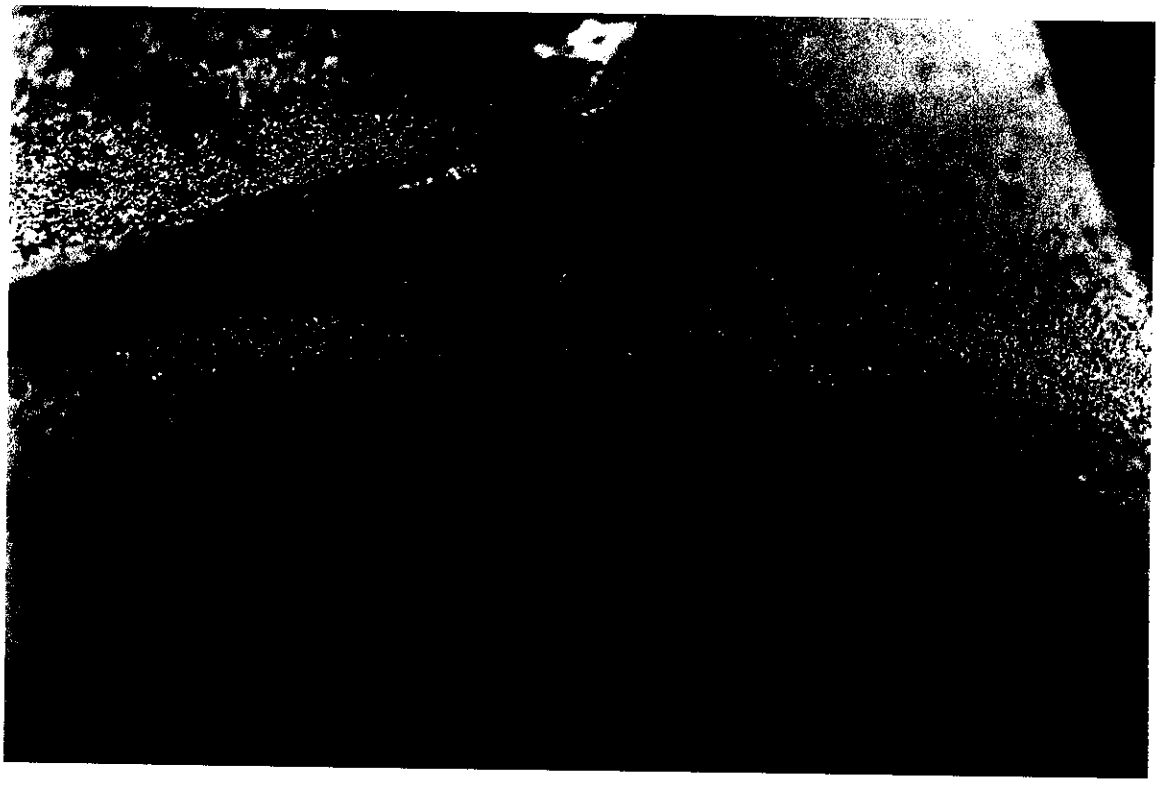


(b)

Figure 11. Color photographs of the failed "Rear Bottom Spar", showing close-up views of the fracture surface. (a) View 3. (b) View 4.

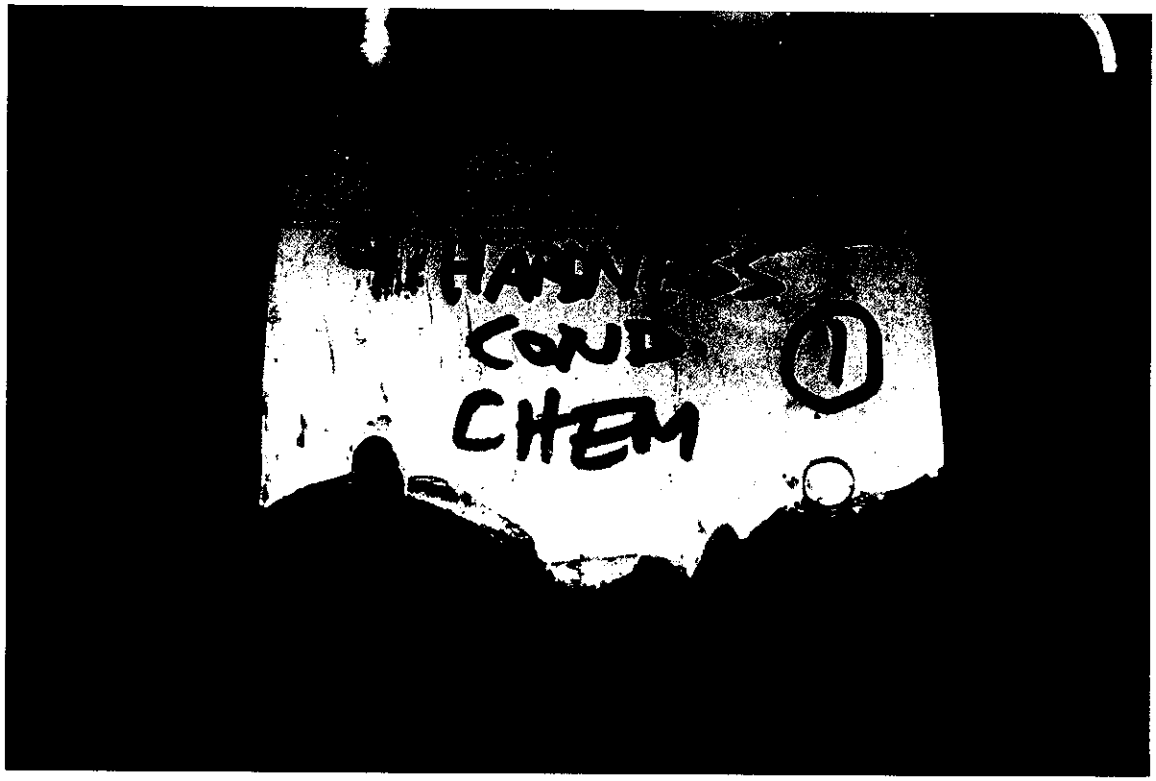


(a)



(b)

Figure 12. Color photographs of the failed "Rear Bottom Spar", showing close-up views of the fracture surface. (a) View 5. (b) View 6.



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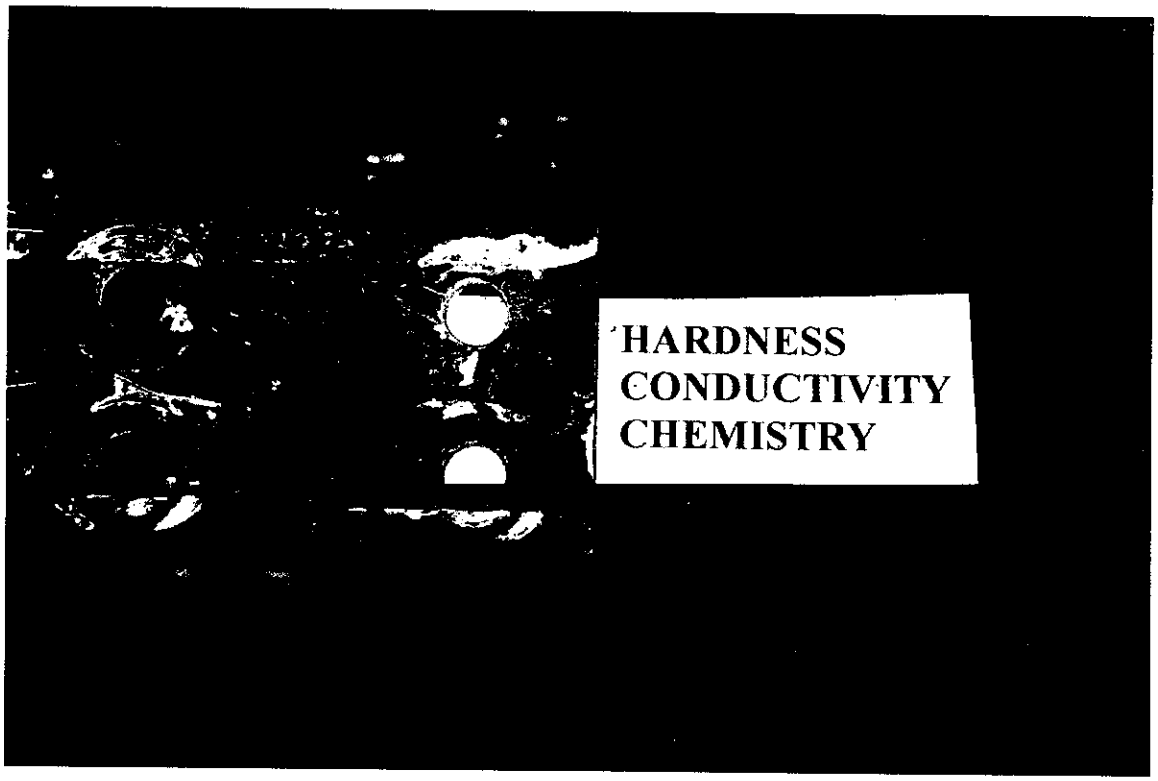
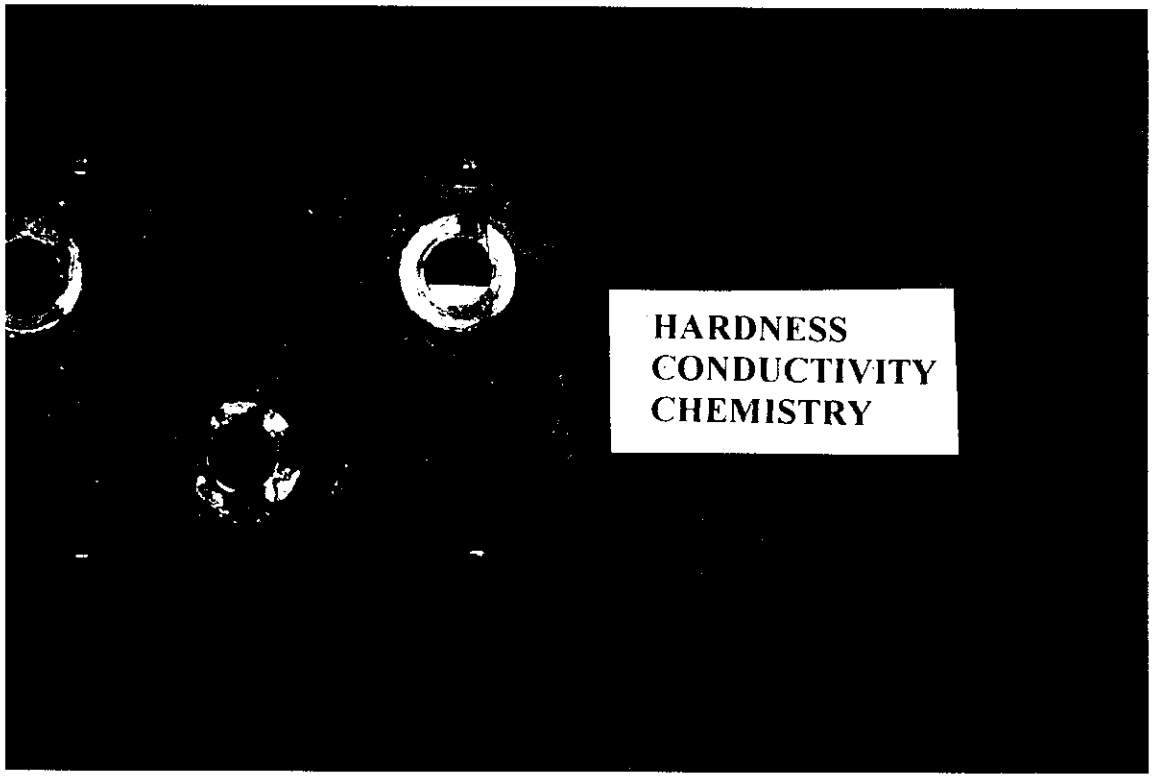


(b)

Figure 13. Color photographs showing the location of specimens for chemical analysis, hardness testing, and electrical conductivity. (a) Front Bottom Spar. (b) Front Top Spar.



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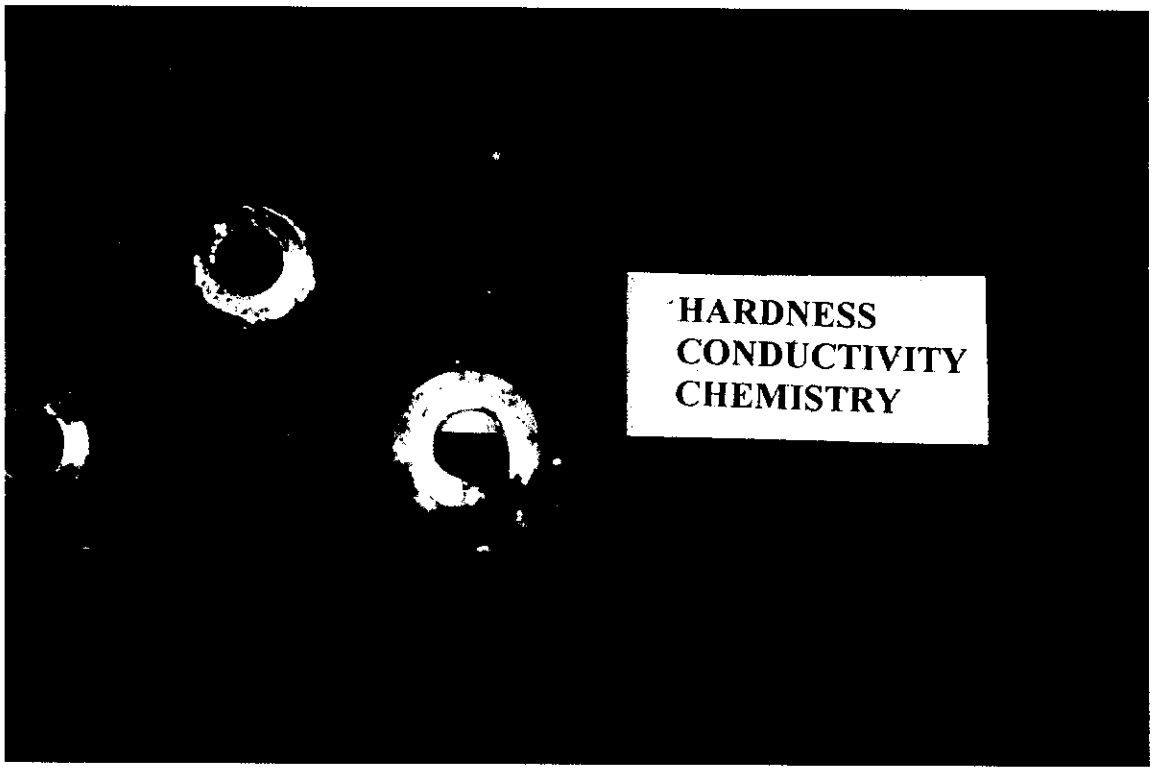
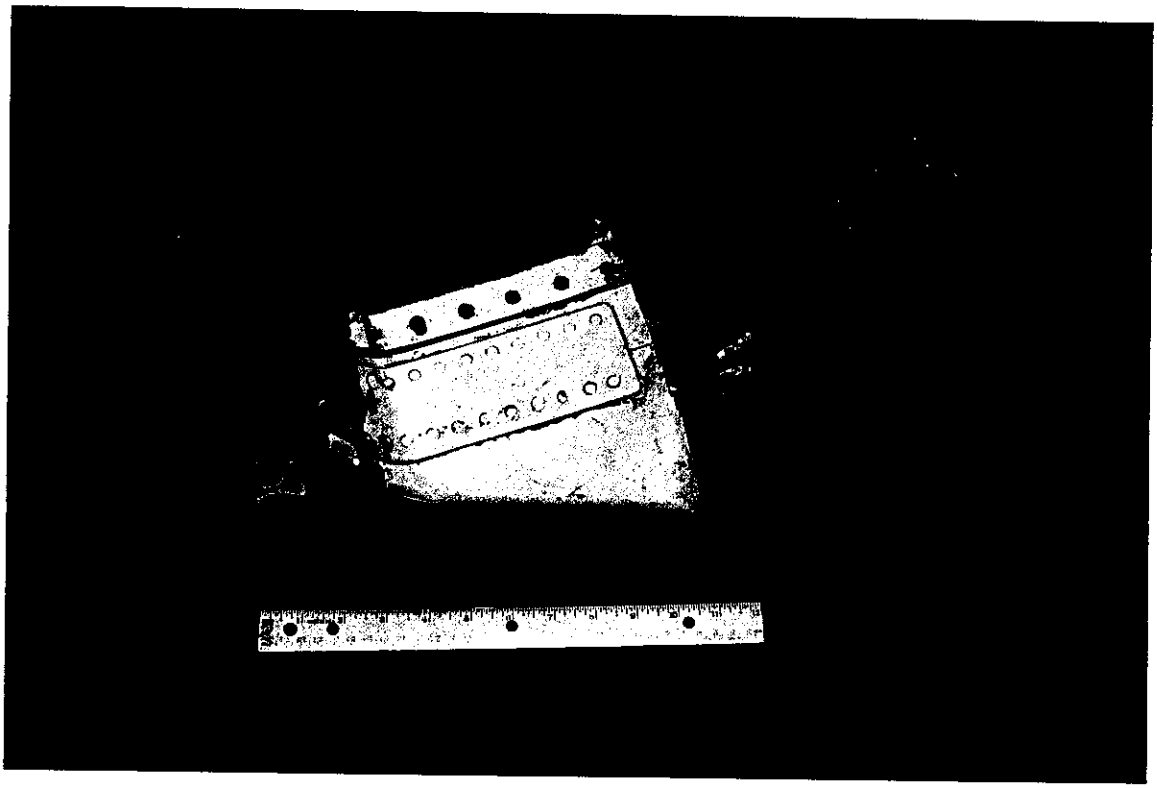


(b)

Figure 14. Color photographs showing the location of specimens for chemical analysis, hardness testing, and electrical conductivity. (a) Rear Top Spar. (b) Rear Bottom Spar.



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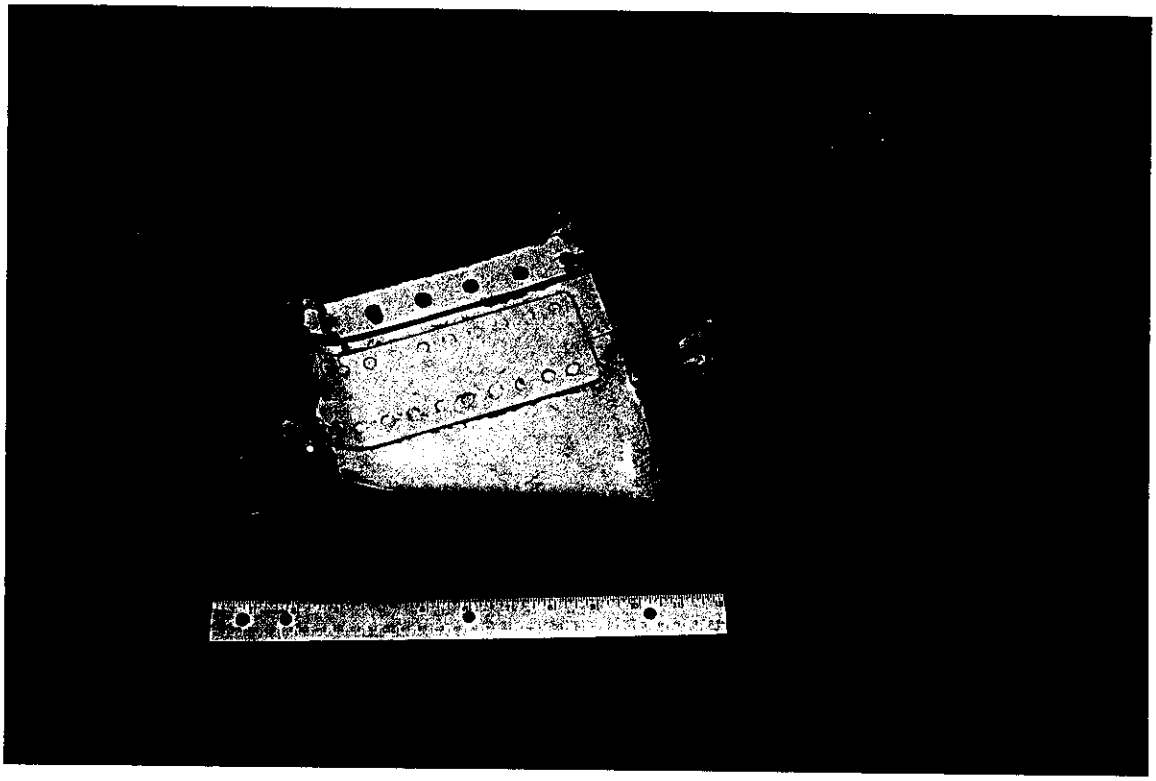
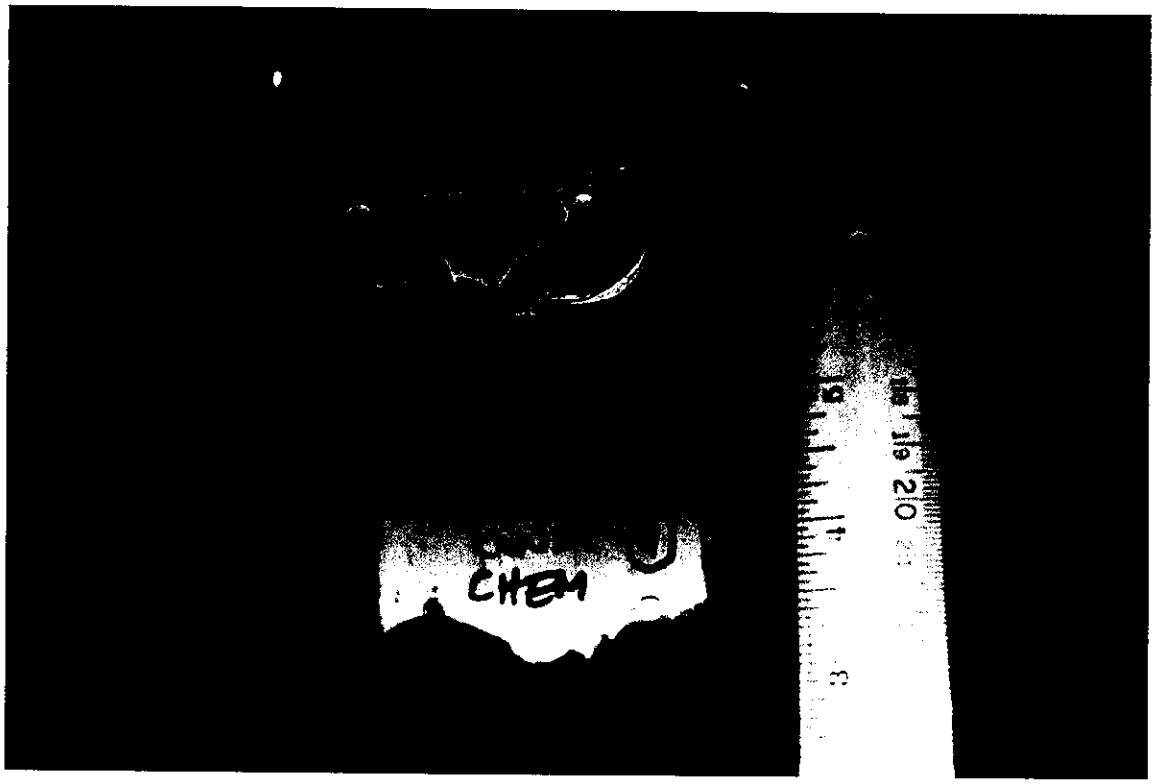


(b)

Figure 15. Color photographs of the failed "Front Bottom Spar", showing a fracture surface after the specimen for chemical analysis was partially cut. (a) View 1. (b) View 2.



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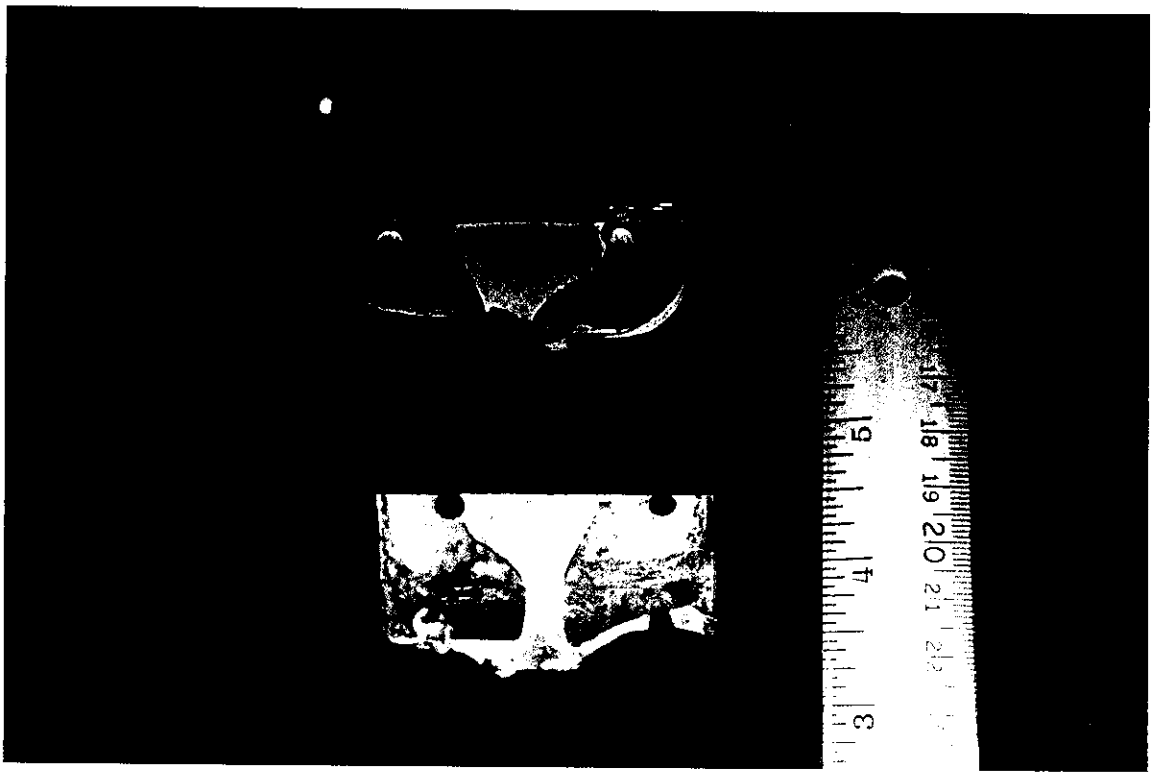
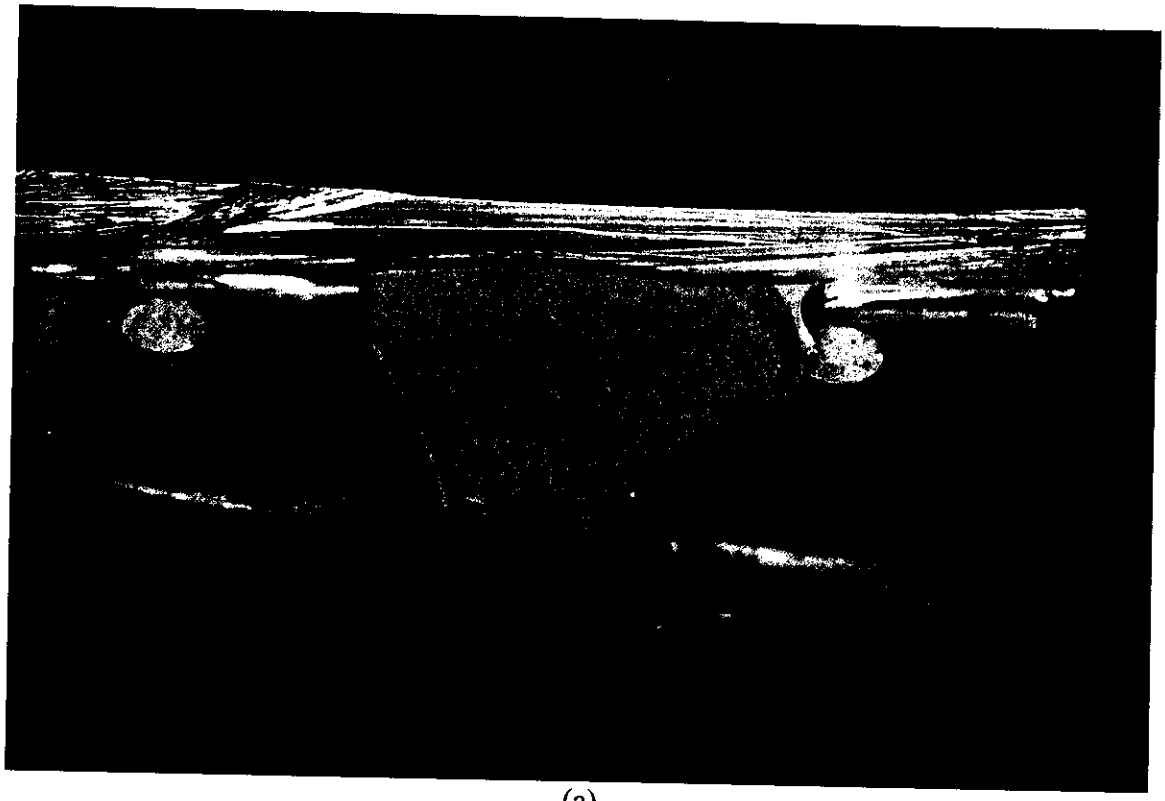


(b)

Figure 16. Color photographs of the failed "Front Bottom Spar", showing the fracture surface revealed after cutting the specimen. (a) View 1. (b) View 2.



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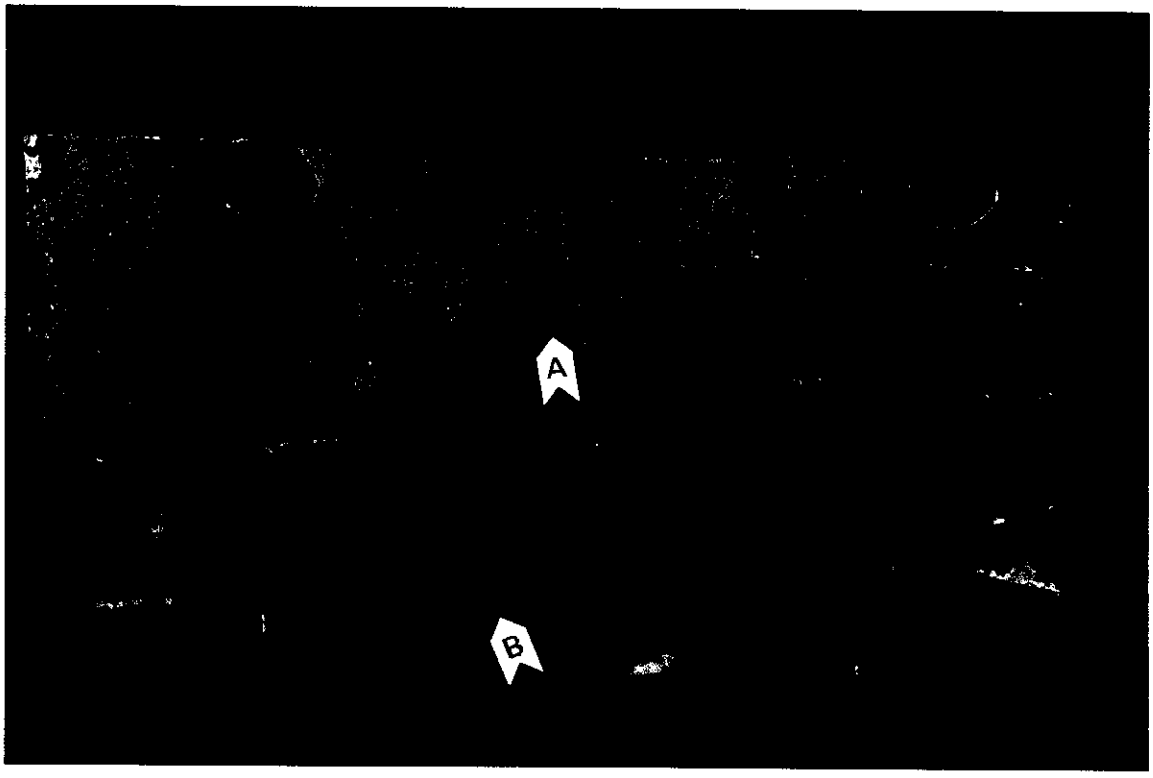
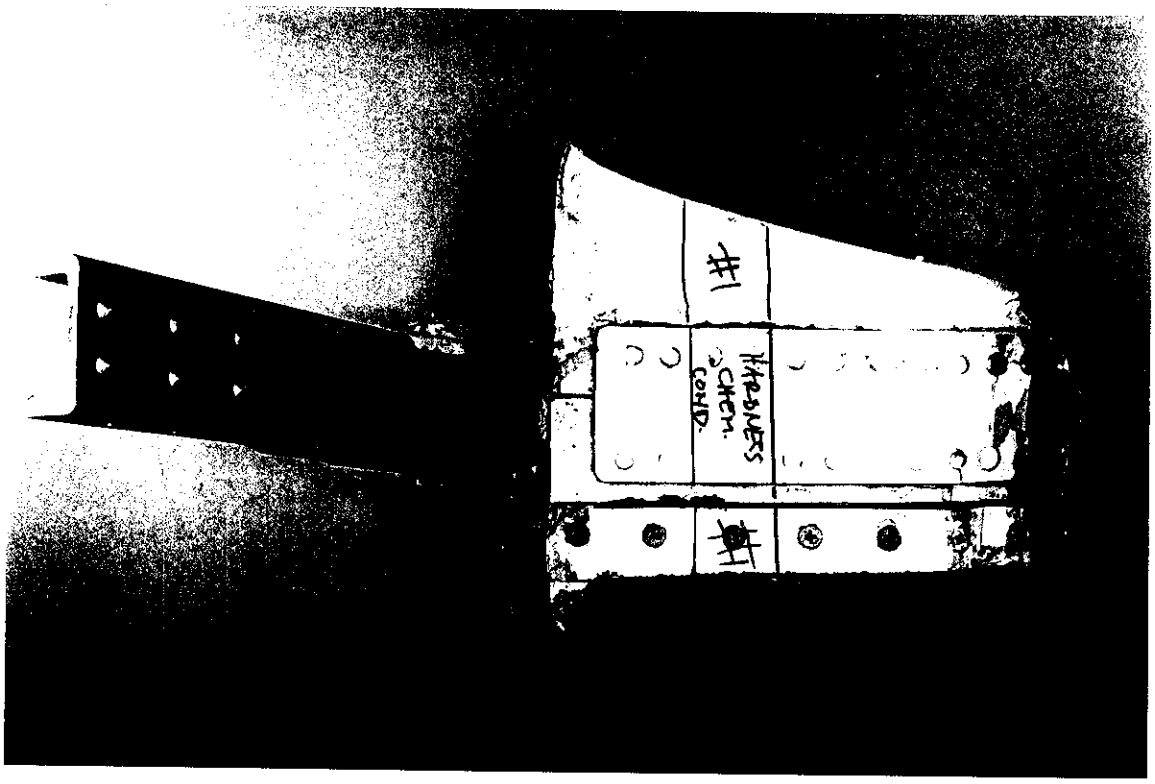
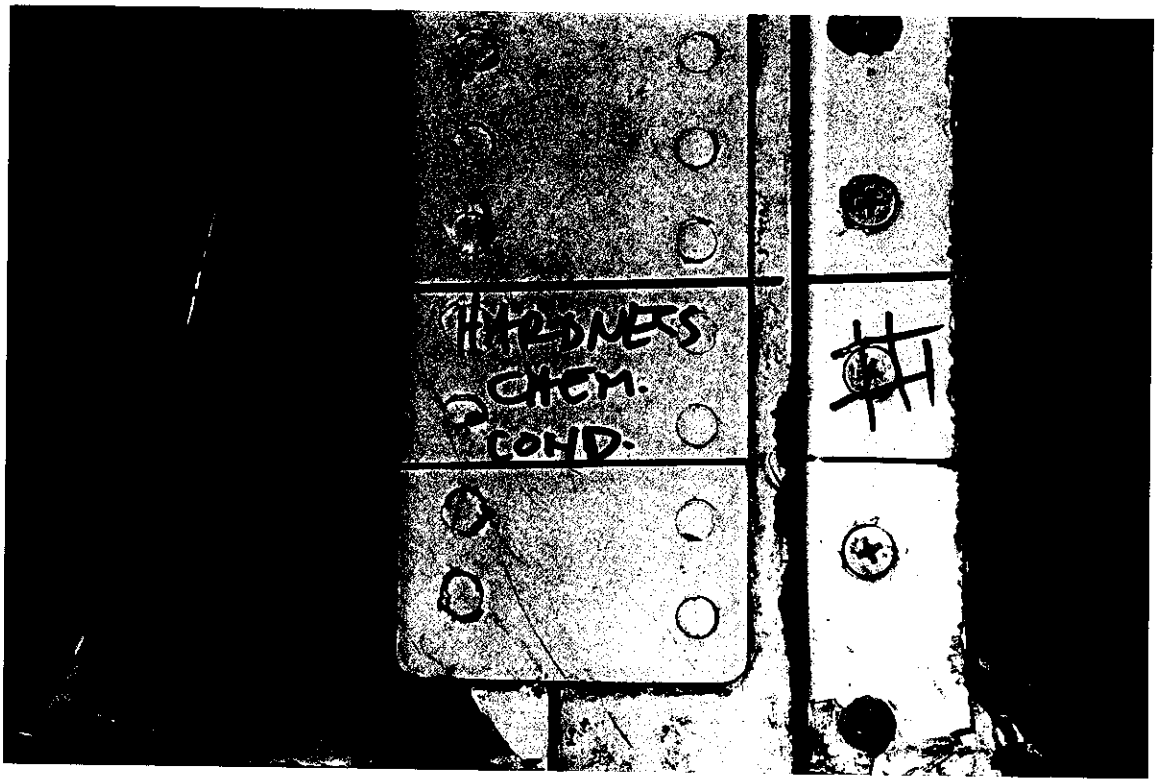


(b)

Figure 17. Color photographs of the failed "Front Bottom Spar", showing close-up views of the fracture surface of the secondary crack. (a) Fracture surface on the spar. (b) Fracture surface on the cut piece.



(a)



(b)

Figure 18. Color photographs of the failed "Front Bottom Spar", showing the new location of specimen for chemical analysis, hardness testing and electrical conductivity. (a) Overall view. (b) Close-up view.

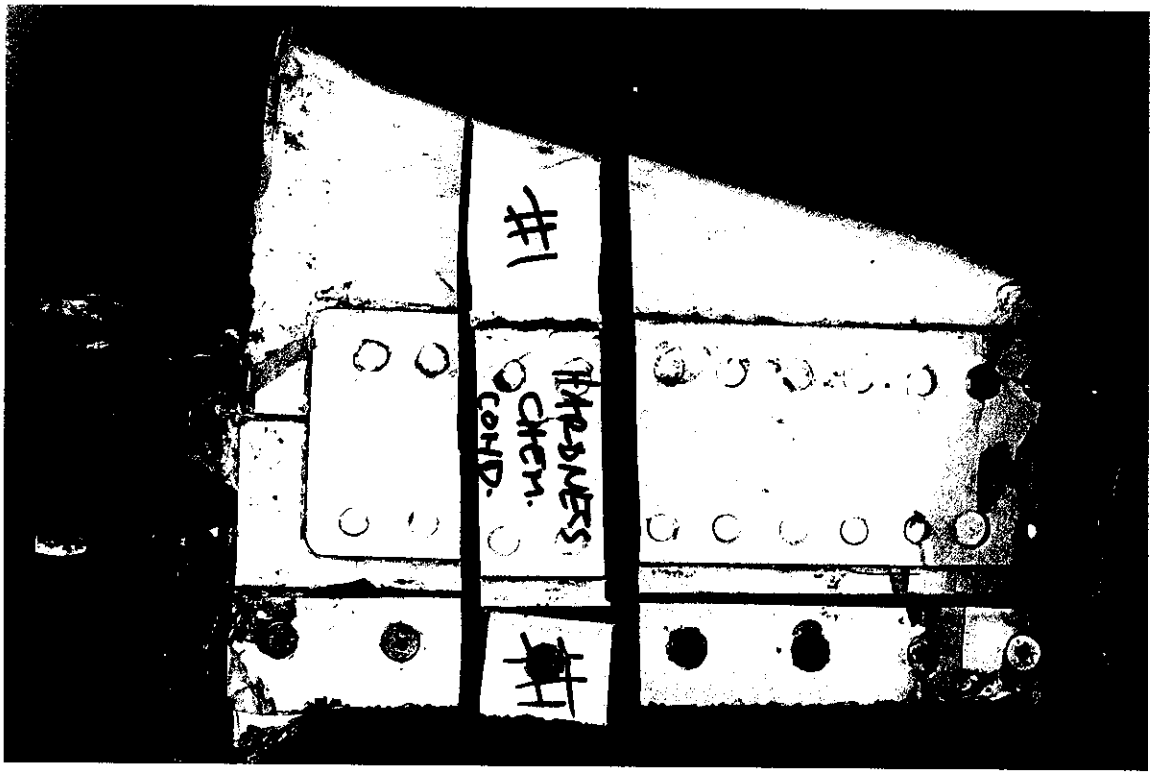
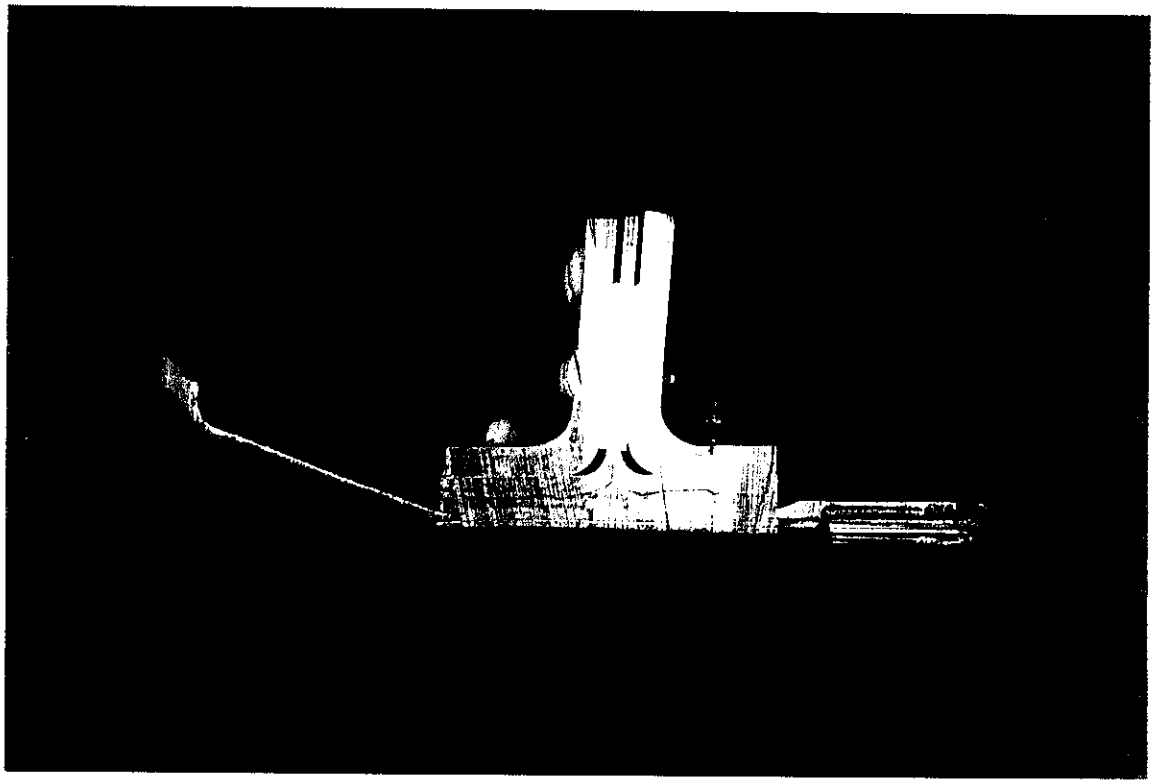
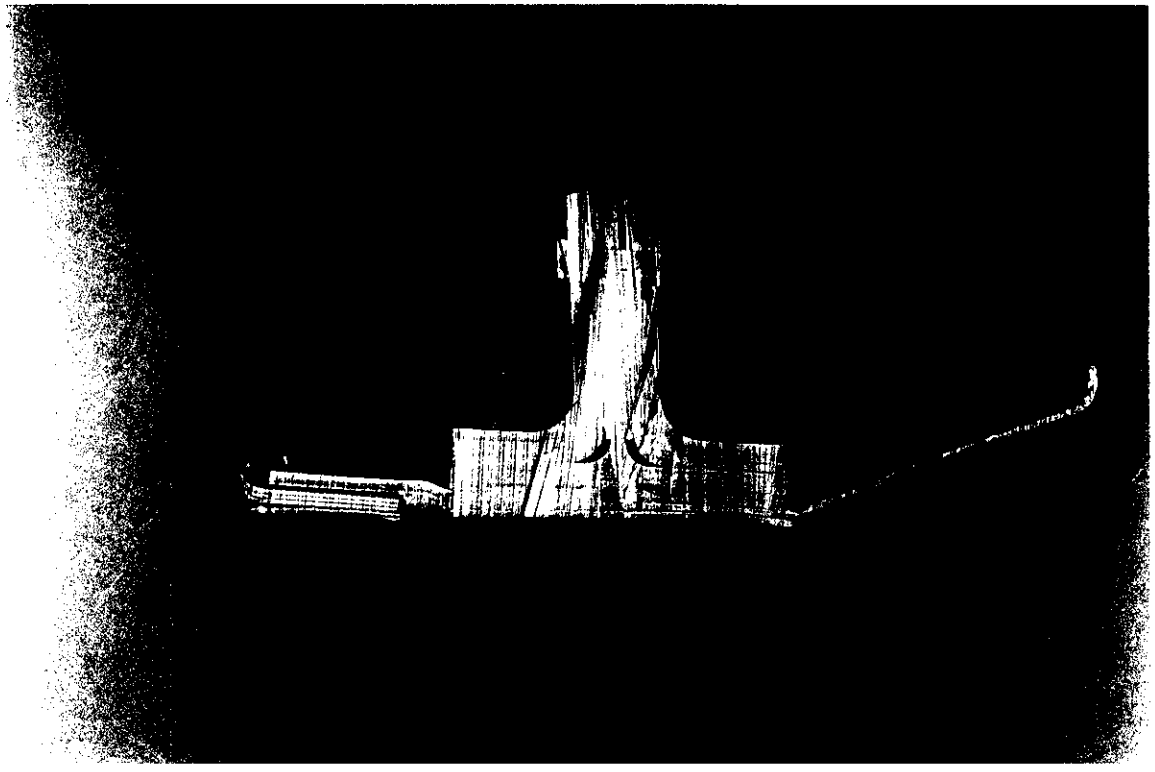


Figure 19. A color photograph of the failed "Front Bottom Spar", showing the specimen for chemical analysis, hardness testing and electrical conductivity after cutting.



(a)



(b)

Figure 20. Color photographs of the failed "Front Bottom Spar", showing the cut specimen for chemical analysis, hardness testing and electrical conductivity. (a) Side 1. (b) Side 2.

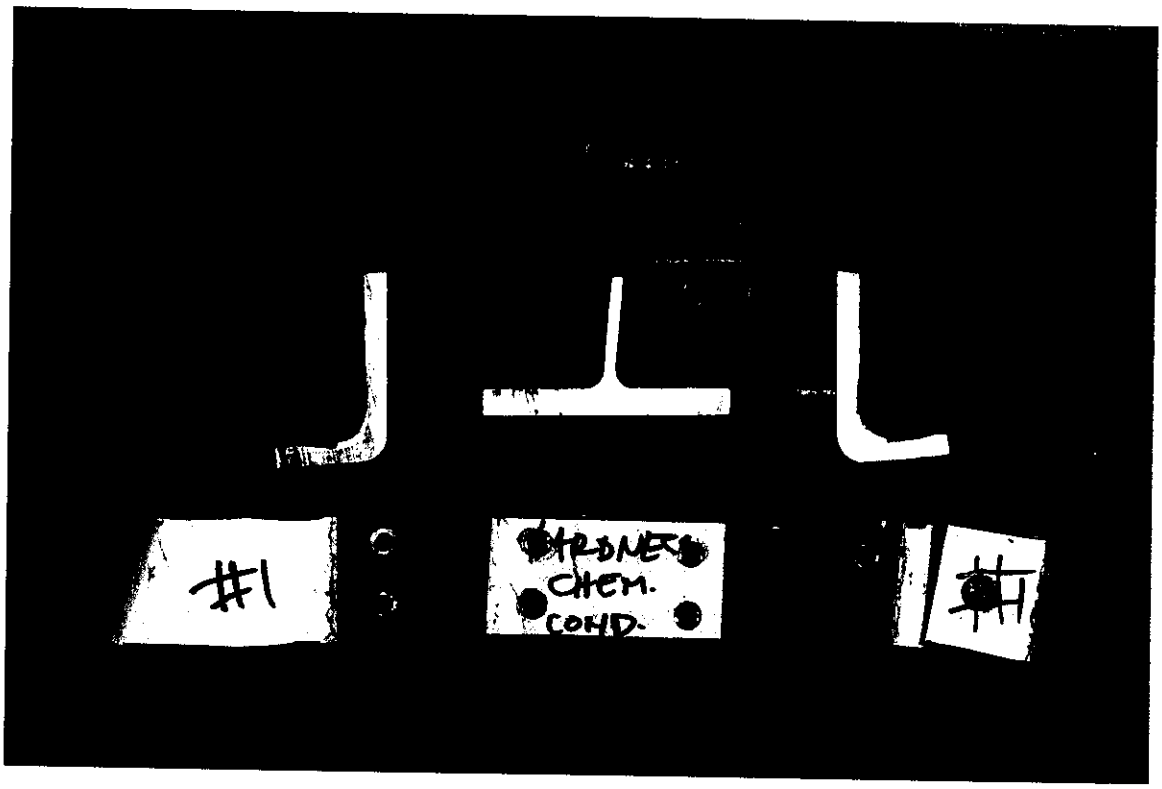


Figure 21. A color photograph of the failed "Front Bottom Spar", showing the disassembled cut piece and the removed specimen for chemical analysis, hardness testing and electrical conductivity after cutting.

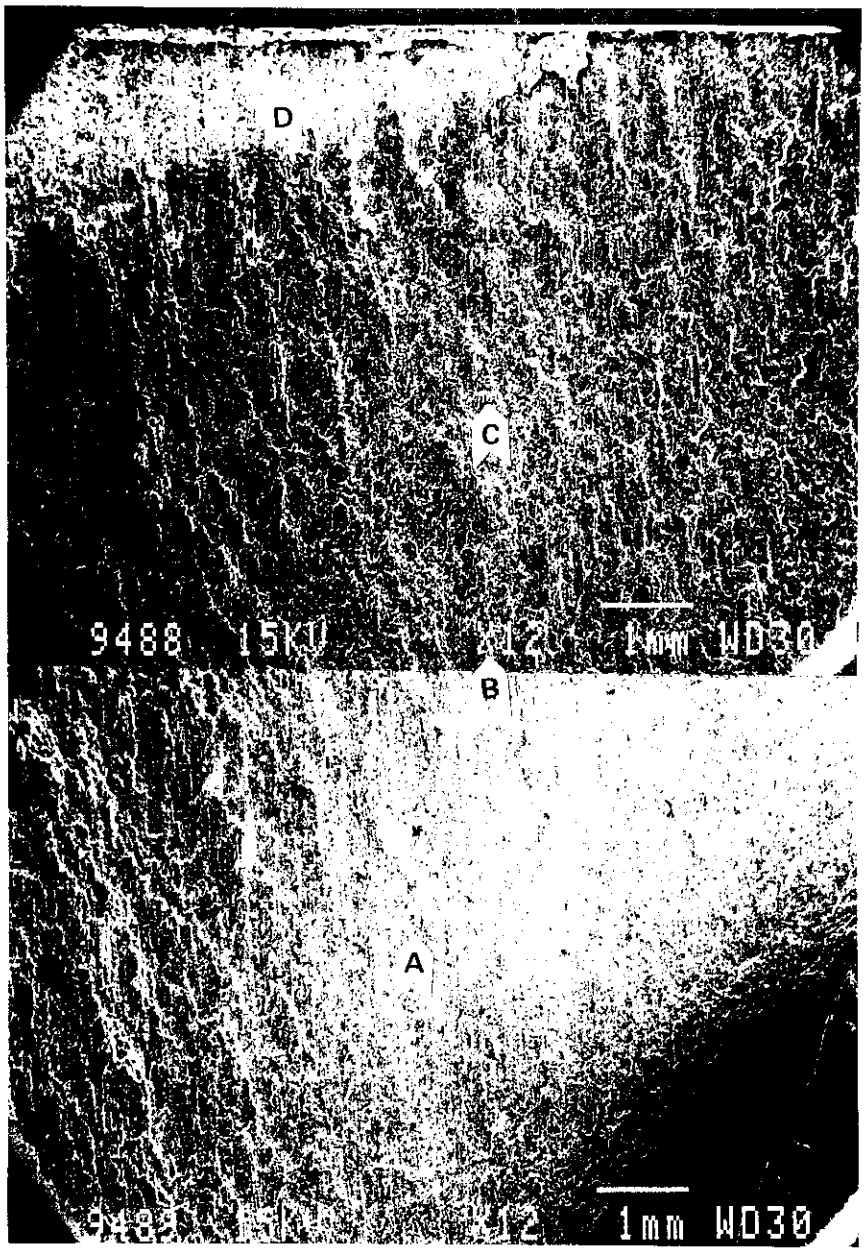
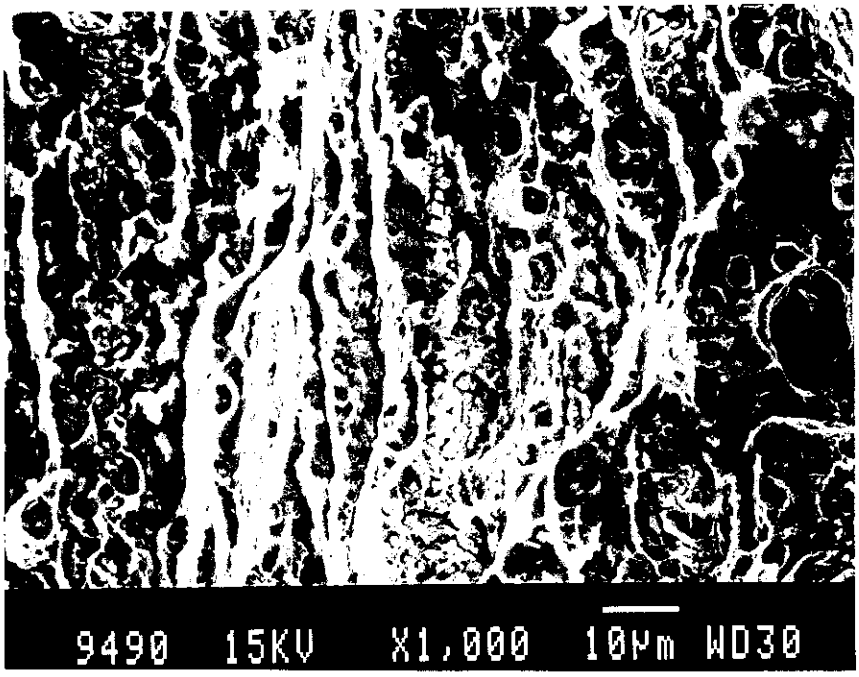
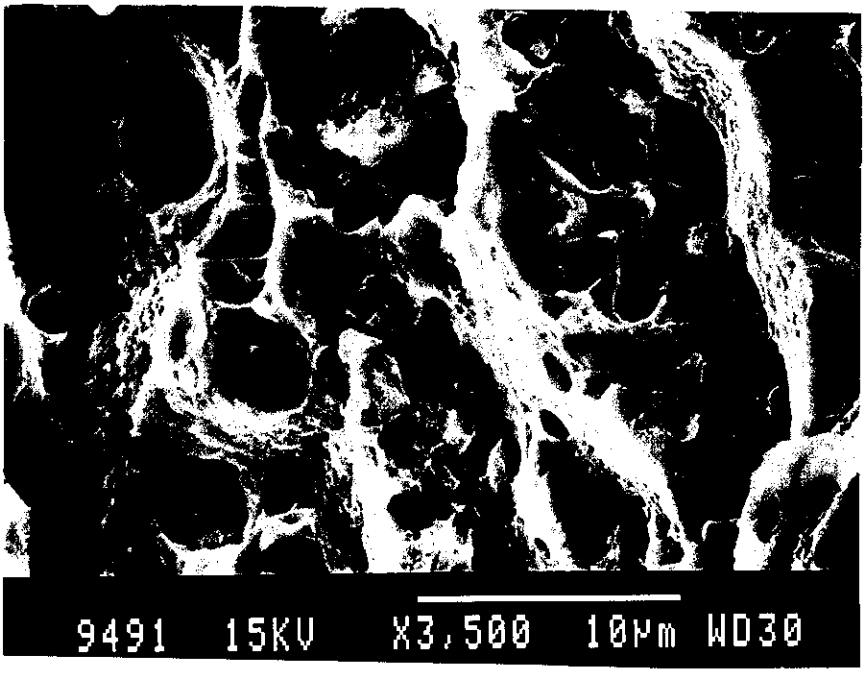


Figure 22. A montage of SEM fractographs obtained from a portion of the fracture surface of "Front Bottom Spar" marked "A" in Figure 17(b), showing the locations of subsequent fractographs; 12X.

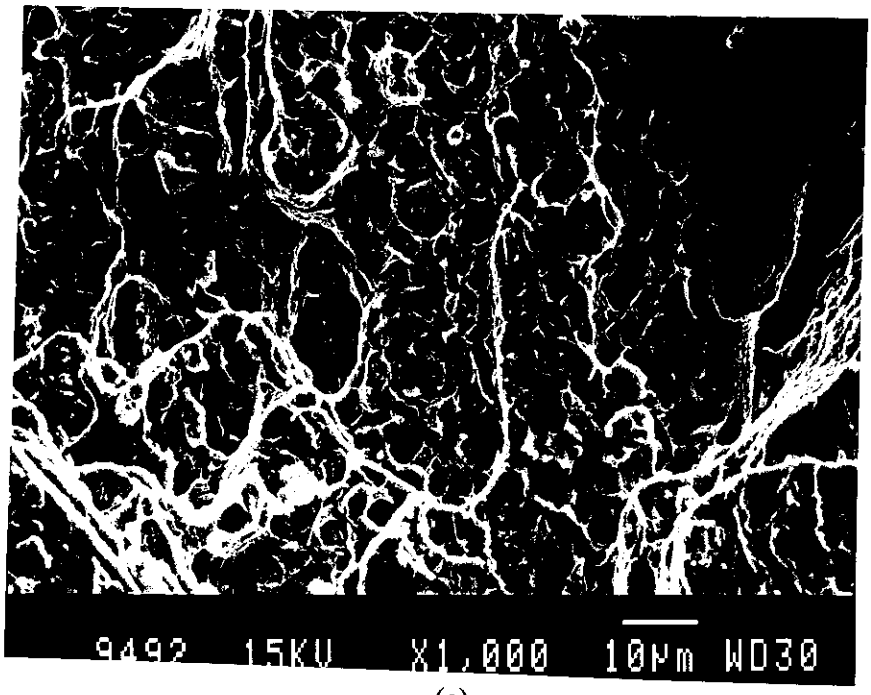


(a)

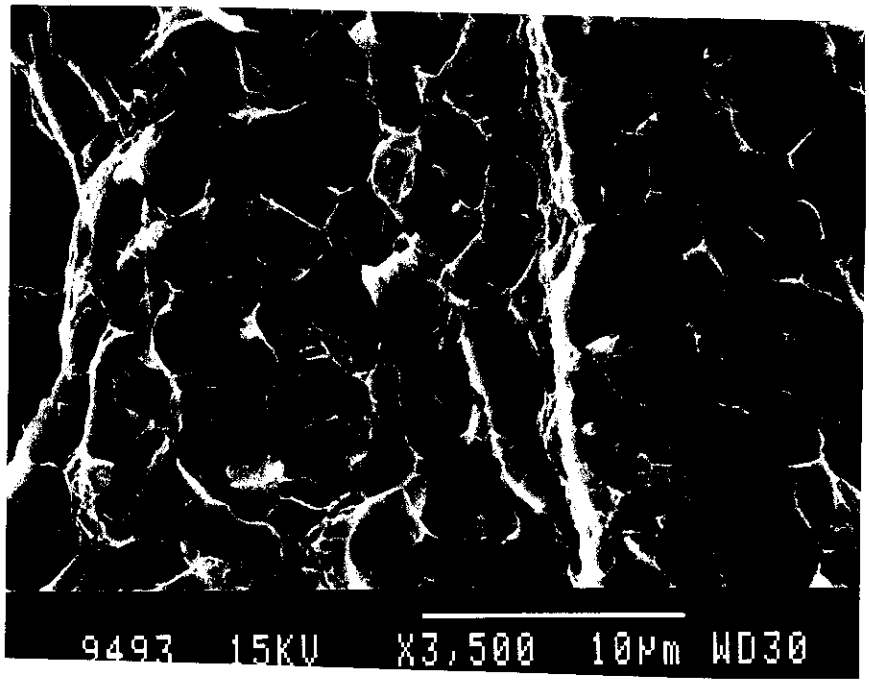


(b)

Figure 23. SEM fractographs obtained from an area marked "A" in Figure 22, showing dimples indicative of an overload fracture. (a) 1,000X. (b) 3,500X.

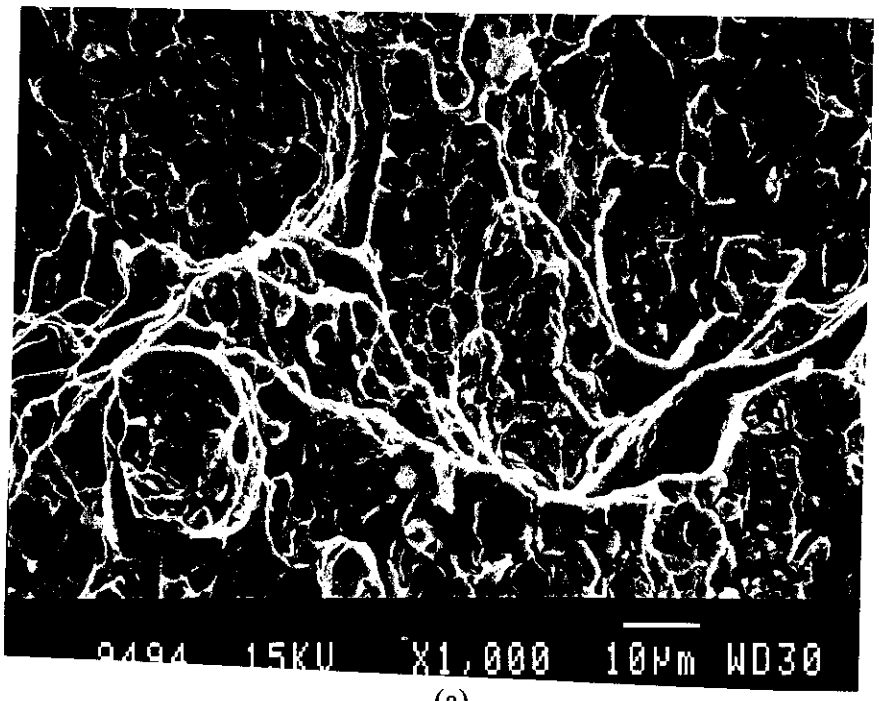


(a)

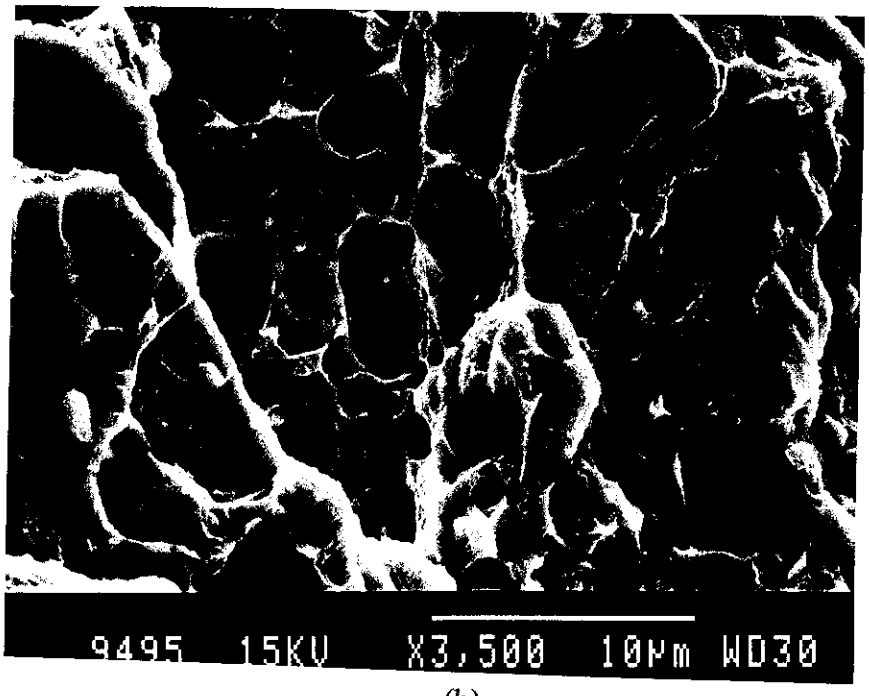


(b)

Figure 24. SEM fractographs obtained from an area marked "B" in Figure 22, showing dimples indicative of an overload fracture. (a) 1,000X. (b) 3,500X.

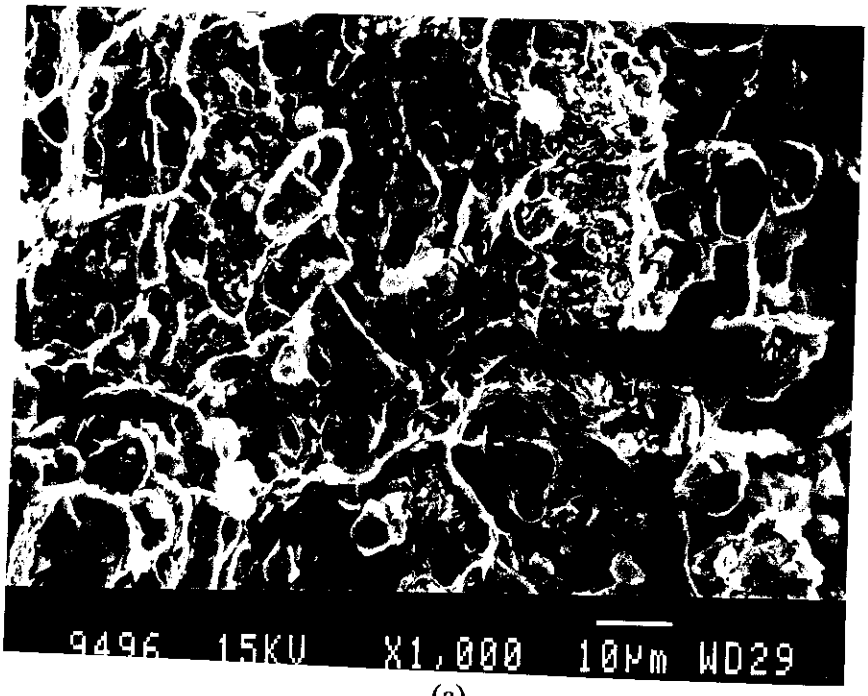


(a)

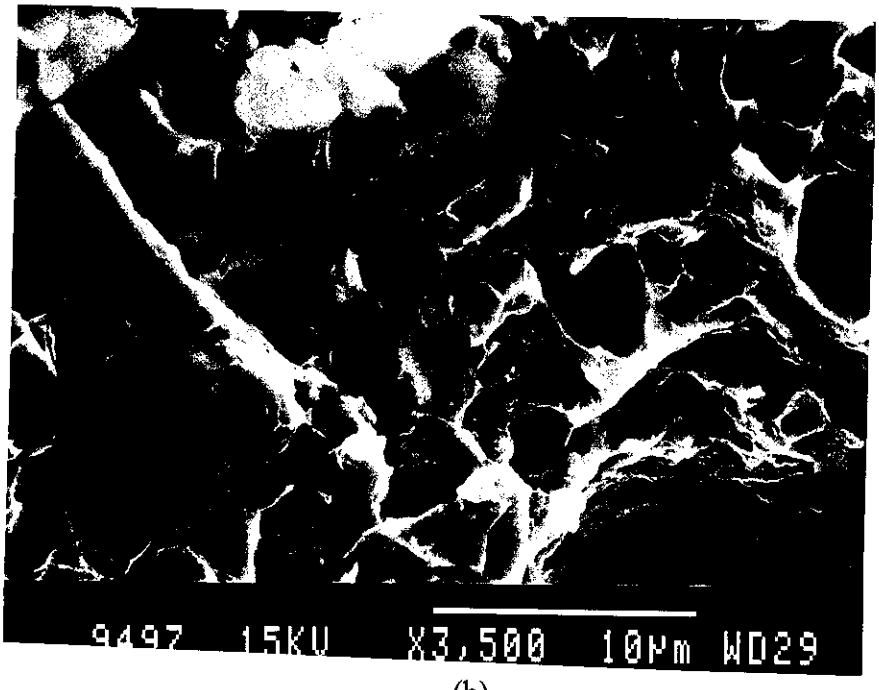


(b)

Figure 25. SEM fractographs obtained from an area marked "C" in Figure 22, showing dimples indicative of an overload fracture. (a) 1,000X. (b) 3,500X.



(a)



(b)

Figure 26. SEM fractographs obtained from an area marked "D" in Figure 22, showing dimples indicative of an overload fracture. (a) 1,000X. (b) 3,500X.

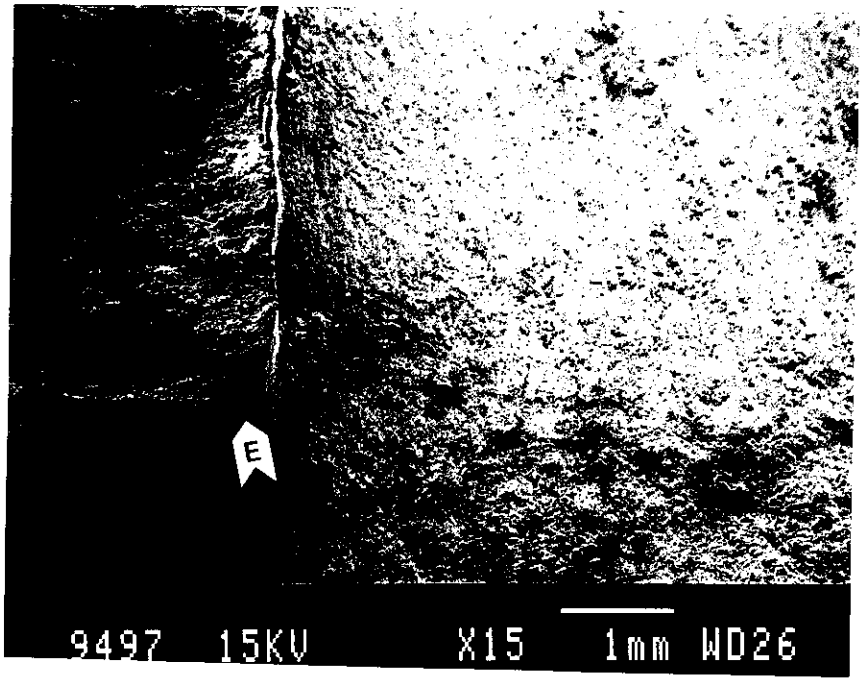
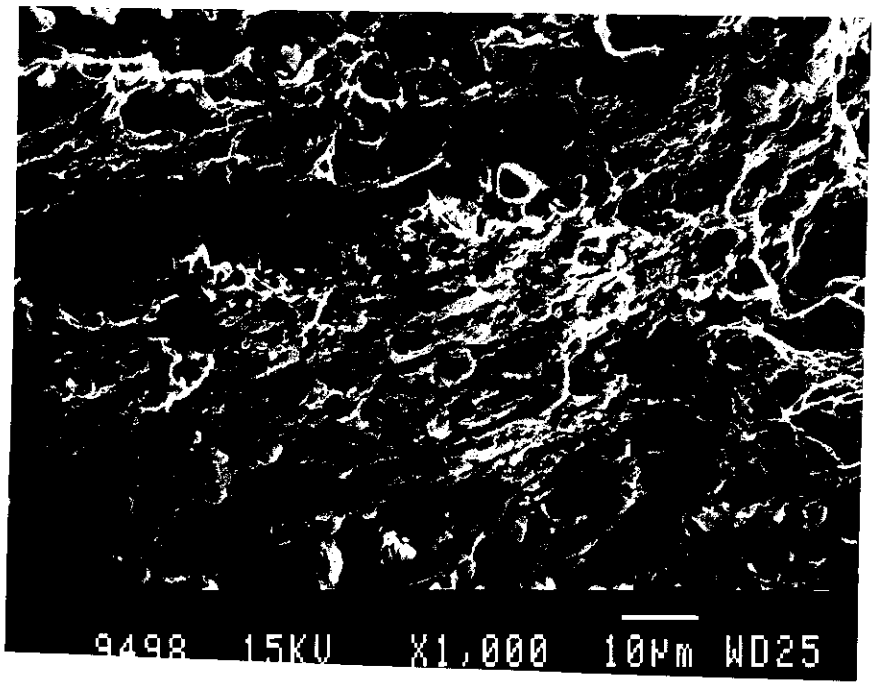
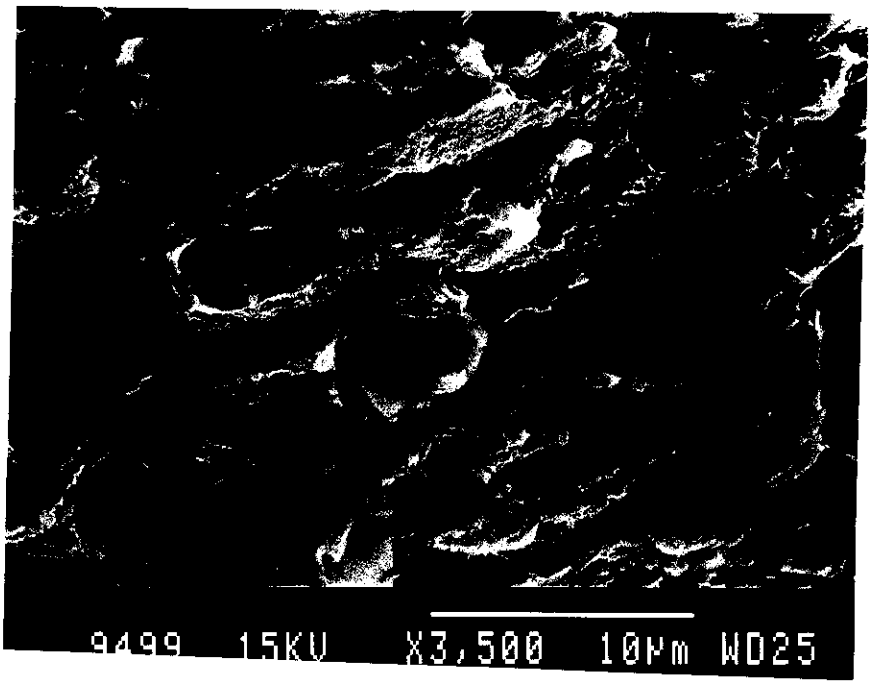


Figure 27. An SEM fractograph obtained from an area marked "B" in Figure 17(b), showing the location of subsequent fractographs; 15X.



(a)



(b)

Figure 28. SEM fractographs obtained from an area marked "E" in Figure 27, showing dimples indicative of an overload fracture. (a) 1,000X. (b) 3,500X.