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SUBMITTAL OF CONTAINMENT SURVEILLANCE TENDON TEST RESULTS

Gentlemen:

In accordance with H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2 Technical Specifications Section 5.6.7.b, Carolina Power & Light (CP&L) Company is submitting the attached report, "Inspection and Evaluation of Containment Prestressed Tendon 25-Year Surveillance Block." The testing was performed after 25 years of operation in accordance with Technical Specifications Section 5.5.6, "Pre-Stressed Concrete Containment Tendon Surveillance Program," to determine if there is any evidence of corrosion of the sheaths or tendons and determine the tendon ultimate strength. Visual inspection of the sheaths and tendons was performed to detect and record evidence of corrosion. Tensile tests of selected bars were performed to develop stress-strain diagrams and determine the bars' ultimate tensile strengths.

CP&L has evaluated the report in accordance with plant procedures, and in accordance with the criteria of 10 CFR 50.59, and has accepted the conclusions presented therein. The Updated Final Safety Analysis Report (UFSAR) Section 3.8.1.7.2 will be revised to reflect completion of the testing.

As noted in the report, only a superficial oxide was noted on the tendons and minor corrosion pitting on some other surfaces. Each of these were determined to be structurally insignificant.

Mechanical testing of each bar was performed using American Society of Testing and Materials (ASTM) standard tensile base specimens. The properties exceed the UFSAR Section 3.8.1.6.1.3 minimum specified values, and are comparable to the results of the previous five-year testing results.

A001

If you have any questions concerning this matter, you may contact me or Mr. H. K. Chernoff of my staff.

Very truly yours,

Jerry M. Wilkerson

T. M. Wilkerson
Manager - Regulatory Affairs

Attachment
JSK/jk

c: Mr. B. B. Desai, USNRC Senior Resident Inspector, HBRSEP
Mr. J. W. Shea, USNRC Project Manager, HBRSEP
Mr. L. A. Reyes, Regional Administrator, USNRC, Region II

H. B. Robinson Steam Electric Plant, Unit No. 2
Attachment to Serial RNP-RA/98-00012
<u>73 Pages</u>

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PROJECT MANAGER: W. McBrine Date: 9/22/97

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INSPECTION AND EVALUATION OF CONTAINMENT PRESTRESSED TENDON 25-YEAR SURVEILLANCE BLOCK

Document No. 96236-TR-01
Revision 0
Volume 1 of 1

prepared for:

Carolina Power & Light Company
H.B. Robinson Nuclear Power Plant

September, 1997

altran

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Altran Corporation
Technical Report No. 96236-TR-01
Revision 0

EXECUTIVE SUMMARY

As part of its licensing commitment, Carolina Power & Light's Robinson Nuclear Power Plant is required to examine and test a containment prestressed tendon surveillance block 25 years after construction. The objective of this surveillance is to inspect the tendons for corrosion and to mechanically test the tendons to assure that no significant changes have occurred over time.

Altran Corporation has disassembled the block and performed a detailed visual inspection of the tendons and other metal components. The results of this inspection noted only a superficial oxide on the tendons and minor corrosion pitting on some other surfaces. Each of these were determined to be structurally insignificant and have probably existed since original construction. Mechanical testing of each bar was performed using ASTM standard tensile base specimens. The properties exceed the updated FSAR minimum specified values and are comparable to the results of the previous five-year test results.

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1.0 INTRODUCTION

At the Robinson Nuclear Power Plant, the reactor containment structure is a steel lined concrete shell in the form of a vertical right cylinder with a hemispherical dome and a flat base supported by means of piles. The structure consists of side walls measuring 126 ft from the liner on the base to the springline of the dome and an inside diameter of 130 ft. The basic structural elements are piles, base slab, side walls, and dome acting as essentially one structure under all loading conditions. The dome of the containment is reinforced concrete, while the cylinder walls are reinforced circumferentially and post-tensioned vertically.

The prestressing system for the containment structure consists of 1 3/8 in. diameter high strength steel bars supplied by Stressteel Corporation, closely grouped into tendons consisting of six bars per tendon. These tendons are placed within heavy wall 6 in. galvanized steel pipe sheaths. The tendons are on the centerline of the wall and are spaced approximately every 3 ft around the periphery of the containment. The bottom anchorage of each tendon system is a steel plate with six threaded holes into which the steel bars are screwed. Couplings consist of internally threaded sleeves into which the high strength steel bars are screwed. The void space between the bars within the coupler body is filled with a binding compound to prevent corrosion. The top anchorage consists of a steel plate bearing on the concrete with three of the Stressteel bars anchored to this plate by means of grip nuts. A second and smaller plate bears on the top of these grip nuts and the remaining three Stressteel bars are anchored similarly to this top plate. The steel sheath surrounding each tendon is made of 6 in. schedule 40 galvanized steel pipe with threaded and flanged connections. The sheath is connected to the bottom anchorage plate by means of a threaded coupling and provides protection of the tendon both during and after constriction. The pipe is then filled with cement grout. The cap over the anchoring grips is also made of galvanized steel filled with cement grout.

The performance of the containment building is critically dependent upon the satisfactory performance of the prestressed tendons. Because of the difficulty in evaluating the embedded tendons, two surveillance tendon blocks were built to use in the testing procedure. These testing blocks are identical in construction to the actual tendon blocks with the exception that the test blocks are shorter in length than the actual ones (Figure 1). The first block was tested in 1976 five years after the construction. Testing of the second block is the subject of this investigation.

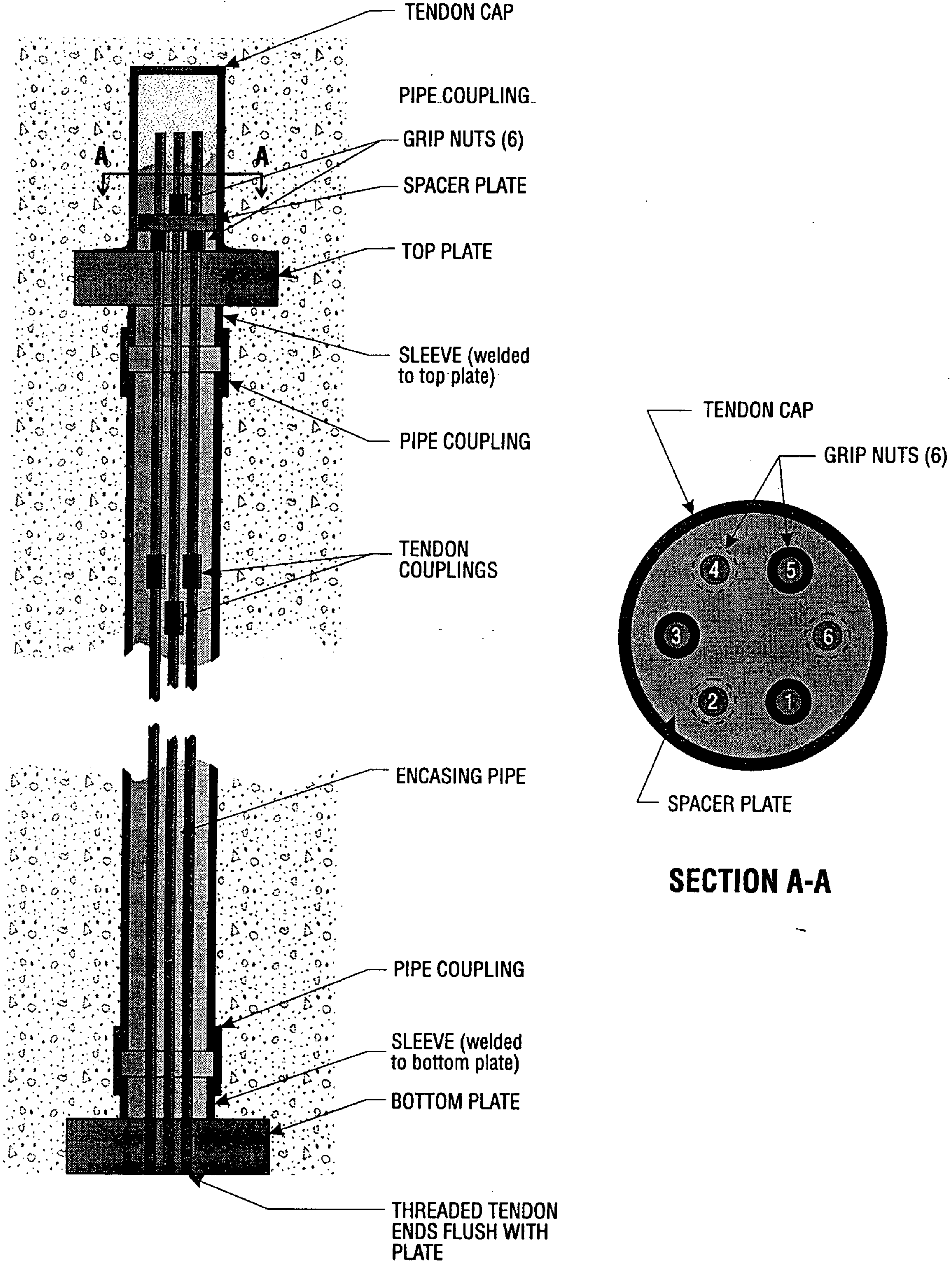


Figure 1
Surveillance Block Arrangement

2.0 OBJECTIVE

The object of this study is to assess the condition of the second surveillance tendon block after 25 years of exposure to the same environmental conditions that the containment building has been exposed to. This report describes the scope and the findings of a visual inspection on all the components of the prestressed tendon assembly and mechanical testing performed on the tendon bars. According to the FSAR [1]:

> *"The tendon bars are to be removed from the sheath and the grout removed. The visual inspection is performed to detect and record evidence of corrosion. Tensile tests are then performed on selected bars to develop stress-strain diagrams and determine the bars ultimate tensile strengths. The results of these tests are compared with the original properties to determine any significant changes."*

3.0 FIELD INSPECTION AND DISASSEMBLY

3.1 Field Inspection

During a site visit to the Robinson Nuclear Power Plant, the surveillance tendon block was visually inspected. The block was standing up-right, adjacent to the containment building (Figure A1). No evidence of damage or deterioration was detected on the exposed surfaces of the block.

3.2 Block Removal and Shipping

Following a radiation safety inspection which was conducted by the plant's personnel, the block was loaded onto a flat bed truck for shipment to a site near Altran's Boston office for cutting and removal of the tendon assembly. Upon arrival, the block was unloaded from the truck, placed on top of four timber planks on the ground, and was covered until disassembly began (Figure A2).

3.3 Visual Examination of the Block

A visual inspection was conducted before cutting the block. No evidence of transportation induced damage was detected when compared with the on-site inspection results. The overall measurement of the block is 26.7' x 3.5' x 4.33', and is made of two distinct concrete sections separated by a construction joint. The top section is 5' deep and was poured after post tensioning of the tendons. The front face of the top section appears to have been made of concrete with a different texture as compared to the rest of the block. The front face surface of concrete at the cap region exhibited a network of micro-cracks. The

pattern can be categorized as map cracking (Figures A3 and A4). Later coring of this section revealed that this was only a mortar-type repair material measuring approximately 0.75" thick. It was applied to the upper section of the block after construction was complete. Concrete under this outer layer was similar in composition to the rest of the block (Figure A5).

3.4 Cutting the Block

Using an 18" diameter diamond concrete cutting saw, the block was cut length-wise on two adjacent sides. One cut was made on the top and the second on the side. The blade was then changed to a 36" diameter blade in order to cut to a depth about two inches from the surface of the tendon pipe (Figures A6 - A8). Water was used as a coolant during the cutting process. A hydraulic chisel (Figure A9) was used to break up the smaller piece and the top portion of the block after cutting in order to expose the tendon assembly (Figure A10). During the entire cutting and tendon exposure process, an engineer was present to perform a visual examination of each component as it was uncovered.

3.5 Retrieval and Visual Examination of the Tendon Assembly

Figures A11 to A19 show the different parts of the tendon assembly immediately after exposure. Figure A11 and A12 show the base plate and a detail view of its bottom side. The superficial corrosion products (stains) on this surface were slightly covered with oil, and corrosion was limited to only the metal surface. The surrounding concrete did not contain any corrosion products. This oily surface indicates that the corrosion had not been active after construction and most likely was present at the time of construction. Figure A13 shows a close-up of the grouting pipe attached to the bottom of the base plate.

Figures A14 to A16 show the outside surface of the galvanized steel pipe housing the tendon rods and the pipe-concrete interface. The entire surface was clean with no sign of corrosion. A pocket of loose, brown, moist powder, approximately 5 cubic inches in volume, was discovered directly beneath the top plate. A small sample was collected and sealed in a plastic bag for further analysis (Figure A17). The powder material was surrounded by cement grout rather than concrete. It appears that this grout had seeped out of the pipe during grout injection and filled a void beneath the top anchoring plate. The chemical constituents of this powder was determined by Energy Dispersive X-ray Analysis (EDX) (Table 1) and was found to be consistent with the normal constituents found in Portland cement. The material is most probably unhydrated cement grout which did not harden due to the partial contamination with foreign materials such as a lubricant or sealing agent used in other components of the tendon assembly. The quantity was insignificant and was not related to any corrosion or aging mechanism. Figures A18 to A20 show the anchoring plate located at the top of the tendon assembly. Figure A18 shows the bottom surface of this plate while Figures A19 and A20 show the exposed galvanized steel cap on the top of this plate.

The outside surface of the galvanized steel cap had no signs of corrosion, but the bottom surface of the plate exhibited superficial corrosion which probably occurred during construction, based upon its uniform appearance. The spiral steel around both portions of the pipe exhibited no sign of corrosion.

Table 1. EDX Test Results

Element	Approximate % By Weight
Si	50.0
Ca	35.0
Fe	3.2
S	2.2
Other	Balance

3.6 Cutting and Inspection of the Tendon Cap

The tendon assembly was removed for a more detailed examination (Figure A21). Except for the superficial oxides mentioned above, no other sign of age related degradation or corrosion was detected on the exterior of the two end plates, galvanized steel pipe, or on the galvanized cap. Figures A22 and A23 show the exterior appearance of the tendon casing. The galvanized tendon cap was removed using a cutting torch by cutting both circumferentially along the base flange and longitudinally down the cap (Figure A24). The cap was pried open and the grout was broken exposing the free ends of the tendons. The internal surface of the cap was free from corrosion (Figure A25). The ends of the tendons were numbered from 1 to 6 (Figure A26). Some reddish oxide was observed on the surface of the tendons and the surrounding grout (Figure A27). No measurable metal loss was associated with this corrosion product which probably existed during construction.

3.7 Cutting and Inspection of the Tendon Casing

The tendon casing was cut circumferentially at the two ends, approximately 2' from each plate (Figure A28). The gap created by the cutting blade closed as the result of stress relief in the bars. The pipe was cut longitudinally from two locations diametrically opposite to each other (Figure A29). The casing was then split open exposing the bars (Figure A30 and A31). The internal surface of the pipe was free from corrosion (Figure A32 and A33). The grout surrounding the bars cracked as the pipe was cut and stress relieved in the bars.

In some areas separated grout had a reddish-brown stain at the contact surface with the bars (Figure A34) that is suspected to be an oxide which occurred during construction.

3.8 Visual Examination of the Tendon Bars

The surface of the bars were covered with a reddish-brown oxide that could be removed simply by wiping the surface clean by hand (Figures A35 - A37). No measurable metal loss or etching could be detected once the dust was removed. The couplings on three out of six tendons had clear marks which indicate that they had been touching the casing (Figures A38 and A39). There were no apparent signs of active corrosion or deterioration because of this. After proper marking to show the number and orientation of each bar, the bars were cut about 2' from each end plate (Figure A40) and all the components were transferred to the Altran materials laboratory facility in Cambridge, MA. Once in the lab, each individual specimen was logged and tagged as received. The components transferred to the lab are:

- The base plate assembly (Figure A41)
- The top plate assembly (Figure A42)
- The bars (a total of six) (Figure A43)
- The casing galvanized pipe (in two halves) (Figure A43)

4.0 LABORATORY EXAMINATION AND TESTING

In the laboratory, each component was further taken apart for visual examination and testing.

4.1 Base Plate Assembly

This section is composed of the base plate (19.25" X 18.75" X 4.0"), a coupling welded to the plate from one end and threaded to the tendon casing from the other end, and six bars directly threaded to the base plate. After removing the bulk of the cement grout inside the casing end and cleaning, the threaded part of the casing appeared to exhibit some corrosion products. Several unsuccessful attempts were made to non-destructively unscrew the casing from the coupling. Finally the casing end was chilled with liquid nitrogen and the casing was broken by impact (Figure A44). Figure A45 shows a closer view of this corroded threaded section. The spot was cleaned with a wire brush. The corrosion was determined to be very superficial and no noticeable metal was lost to the corrosion (Figure A46). The cause of corrosion appears to be from lack of galvanization at this section. The probable scenario is that the pipe was threaded after galvanization, causing removal of the protection at this section. The corrosion products observed likely formed during construction.

No sign of corrosion was detected around the bars. Bar number three was removed and the threaded sections inspected. There were no signs of corrosion either in the plate or on the threaded part of the bar (Figures A47 and A48).

4.2 Top Plate Assembly

This section of tendon block consists of a plate 18.75" x 18.75" x 4", a coupling, a 2" thick anchor plate, the flange from the cap cut before, six bars, and six anchoring grip nuts (Figure A49).

The only noticeable sign of corrosion was on the outside surface of the casing pipe coupling which spread over an estimated 15% of the surface (Figure A50). A spot which appeared to be the most severe, was cleaned and the depth of pitting was measured with a caliper (Figures A51 and A52). The depth of pitting was approximately 10 mils which was determined to be insignificant. This was very localized corrosion since no sign of propagation in the surrounding concrete or rebars could be detected when the block was cut. Owing to the high alkalinity and impermeability of the concrete surrounding the pipe coupled with the lack of moisture corrosion probably ceased shortly after construction.

Both the coupling and the pipe welded to the top plate were cut and removed. The bars were pushed through the plates to expose the embedded lengths (Figure A53). A small spot of oxide on bar number 3, located about 0.5" inside the plate was found (Figure A54). Once the spot was cleaned with a wire brush, the loss to the metal due to corrosion was not measurable (Figure A55). No other signs of corrosion were found on the surface of the bars or grip nuts.

The top surface of the plate under the flange also exhibited some corrosion (Figure A56 and A57). A spot was cleaned and the deepest pitting measured was about 5-8 mils deep. The crevice corrosion likely occurred during construction and is considered only superficial with no consequence to the tendon block functionality.

The grip nuts were all in good condition. No sign of corrosion was detected on the outer surface. The grip nut on bar number 4 was randomly selected and cut. Figures A58 to A60 show the components within this grip nut and the area of the bar encased by the nut after cutting. Similar to the external surface, the internal surface was also free from corrosion.

4.3 Bars and Couplings

No visible sign of corrosion was found on the surface of the tendons or the couplings. The couplings were cut open lengthwise, and their internal surfaces were visually examined.

Figures A61 to A67 show the cutting process and the internal surface of the couplings as well as the threaded ends of the bars.

4.4 Mechanical Testing of the Bars

One tensile specimen from each bar was cut and tested for tensile strength and mechanical properties. The testing was performed in accordance with the ASTM E8 [2]. Figures 2 to 7 show the stress/strain graphs of the specimens and results are presented in Table 2.

The objective of the mechanical tests is to determine if there has been any significant changes in the material's mechanical properties over time. This comparison is somewhat complicated by the fact that the test methods and specimen sizes vary between the representative test results published in the FSAR, the five-year surveillance test, and the 25-year tests presented in this report. Hardness readings taken across the face of a cut tendon indicates a noticeable change from the center to the outside edge.

Rockwell Hardness

Location	C Scale	Est. Equiv. Tensile
Center	31.0	141 ksi
Midpoint between Center and O.D.	32.3	147 ksi
Near O.D.	34.4	154 ksi

A slight variation in hardness through a material thickness is not an unusual finding. It is generally a result of the fabrication process which in this case resulted in a slightly harder bar surface as compared to the center. Based on these results, it can be concluded that a prepared tensile specimen, which has a smaller diameter than the full size tendon, may demonstrate certain reduced tensile properties.

A correction of 5% is estimated for a ½ inch diameter specimen as compared to a full size tendon. A comparison with certain parameters presented in Section 3.8.1.6.1.3 of the updated FSAR is as follows:

Minimum Specified Tensile Strength	= 160,000 psi
25-yr. Adjusted Measured	= 1.05(154,200) = 161,900 psi
Minimum Stress Specified at .7% Strain	= 140,000
25-yr. Adjusted Measured	= 1.05(135,300) = 142,100

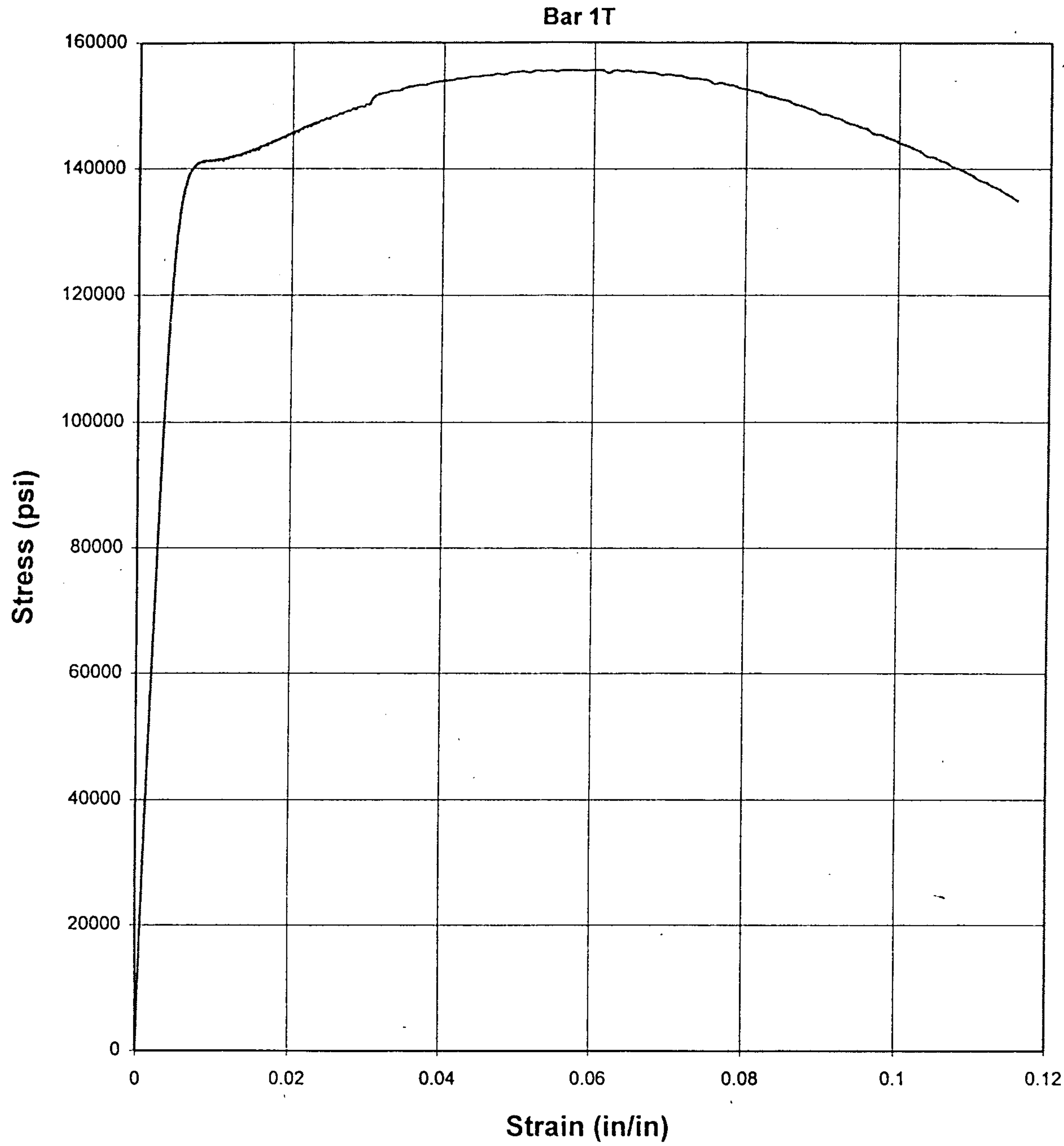


Figure 2 Stress-Strain Curve for Tendon Bar No. 1

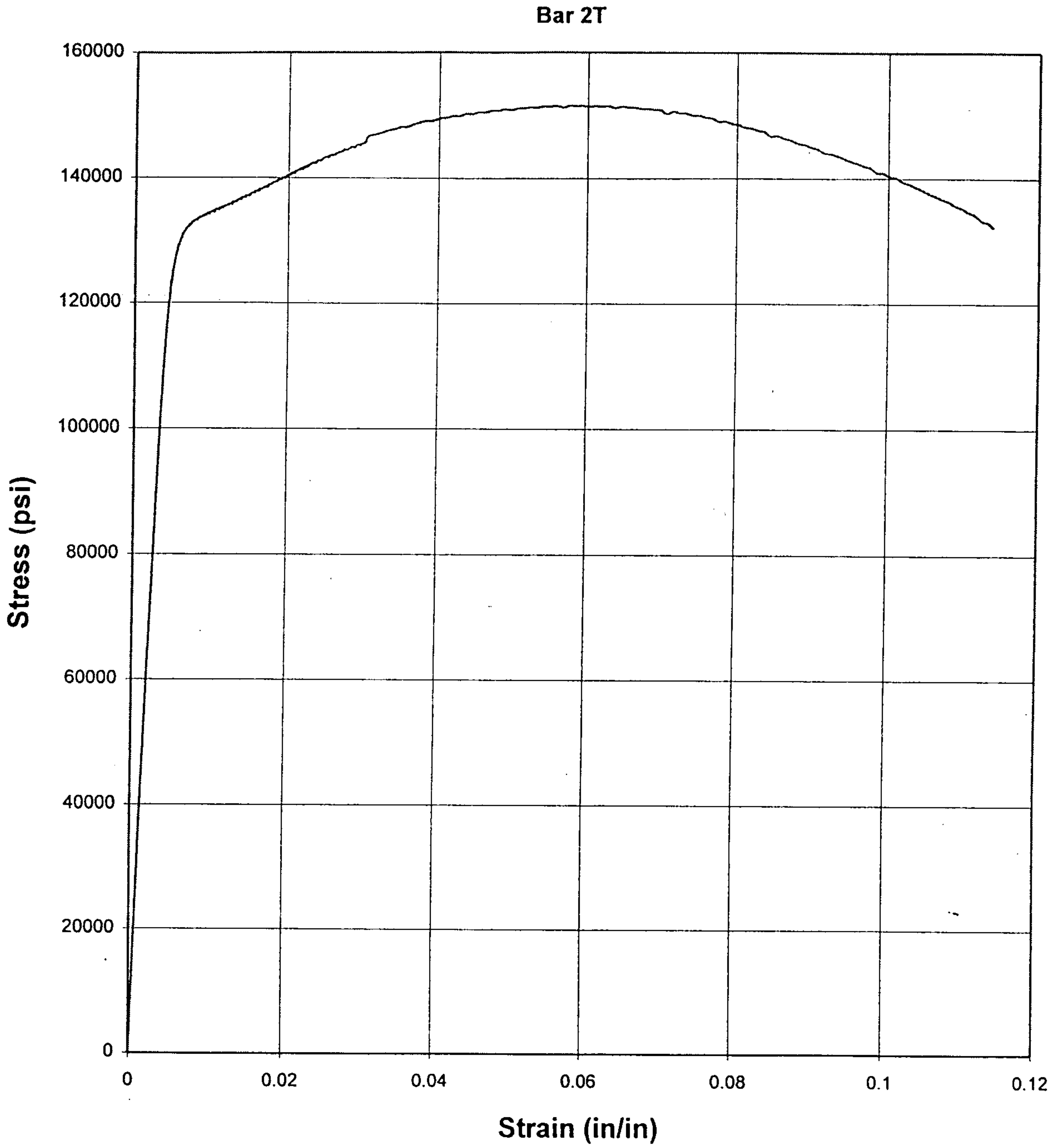


Figure 3 Stress-Strain Curve for Tendon Bar No. 2

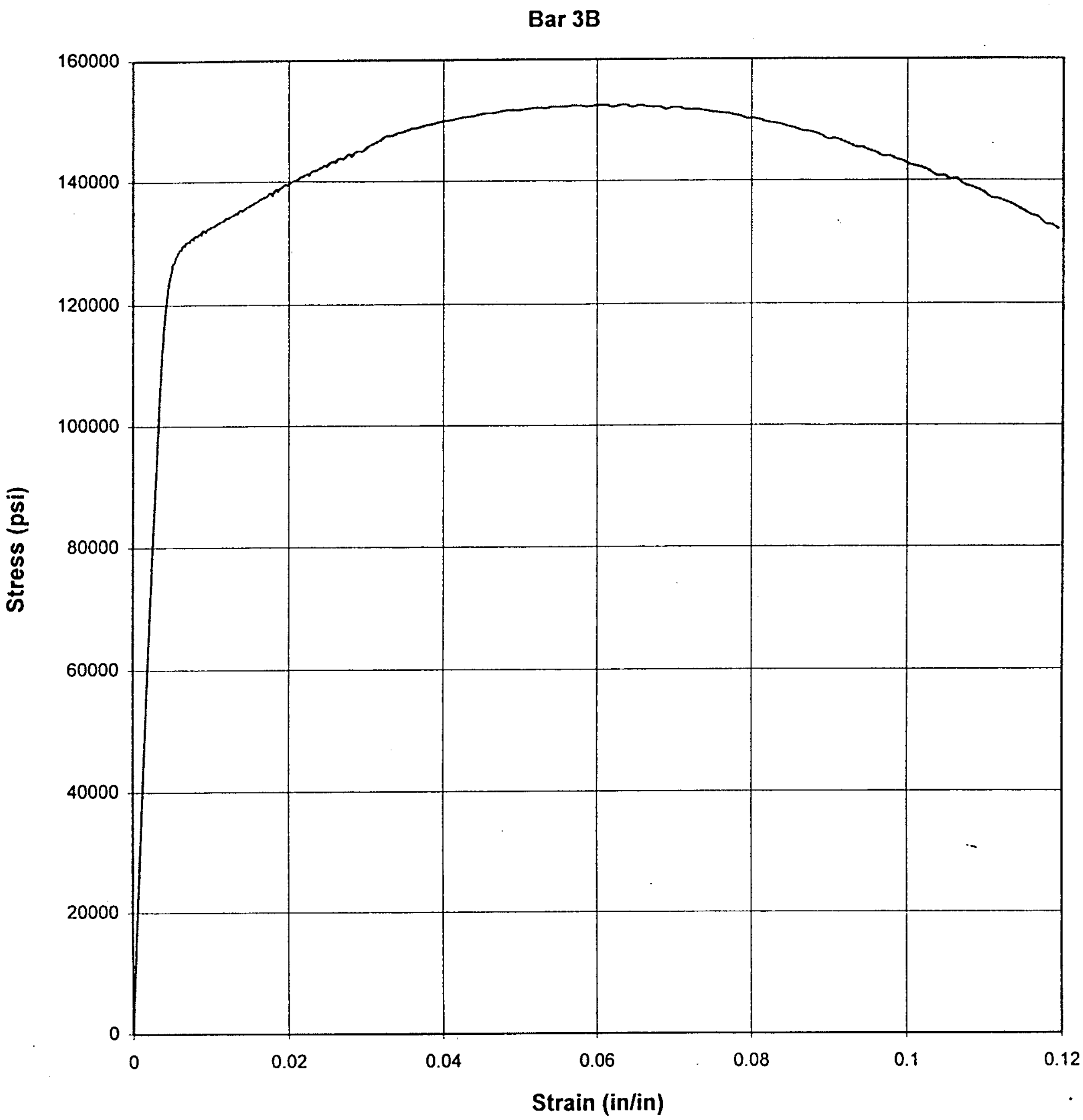


Figure 4 Stress-Strain Curve for Tendon Bar No. 3

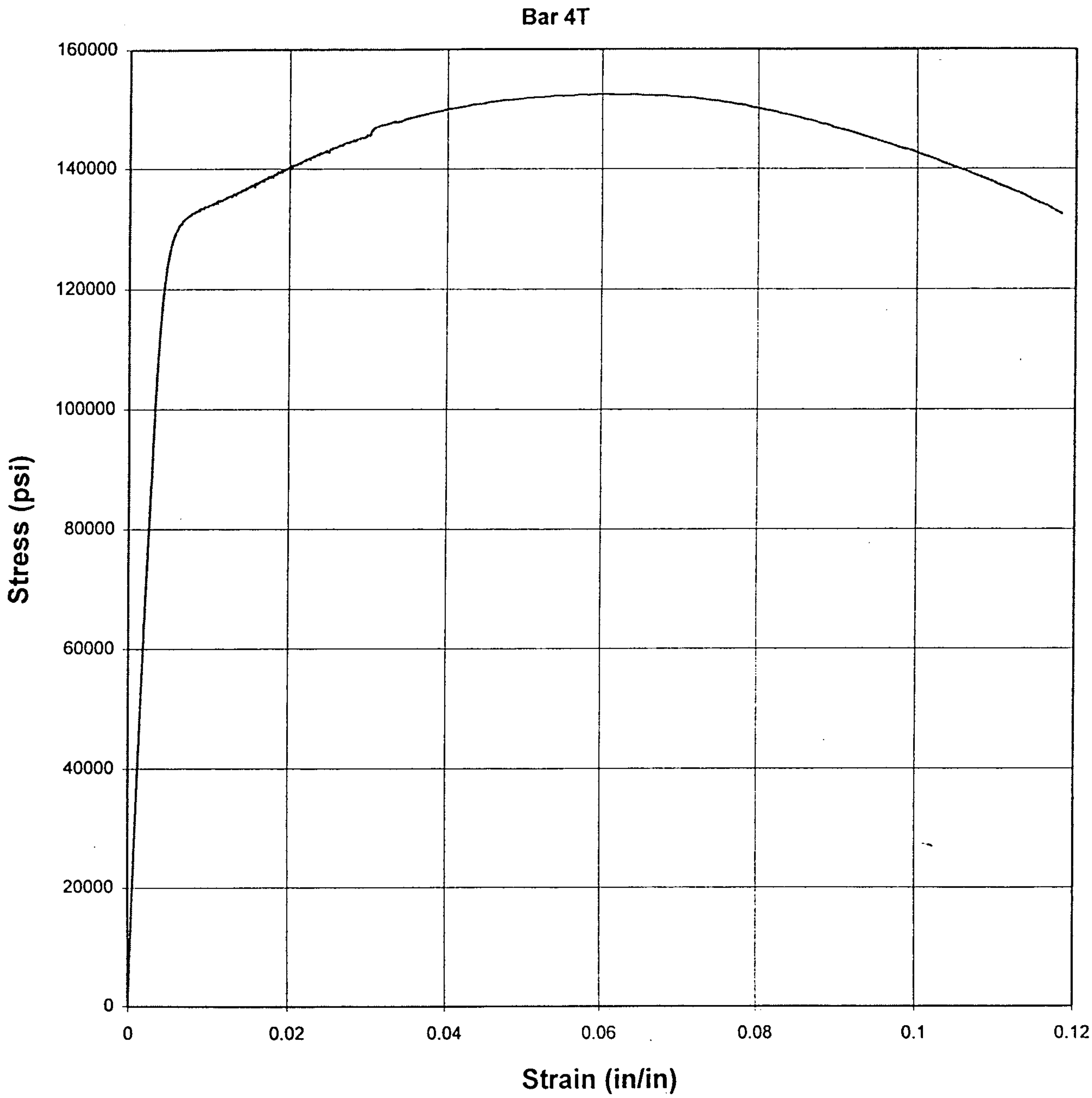


Figure 5 Stress-Strain Curve for Tendon Bar No. 4

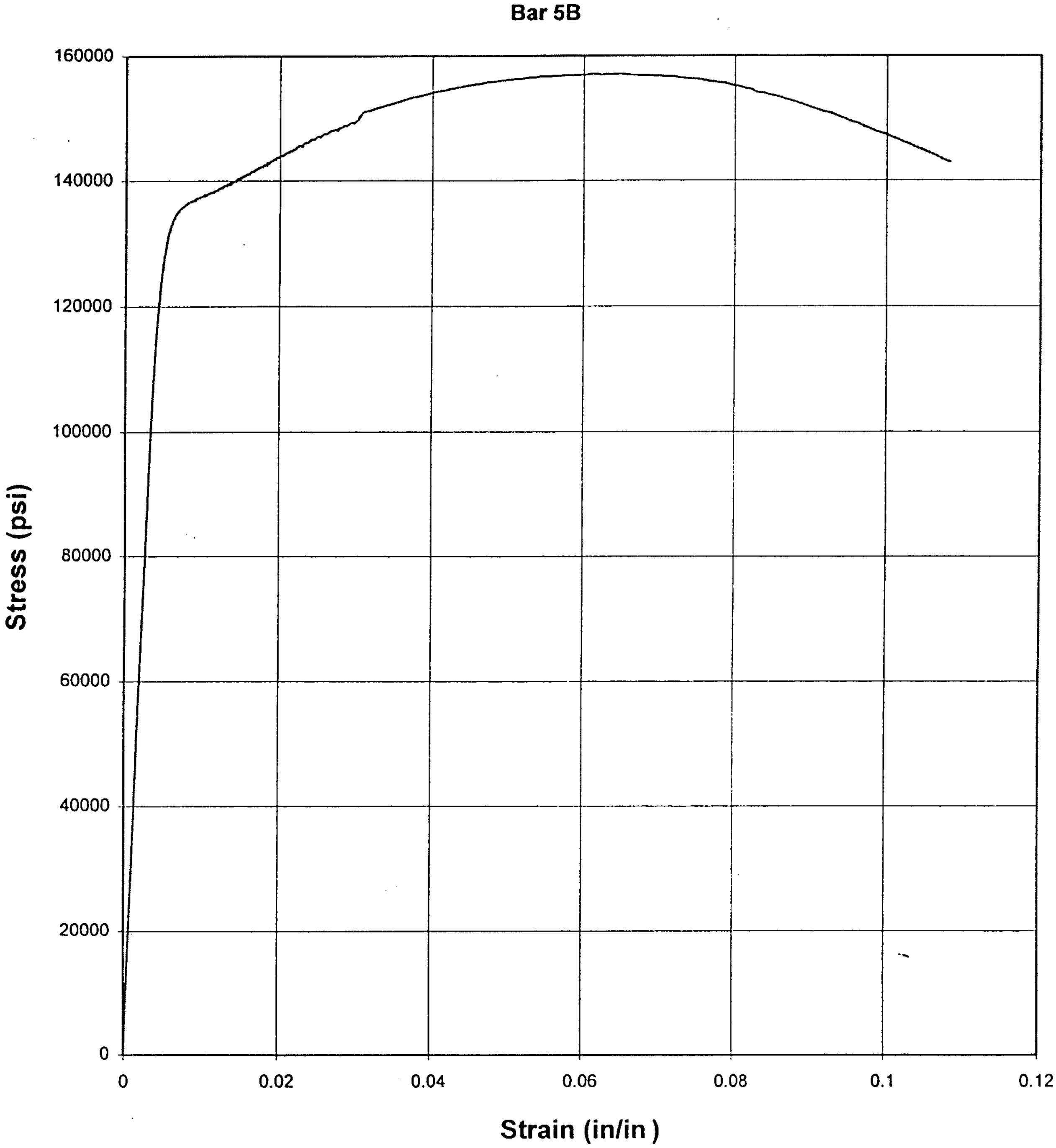


Figure 6 Stress-Strain Curve for Tendon Bar No. 5

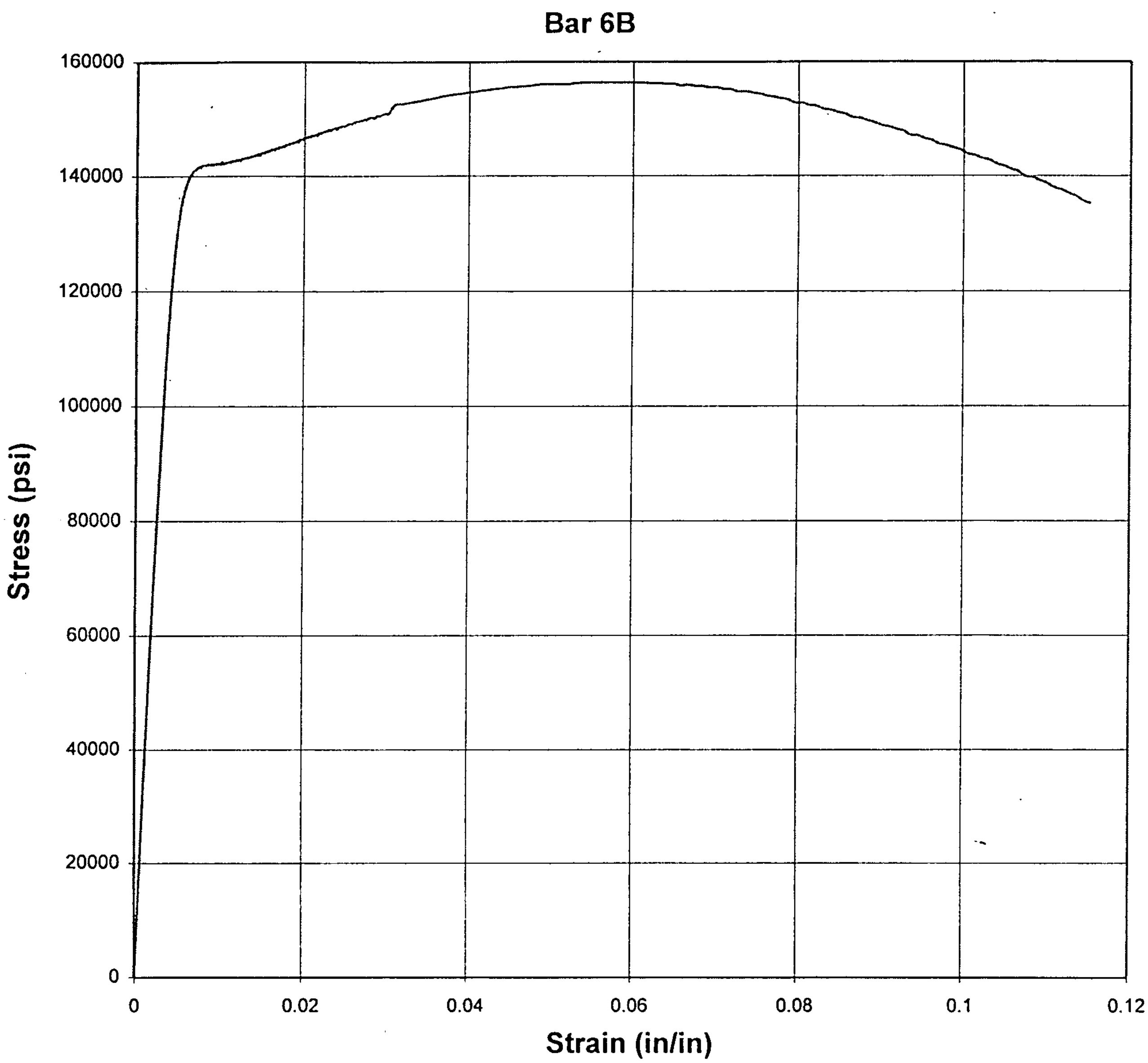


Figure 7 Stress-Strain Curve for Tendon Bar No. 6

Minimum Specified Reduction in Area	= 20%
25-yr. Measured	= 31.5%
Approximate Modulus of Elasticity	= 30,000,000 psi
25-yrs. Measured Modulus of Elasticity	= 31,150,000 psi

(Elongation is not directly comparable based on different specimen sizes.)

The measured properties are slightly less than test results presented in Figure 3.8.1-42 of the FSAR which are as follows:

Tensile Strength	= 167,700 psi
Stress at .7% Strain	= 150,500 psi
Reduction in Area	= 40%

The difference is not considered significant considering the test methods and number of tests performed are not reported.

In order to confirm that there is no age related strength loss mechanisms present, a comparison with the 5-year test results [3] was also performed, exhibiting very good correlation. The 5-year test results are as follows:

Tensile Strength	= 157,600 psi
Stress at .7% Strain	= 144,400 psi
Reduction in Area	= 28.8%

Based on these results, it can be concluded that there has been no significant age related reduction in mechanical properties.

TABLE 2. Tendon Bar Tensile Test Mechanical Properties Results

ID	Diameter (in)	Area Reduction (%)	Total Elongation (%)	Stress (ksi) @ 0.3%	Stress (ksi) @ 0.7%	Stress (ksi) @ Peak	Elastic Modulus (psi)
1T	0.500	33.5	12.5	89.0	140.0	155.6	30,260,000
2T	0.501	31.4	12.0	90.0	132.0	151.6	30,270,000
3B	0.500	32.9	12.5	94.0	131.0	152.0	31,300,000
4T	0.504	32.2	12.5	93.0	132.0	152.5	32,000,000
5B	0.500	27.1	11.0	91.0	136.0	157.0	30,750,000
6B	0.502	32.0	12.0	93.0	141.0	156.4	31,820,000
Avg	N/A	31.5	12.3	91.7	135.3	154.2	31,100,000

5.0 CONCLUSION

Based upon the results of the investigations documented in this report, it is concluded that there is no significant corrosion in the Robinson Nuclear Power Plant 25-year containment surveillance block provided for investigation. Mechanical testing of the tendon bars also shows no significant change in properties when compared with updated FSAR data and the previous five year surveillance block test results.

6.0 REFERENCES

1. Robinson Nuclear Power Plant, Updated FSAR.

2. ASTM E8-94a, "Standard Test Methods for Tension Testing of Metallic Materials," Annual Book of ASTM Standard, 1994.

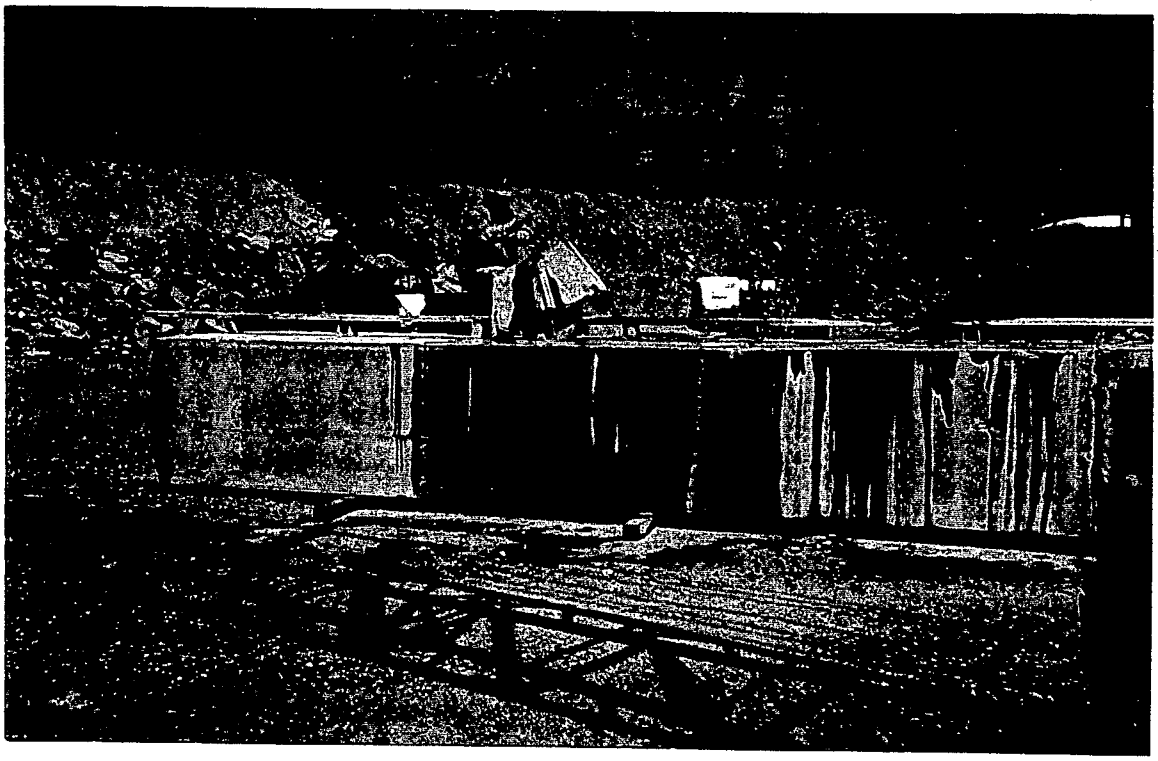
3. Inspection of Containment Prestressing Surveillance Tendon from H.B. Robinson Unit No. 2 Plant, September 28, 1976, Battelle Columbus Labs.

APPENDIX A

PHOTOGRAPHS

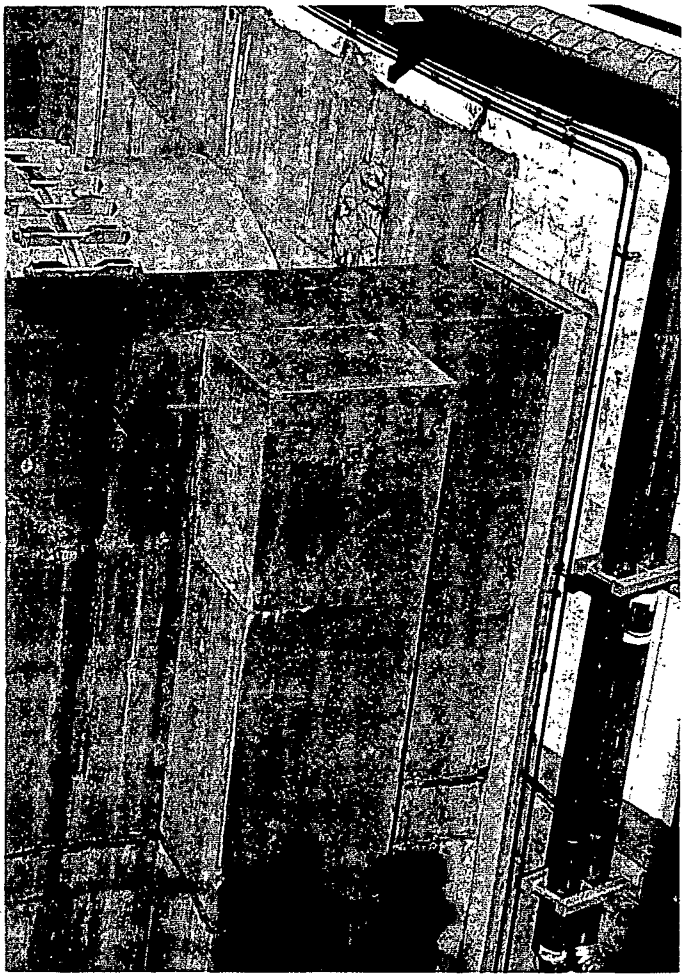
Surveillance Tendon Block at Robinson Nuclear Power Plant

FIGURE A1.



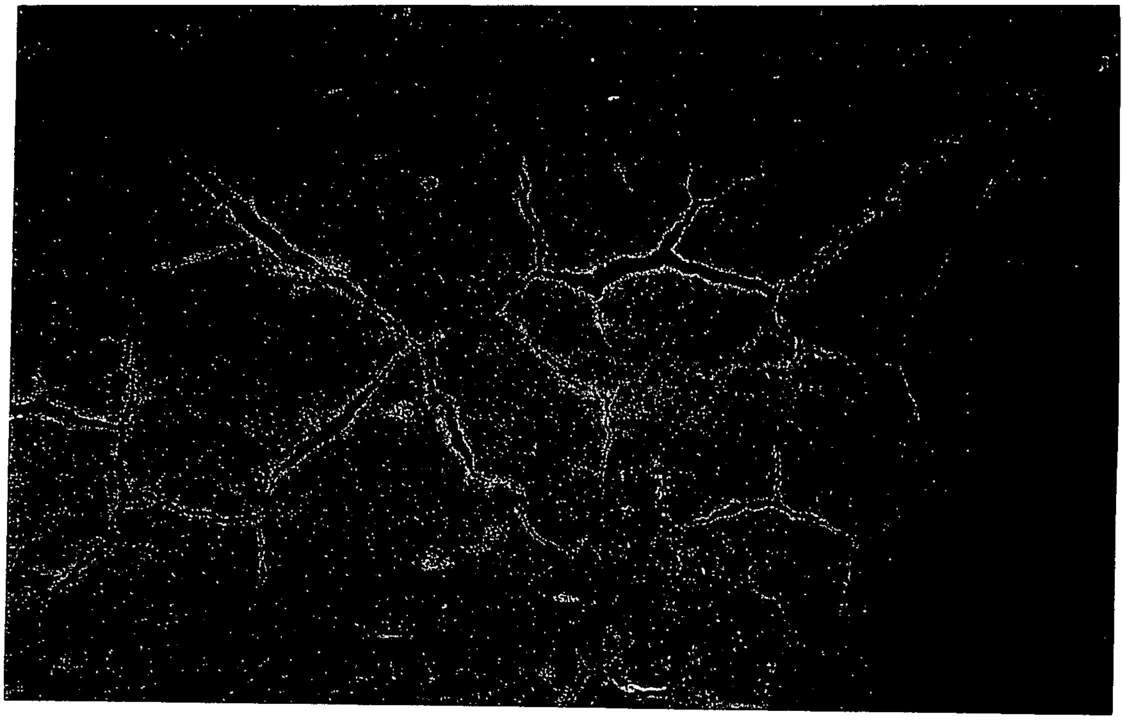
The Unloaded Block Near Altran's Boston Office

FIGURE A2.



Surface Cracks On The Top Portion Of The Block

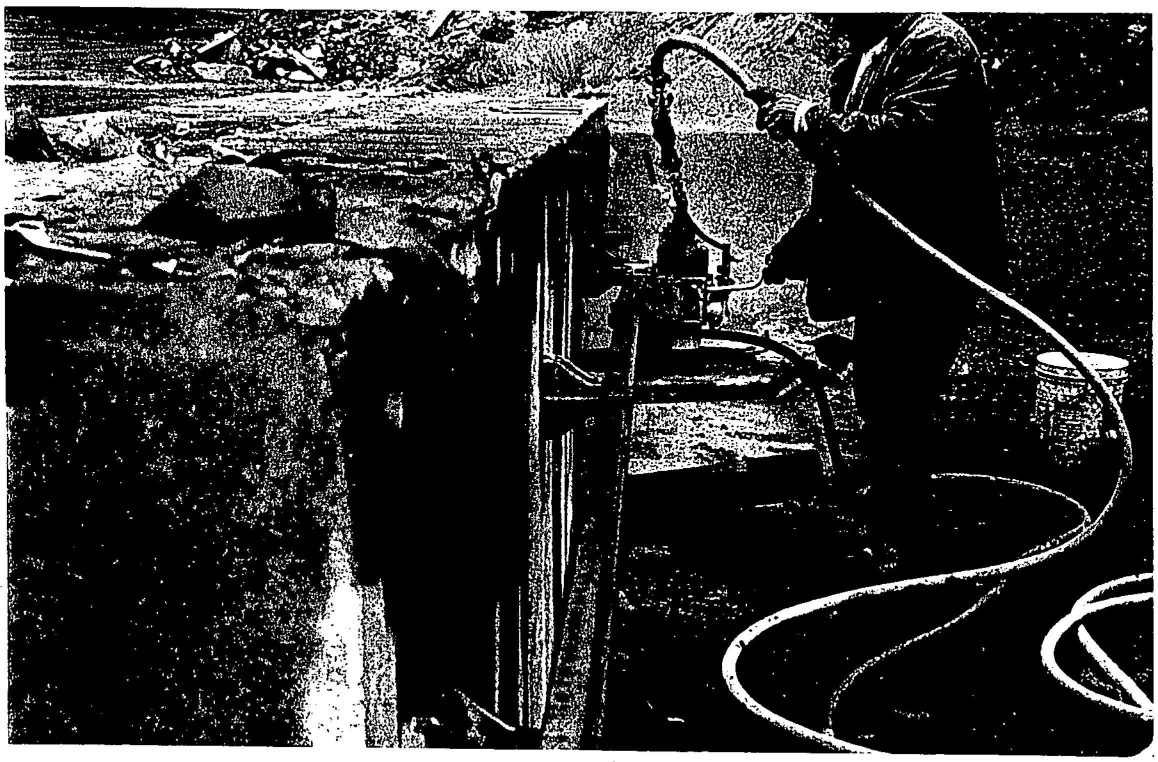
FIGURE A3.



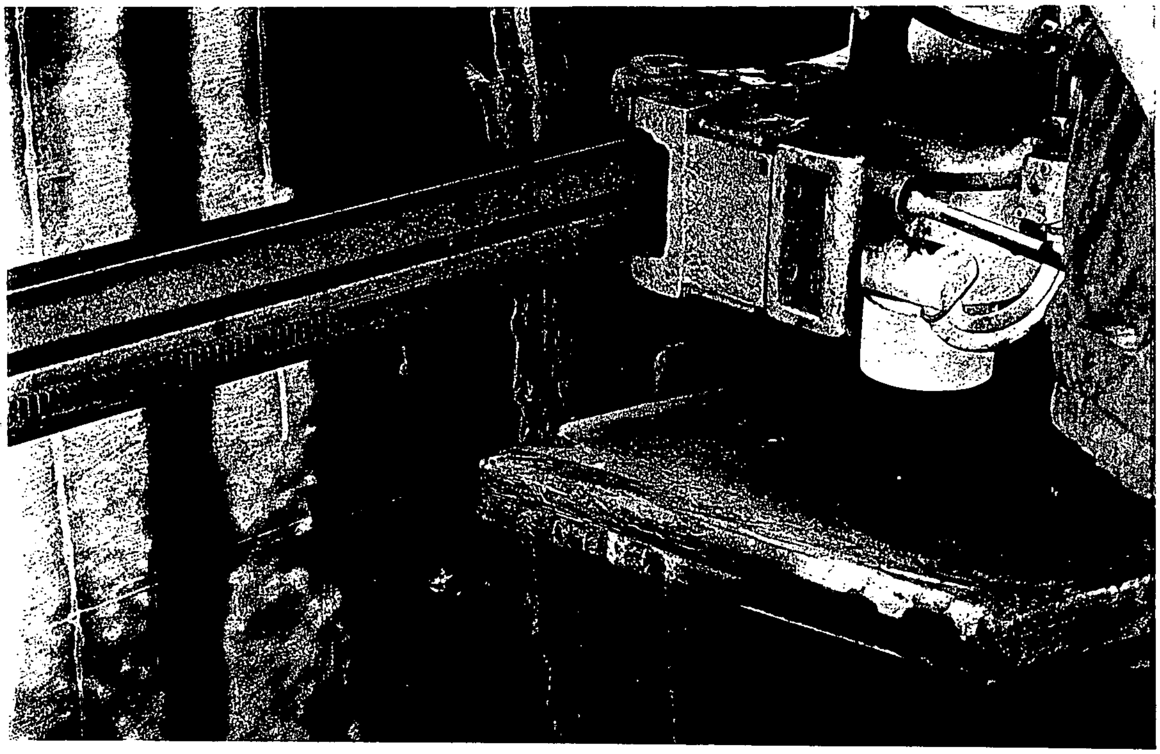
Close-Up View of the Cracked Surface
FIGURE A4.

Depth of Repair Material Applied to the Surface
FIGURE A5.

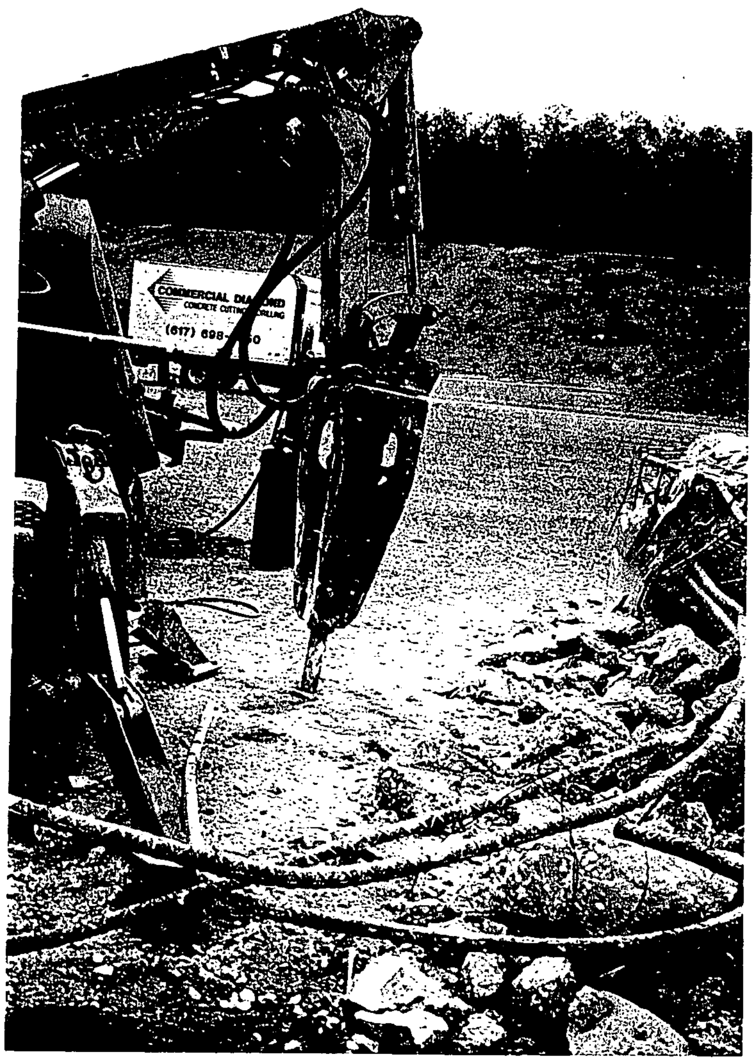
Cement Block Being Cut from the Top
FIGURE A6.



The Block Being Cut from the Side
FIGURE A7.



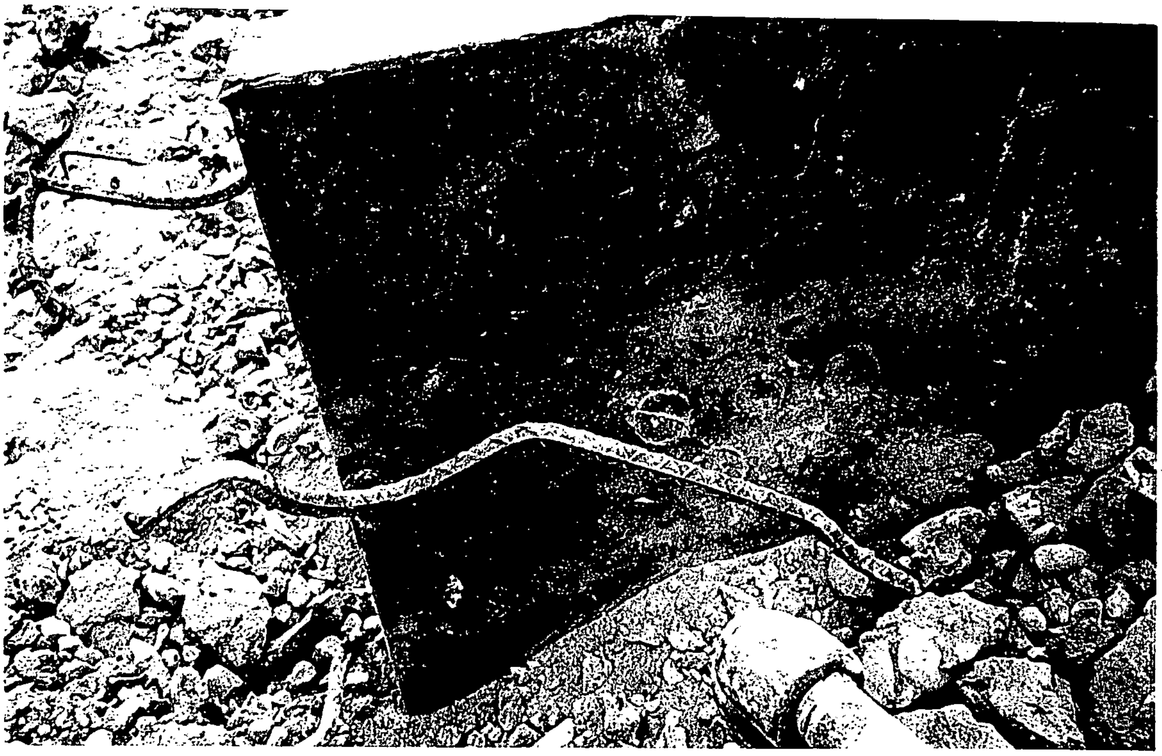
Close-up View of the Water Cooled Cement Cutting Saw
FIGURE A8.



View of Hydraulic Demolition Chisel being Used to Break up the Block
FIGURE A9.

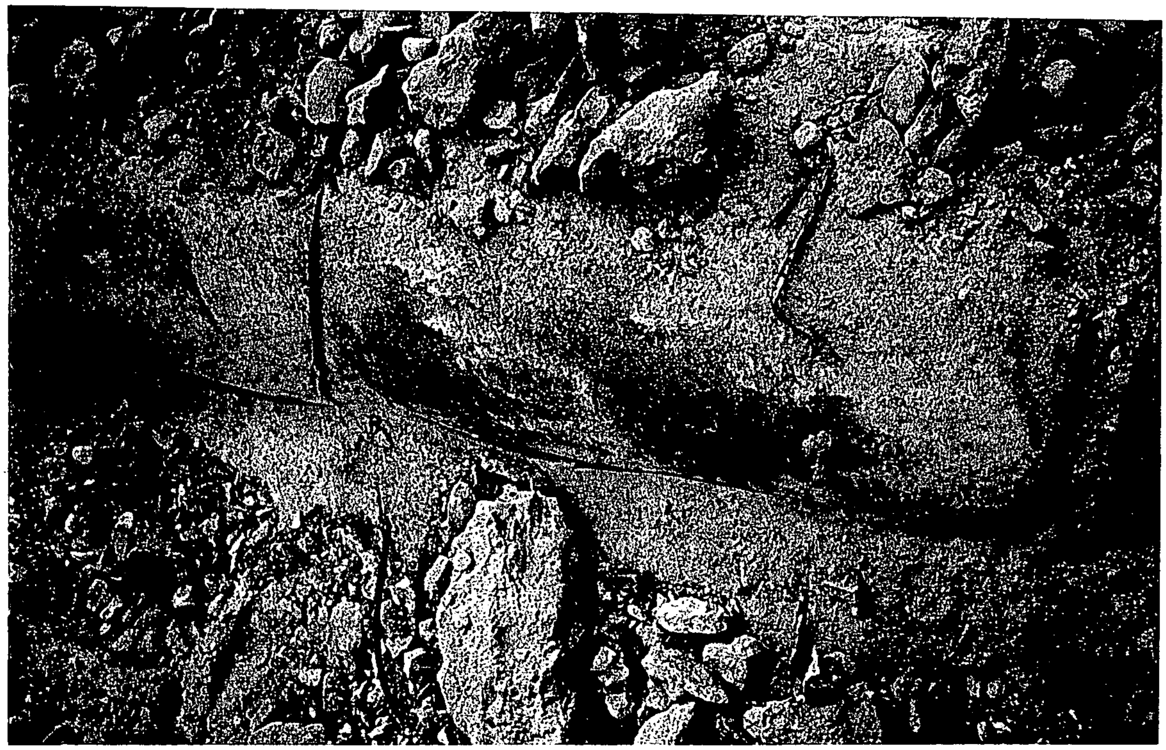
Tendon Assembly Exposed
FIGURE A10.

The Bottom Base Plate
FIGURE A11.



View of the Bottom Face of the Bottom Base Plate
FIGURE A12.

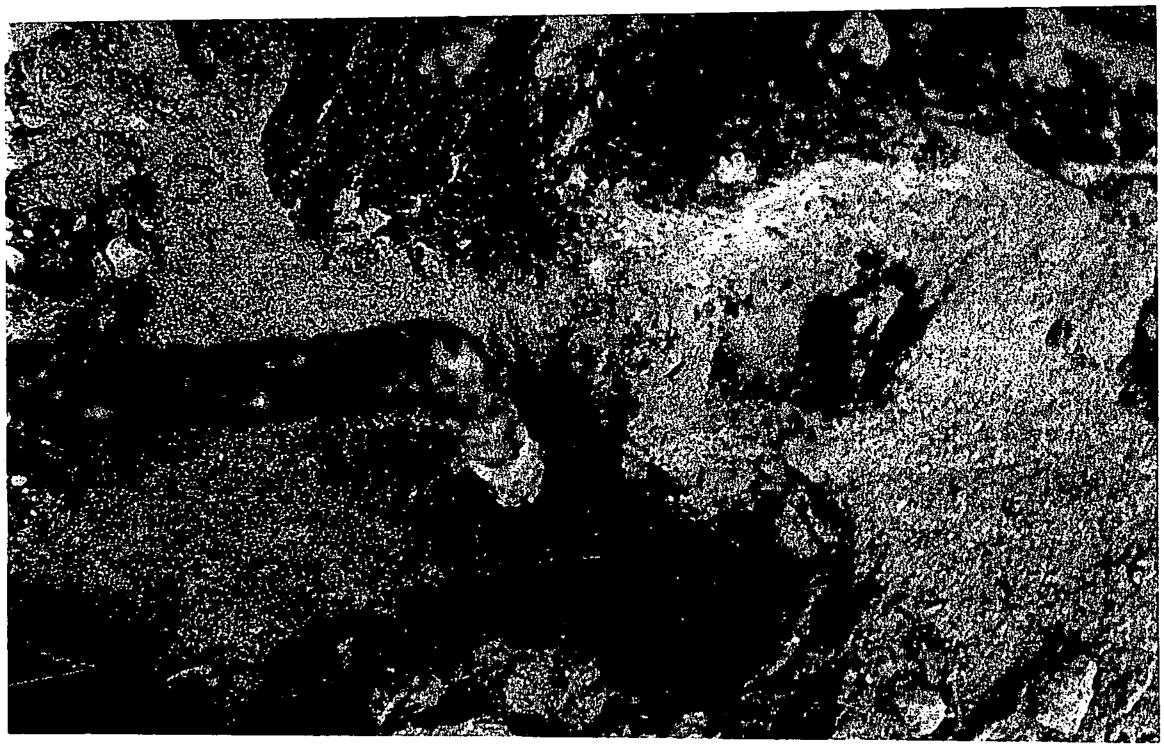
Grouting Pipe Attached to the Bottom Base Plate
FIGURE A13.



Surface of the Pipe Encasing the Tendon Bars
FIGURE A14.

Close-up of Pipe Surface Encasing the Tendon Bars
FIGURE A15.

Concrete to Pipe Interface Region
FIGURE A16.

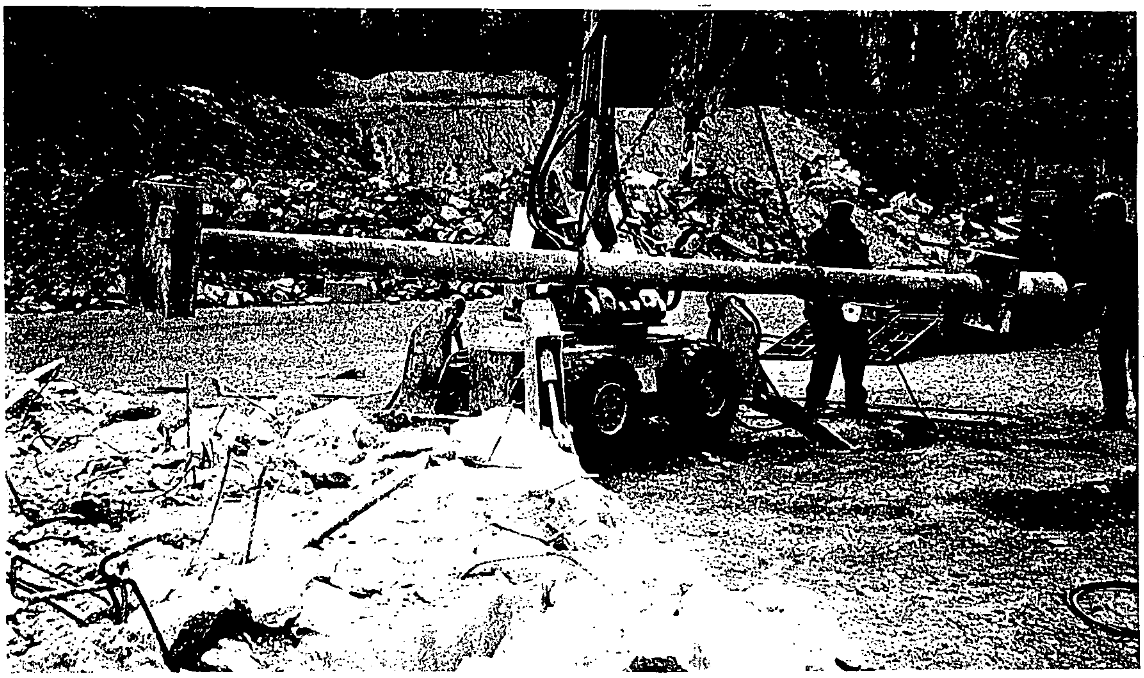


Unhydrated Grout Pocket Under Top Plate
FIGURE A17.

Top Plate Immediately After Exposure
FIGURE A18.

Cap Surface on Top Plate Immediately After Exposure
FIGURE A19.

End Surface of Top Plate Cap Immediately After Exposure
FIGURE A20.



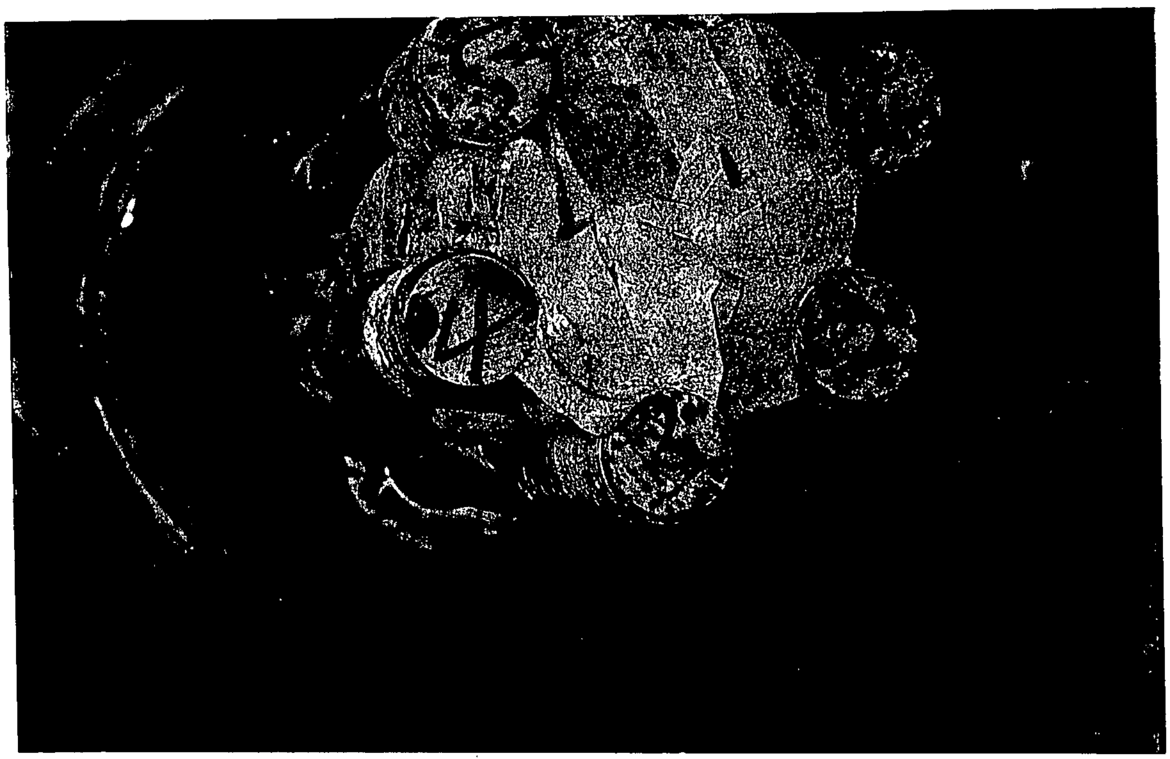
Tendon Assembly after Removal From Cement
FIGURE A21.

Surface of Encasing Pipe Immediately After Removal
FIGURE A22.

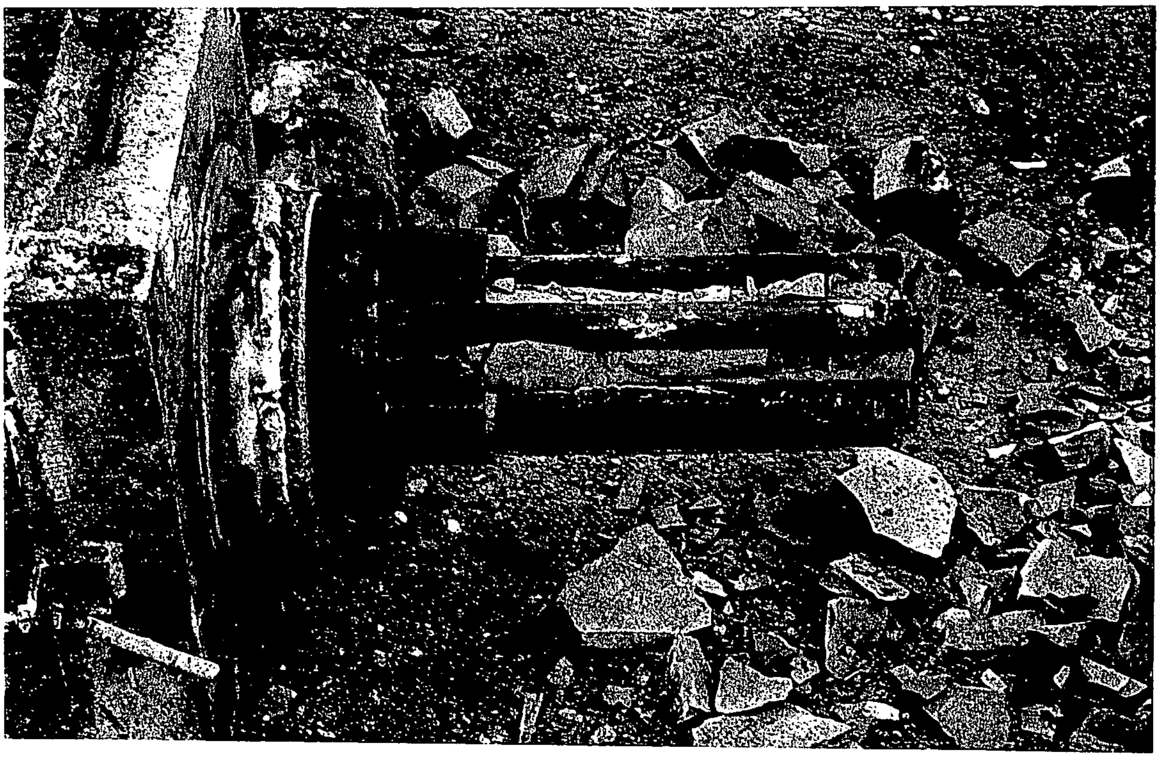
Surface of Encasing Pipe Immediately After Removal
FIGURE A23.

Tendon Cap Being Cut for Removal
FIGURE A24.

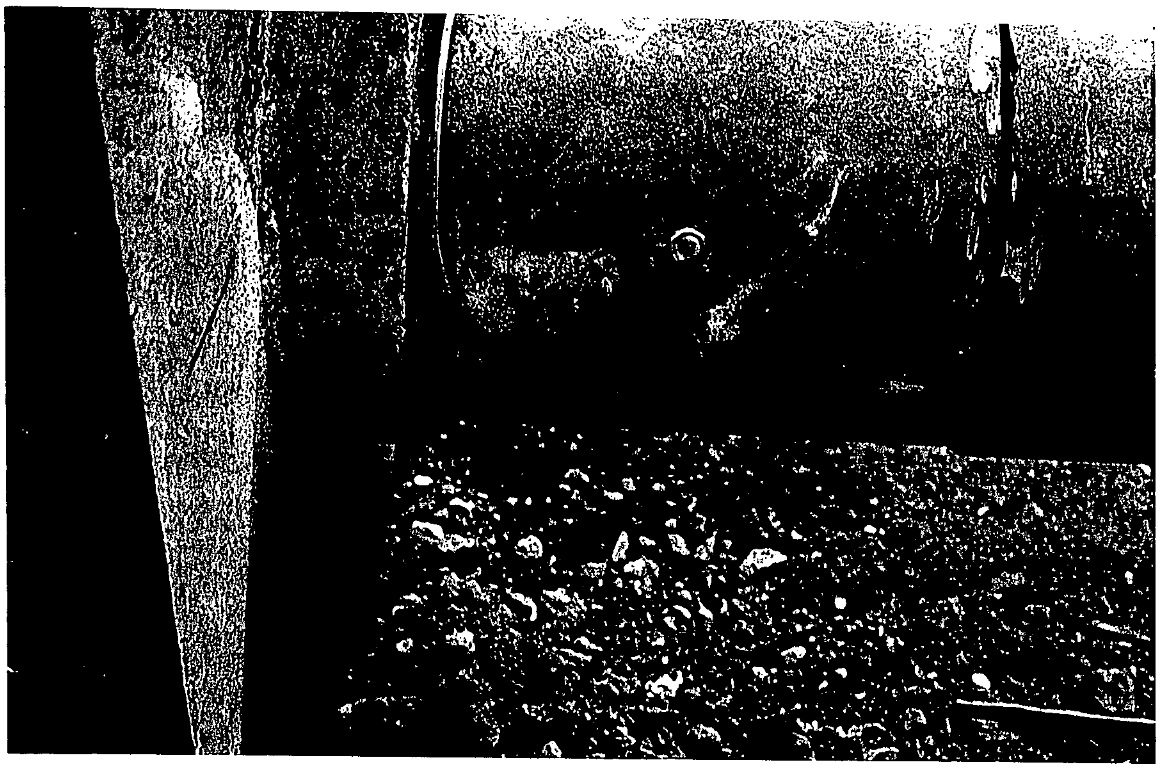
Internal Surface Condition of the Tendon Cap
FIGURE A25.



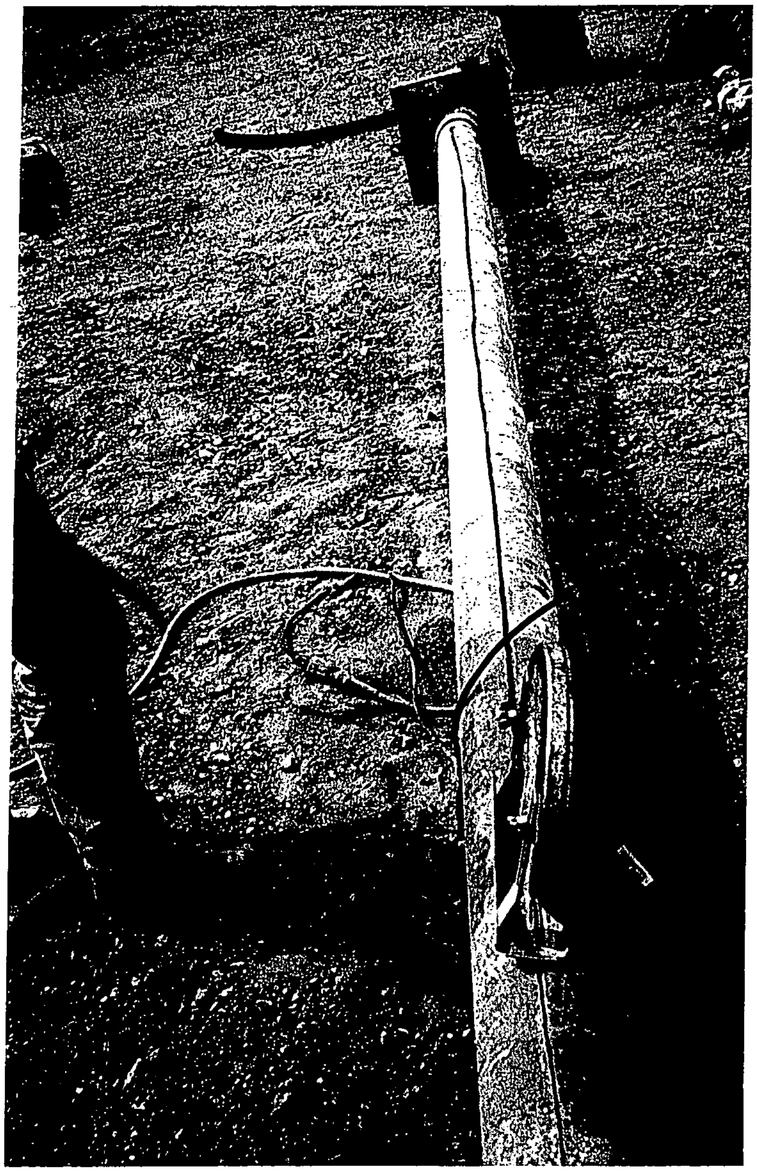
Original Numbers on the Ends of the Bars
FIGURE A26.



Surface Appearance of the Bars and Plate
FIGURE A27.



Tendon Casing Being Cut Near the End Plates
FIGURE A28.



Tendon Casing Being Cut Longitudinally
FIGURE A29.

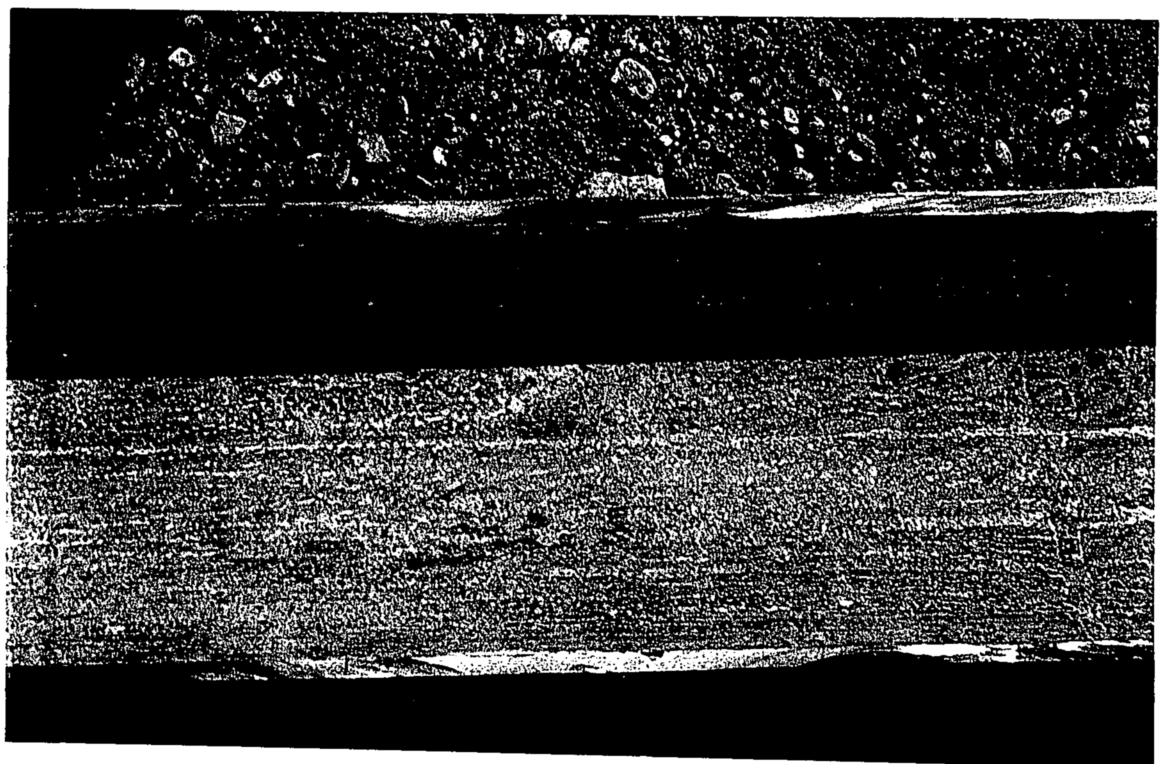
The Tendon Casing Split Open After Longitudinal Cutting

FIGURE A30.

Both Halves of the Casing Removed

FIGURE A31.

The Internal Surface of the Pipe Following Removal
FIGURE A32.



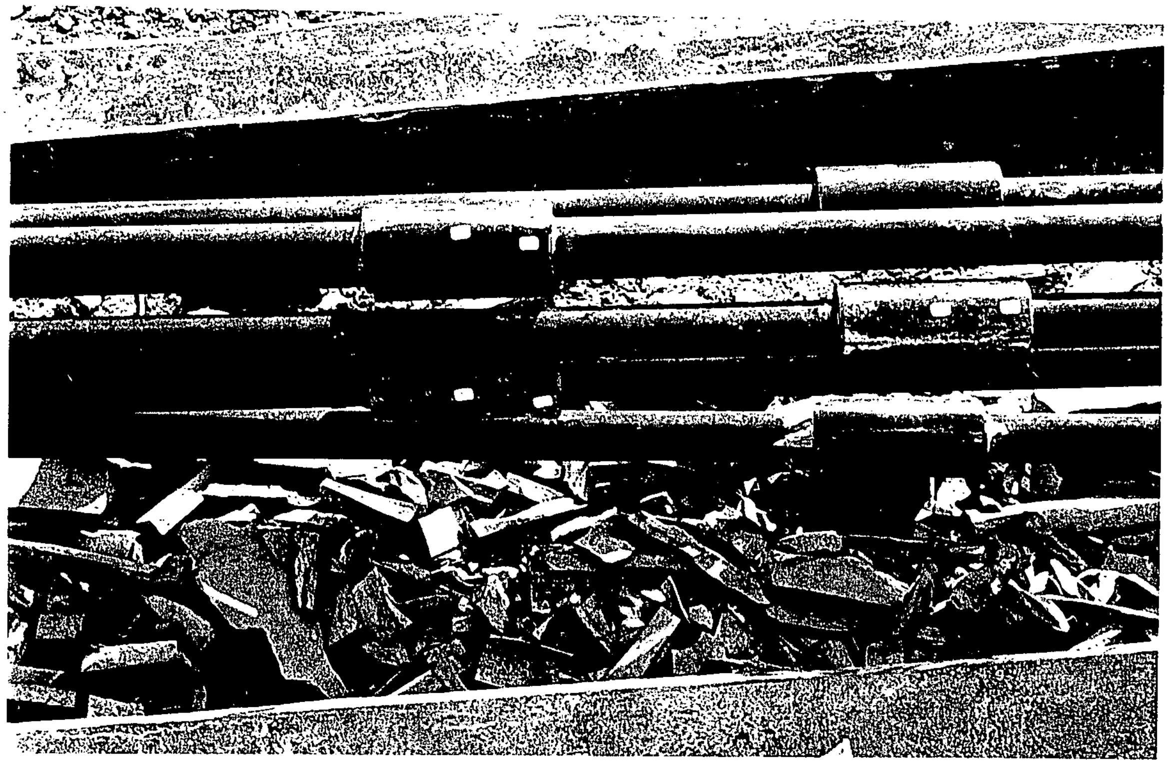
The Internal Surface of the Pipe Following Removal
FIGURE A33.

View Depicting Reddish Stains on the Grout
FIGURE A34.

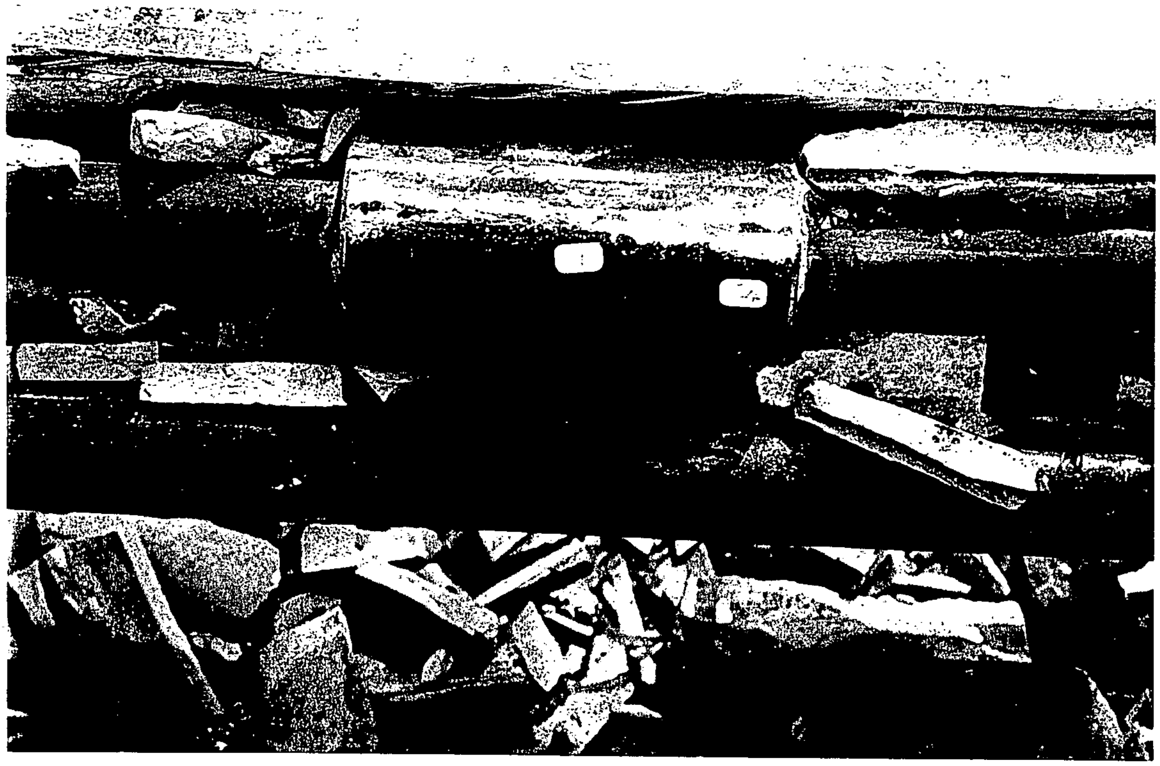
Corresponding Reddish Stain on the Bars
FIGURE A35.

View Showing the Reddish Stain on the Bars
FIGURE A36.

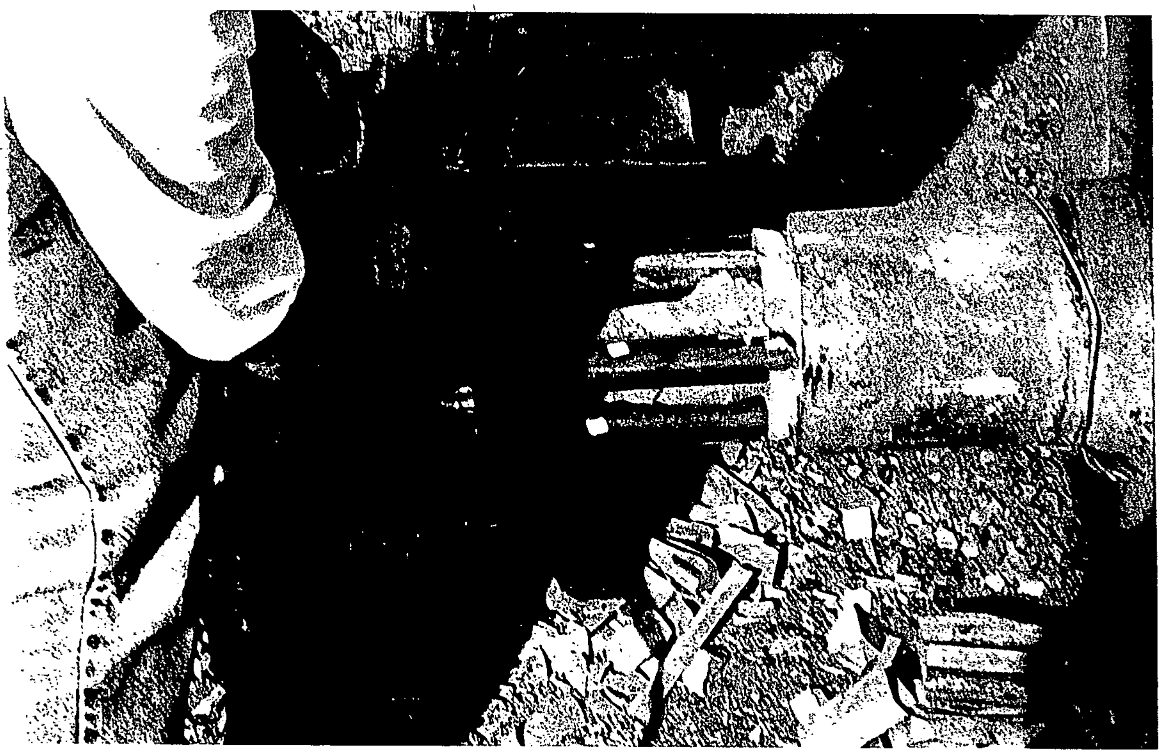
View Showing the Reddish Stain on the Bars
FIGURE A37.



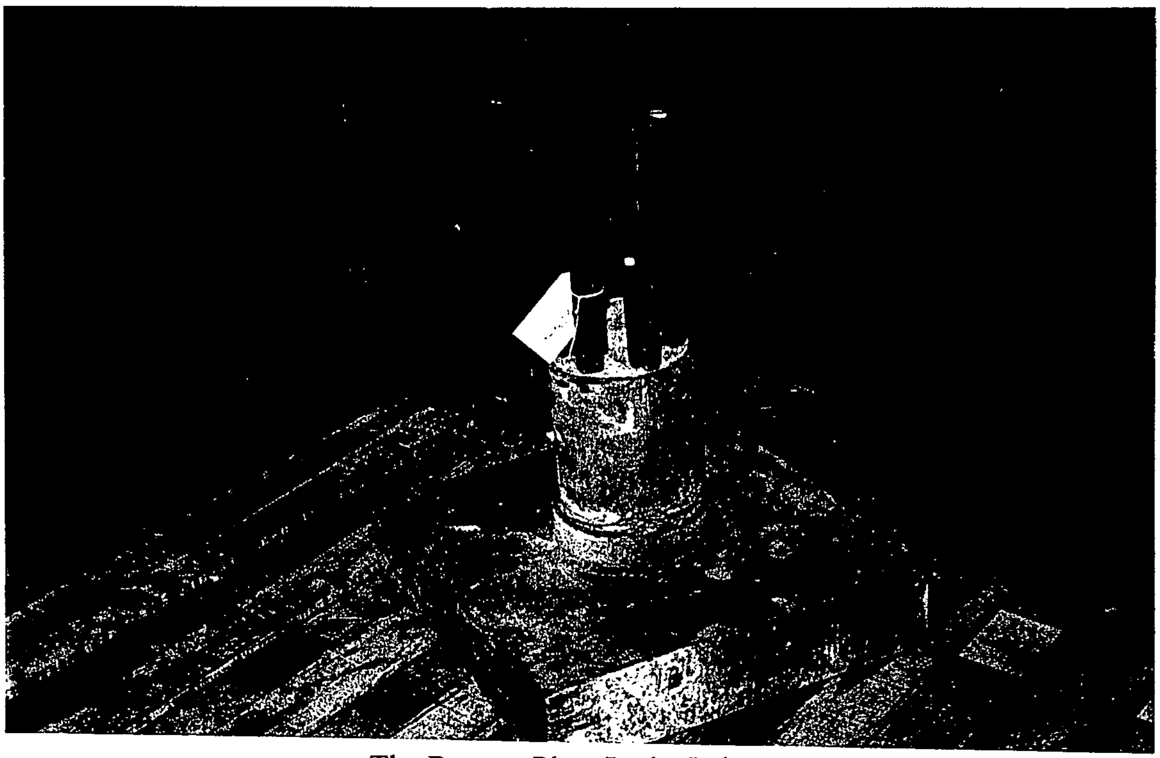
Overall View of the Bar Couplings and Their Arrangement
FIGURE A38.



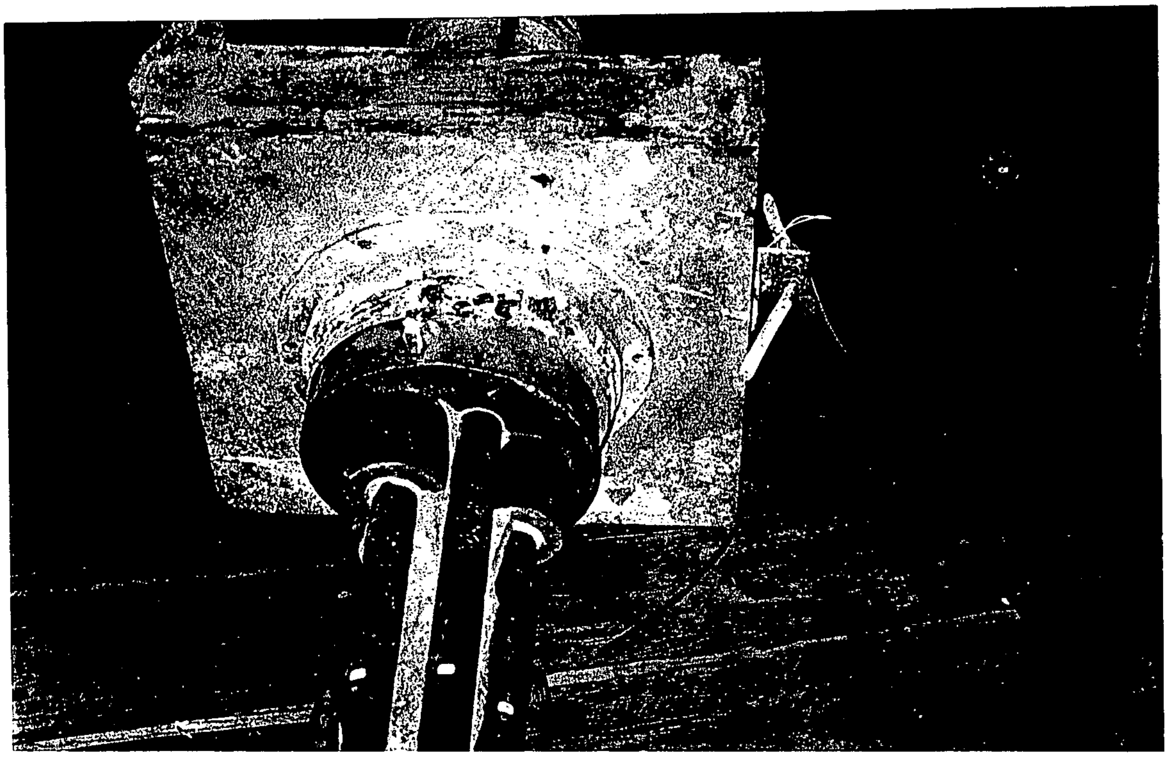
The Couplings Touching the Casing Marks
FIGURE A39.



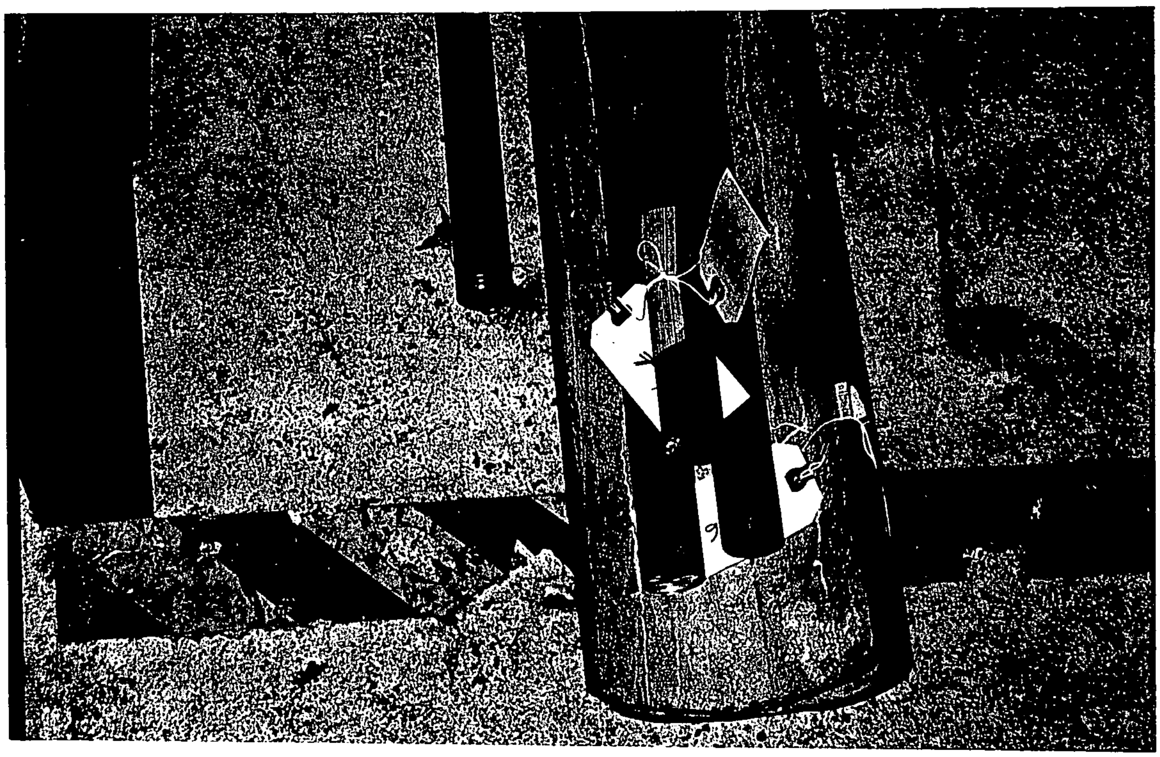
The Bars Being Cut About 2 Feet From the End Plates in Preparation for Shipment to the Lab
FIGURE A40.



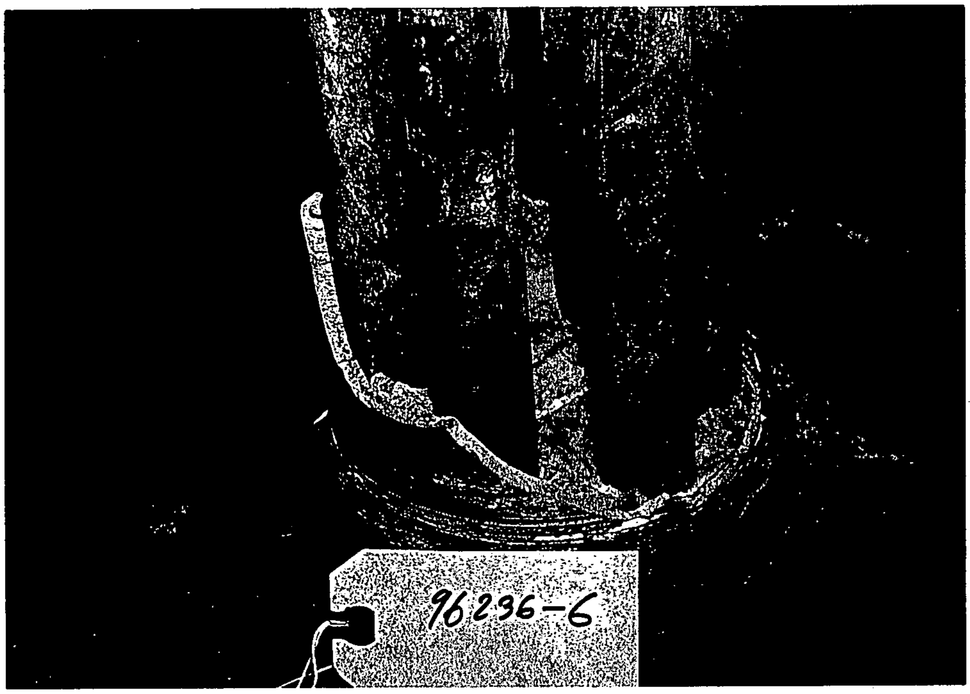
The Bottom Plate In the Lab
FIGURE A41.



The Top Plate Assembly in Altran's Material Testing Lab
FIGURE A42.



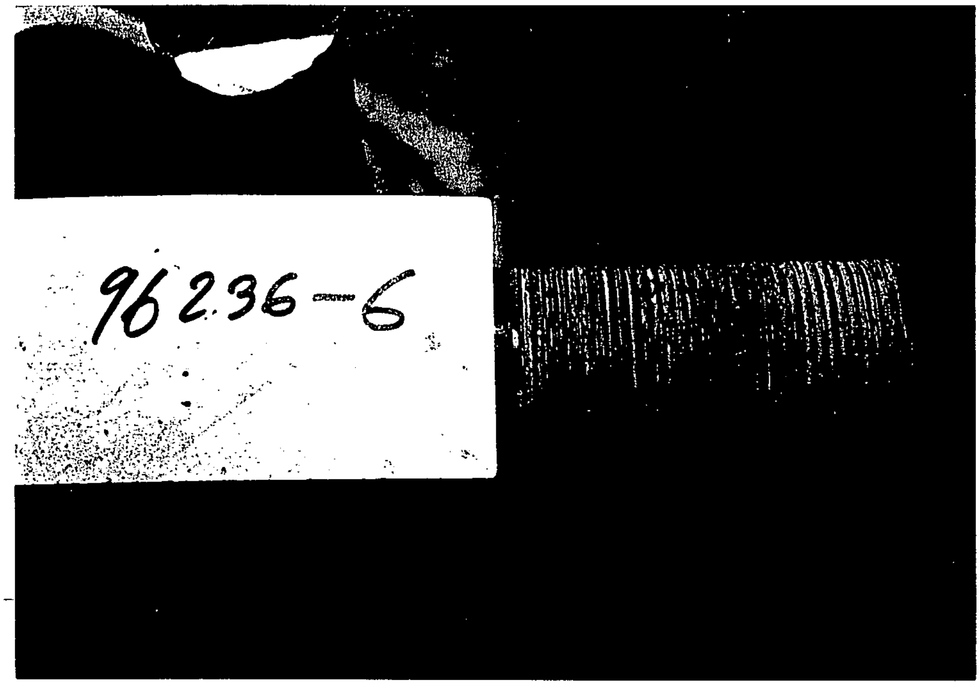
The Bars and Casing in the Lab
FIGURE A43.



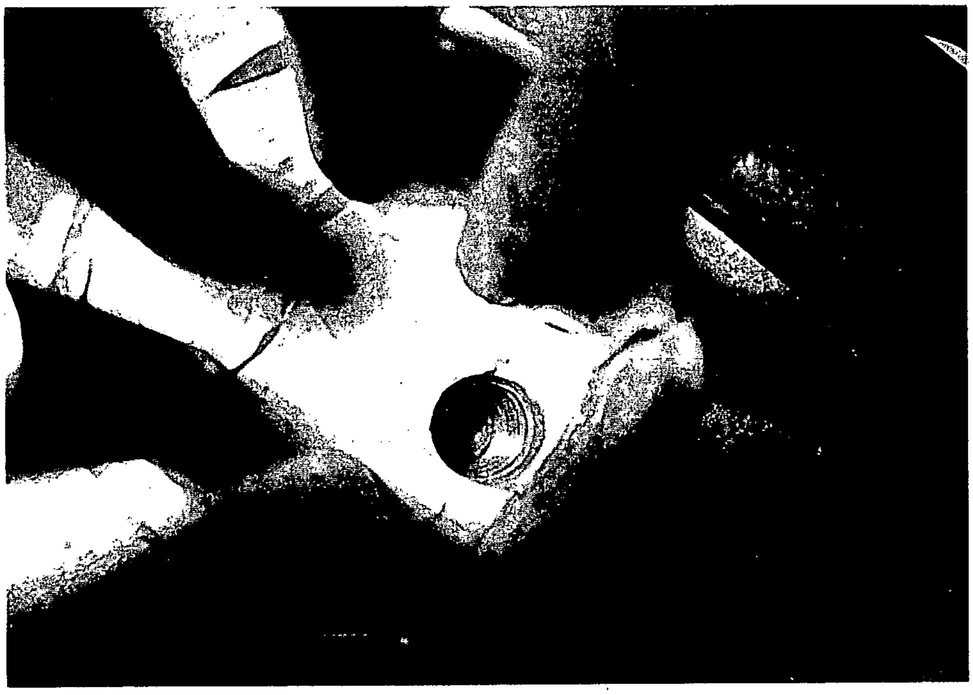
Casing Broken for Inspection
FIGURE A44.

Detail View Depicting Corrosion at the Casing Threads
FIGURE A45.

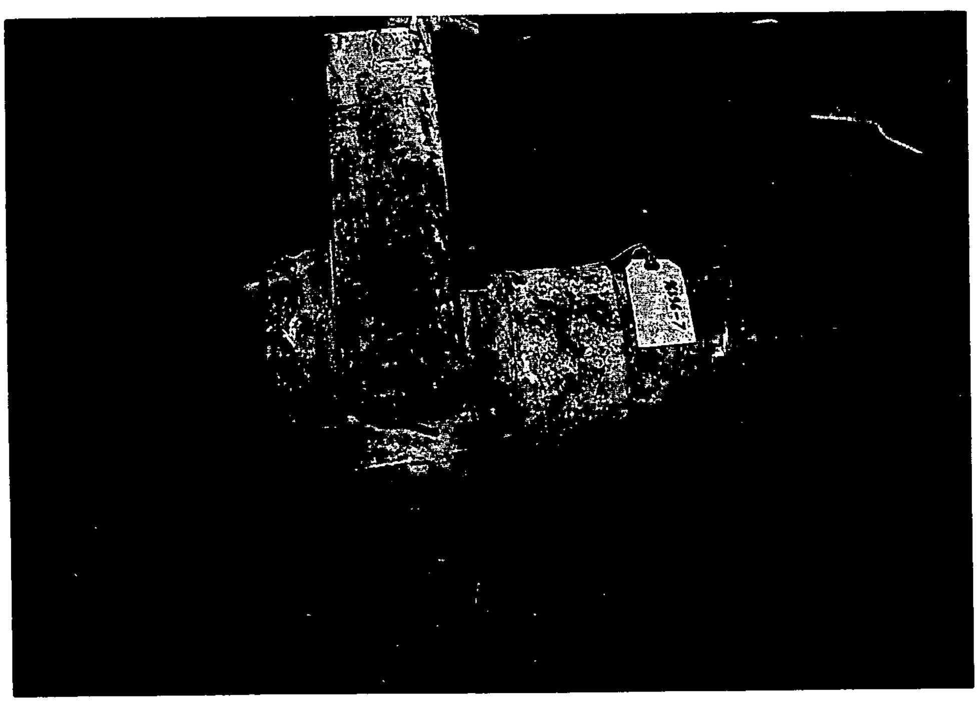
Same Corroded Section After Cleaning with a Wire Brush
FIGURE A46.



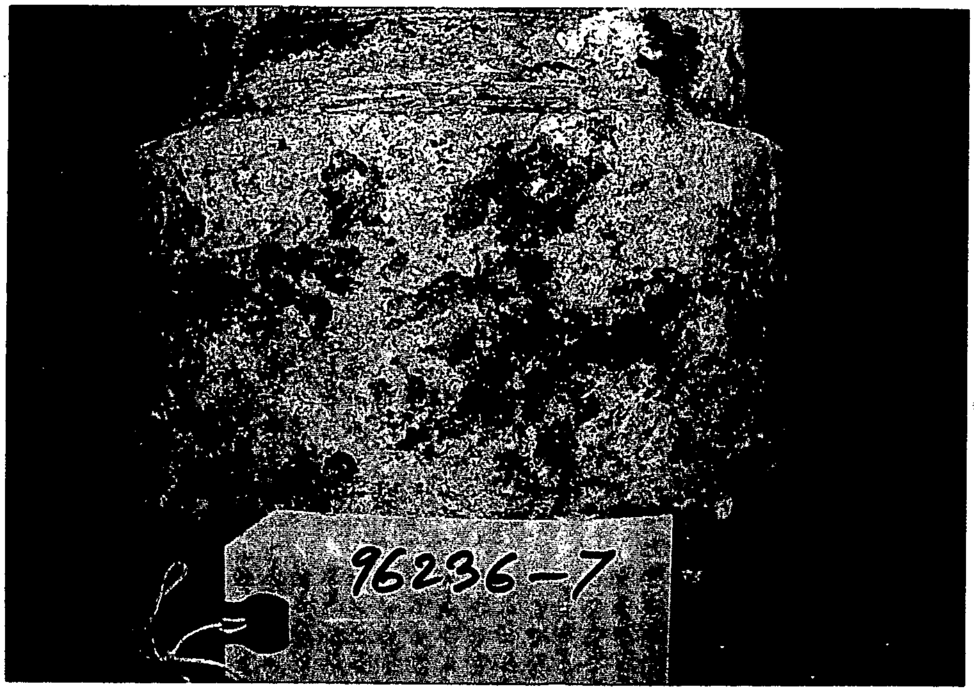
The Threaded End of a Bar Removed from the Bottom Plate
FIGURE A47.



View of the Threaded Bottom Plate After Bar was Removed
FIGURE A48.

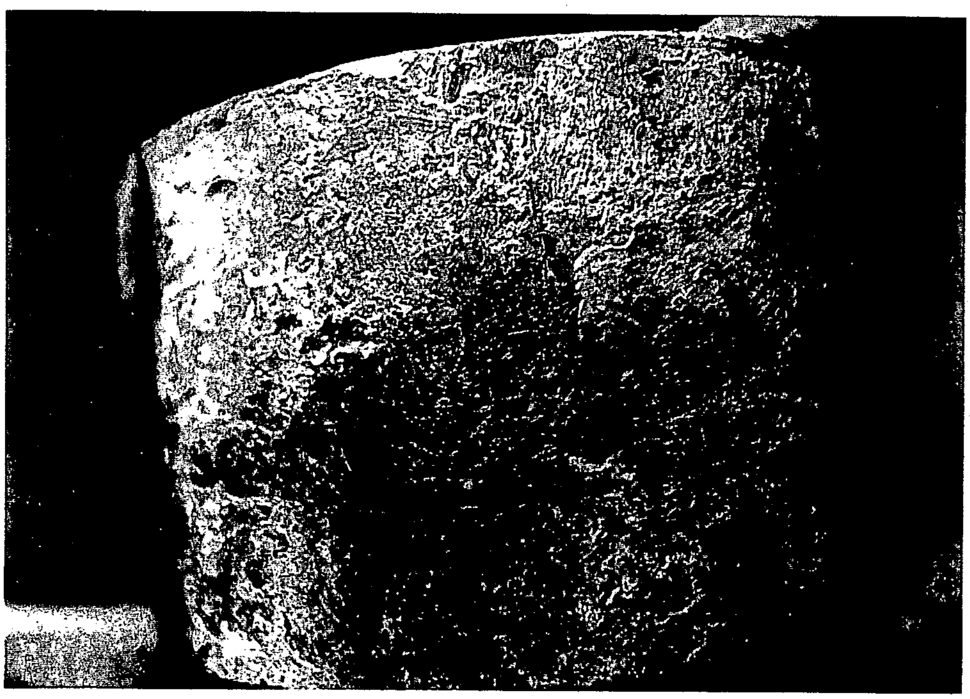


Top Plate Assembly
FIGURE A49.

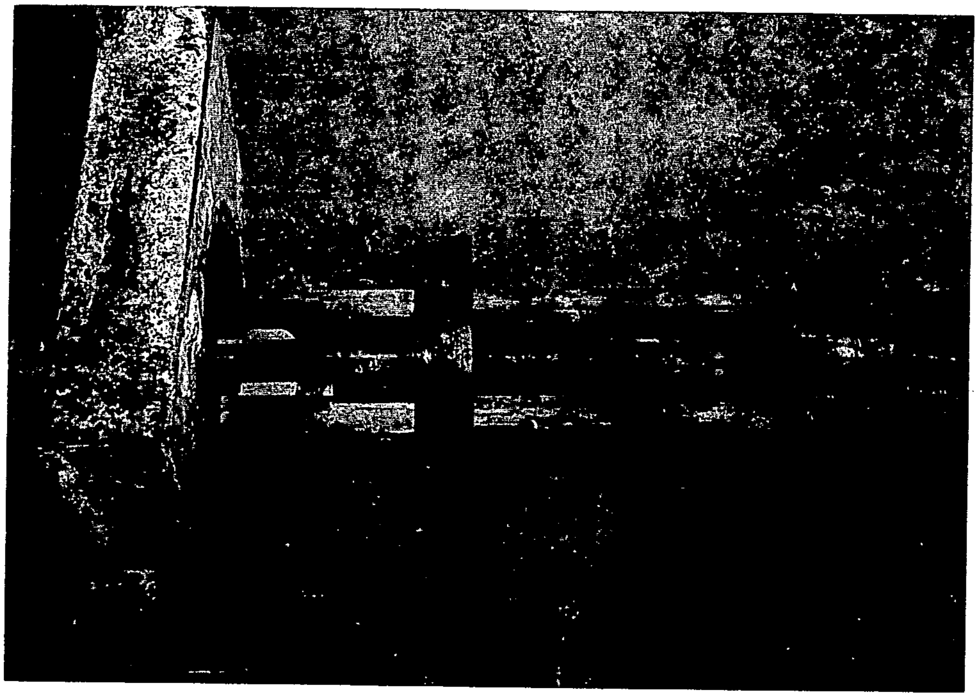


Pipe Coupling Exhibiting Some Corrosion
FIGURE A50.

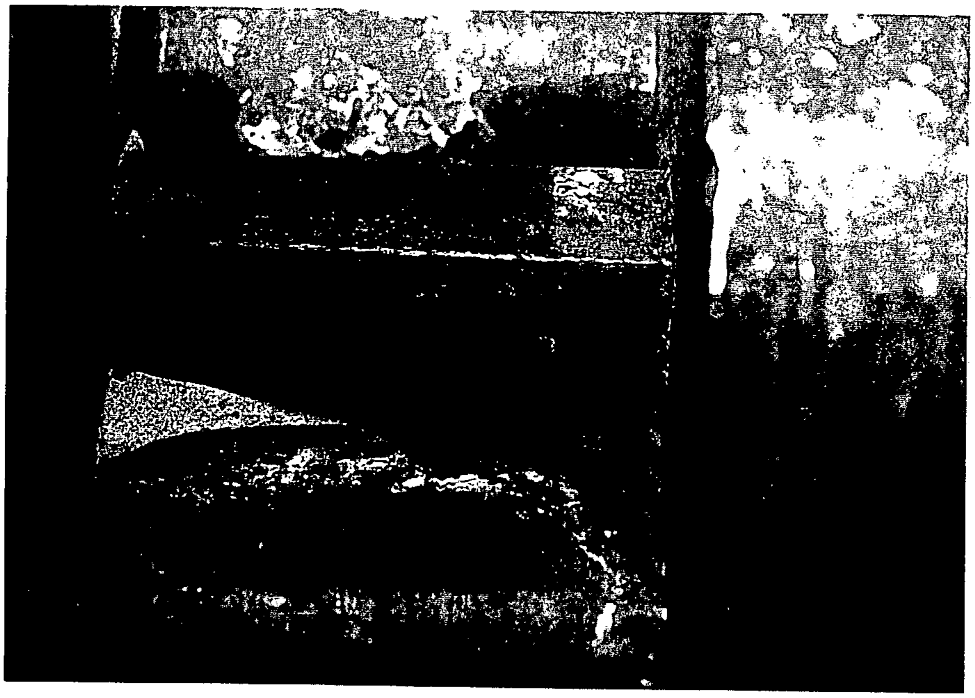
Close-up View of the Corroded Region on the Pipe Coupling
FIGURE A51.



The Corroded Spot on the Pipe Coupling After Cleaning
FIGURE A52.

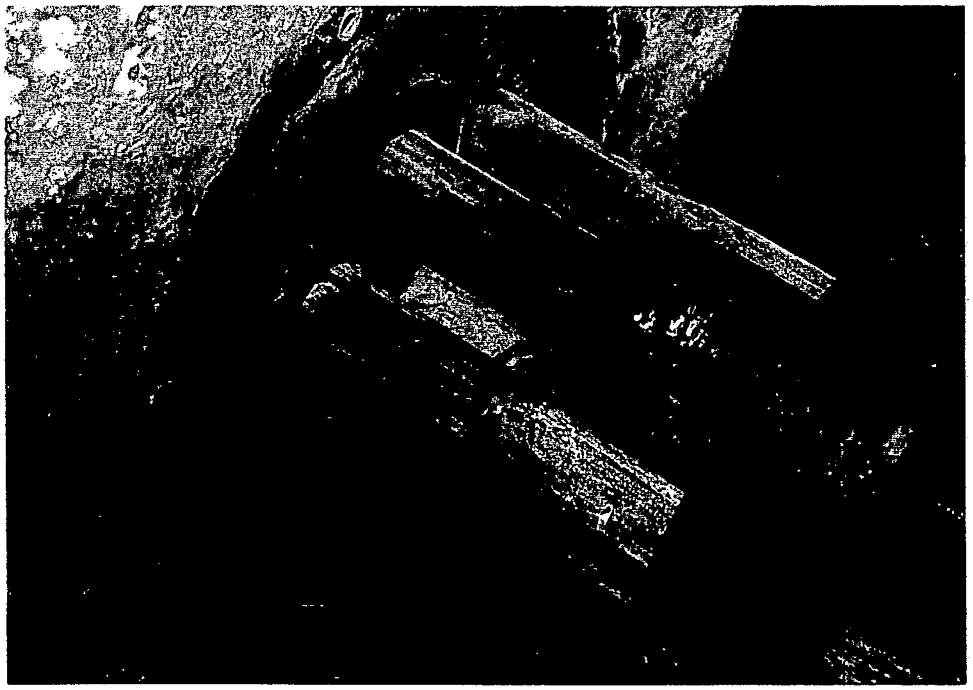


The Bars After Being Driven out of the Top Plate
FIGURE A53.

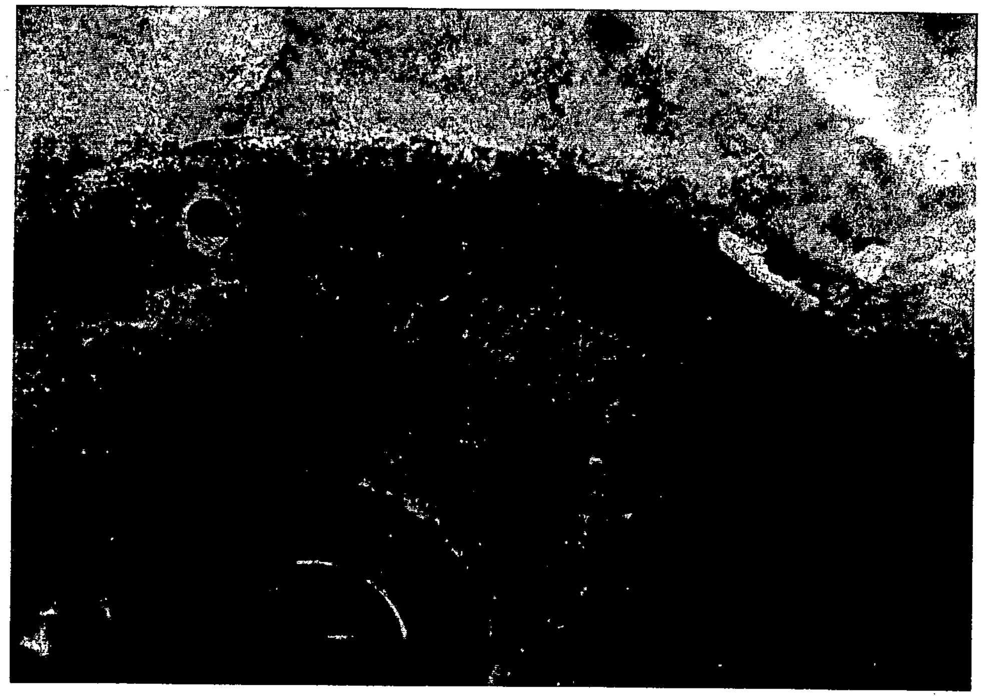


Close-up of a Corroded Spot on Bar Number 3
FIGURE A54.

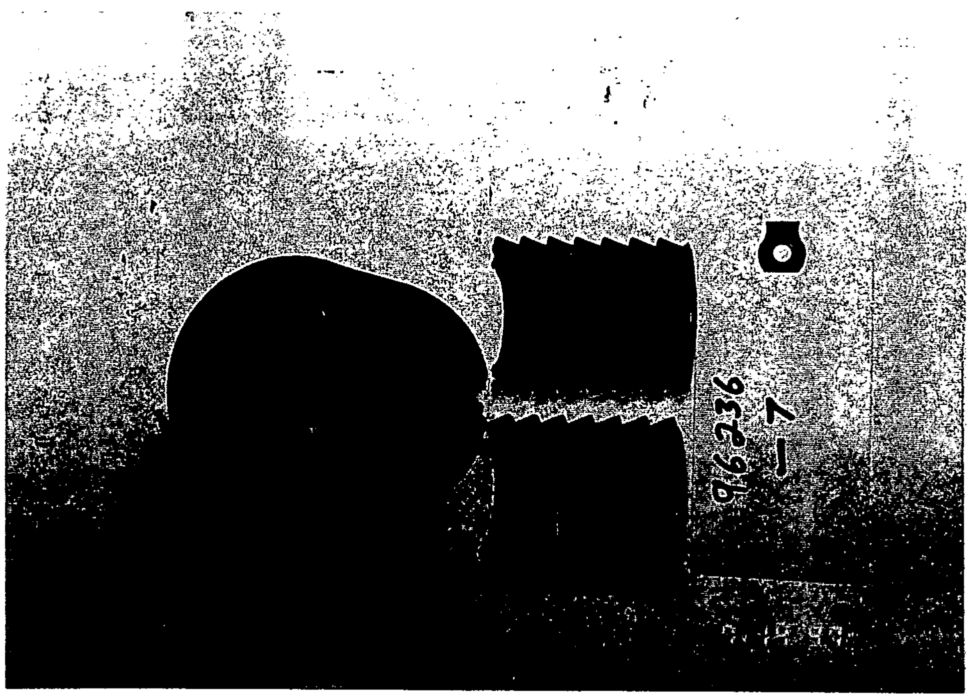
Corroded Bar Surface Following Cleaning
FIGURE A55.



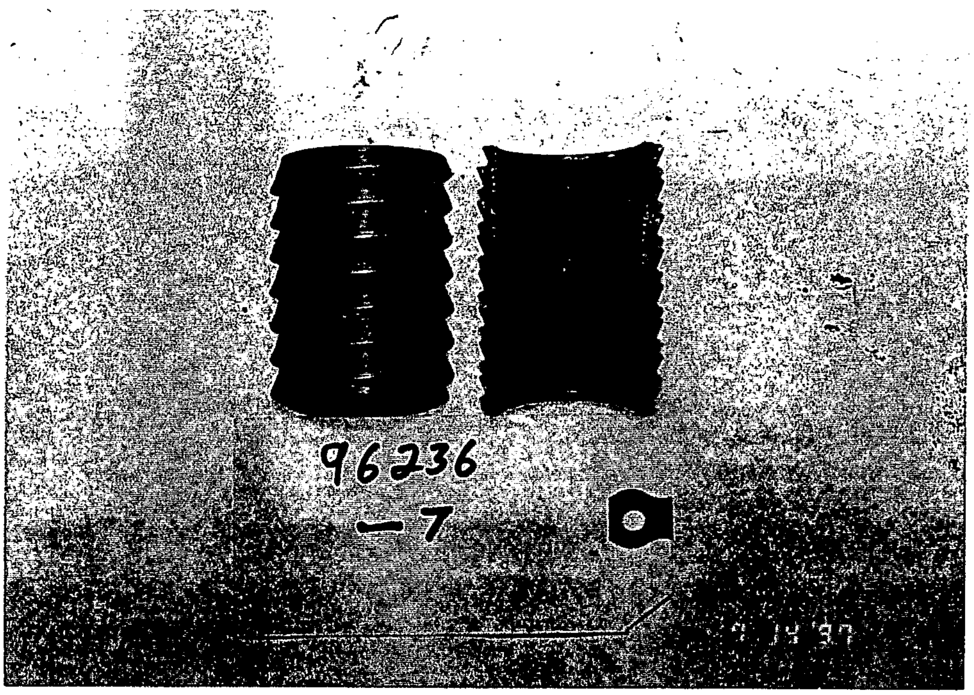
Corrosion on the Surface of the Top Plate
FIGURE A56.



Detail of Corroded Surface on the Top Plate
FIGURE A57.

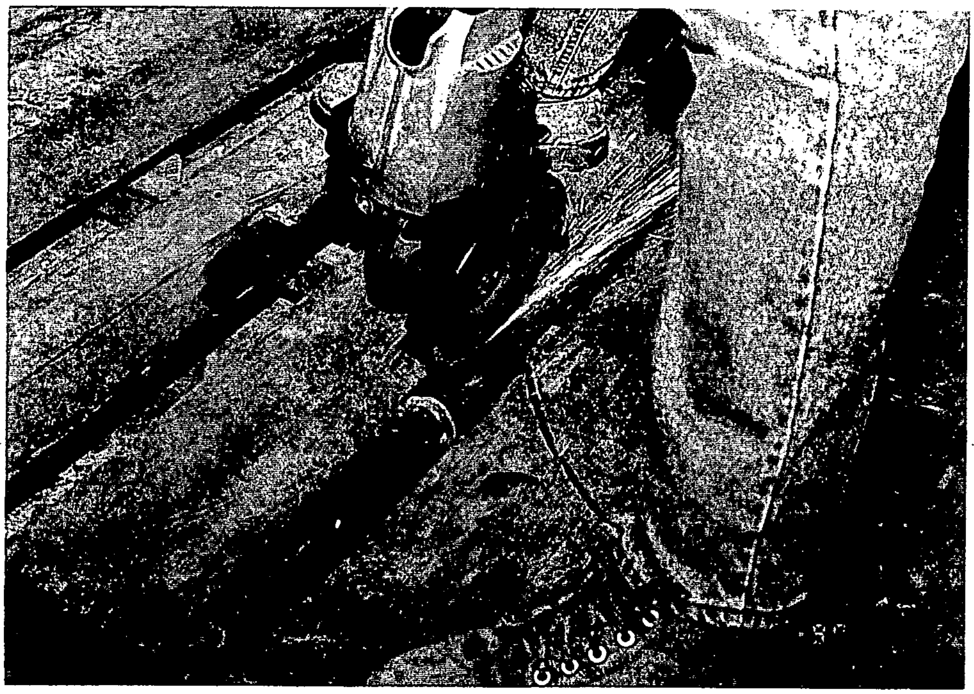


The Cut Grip Nut
FIGURE A58.

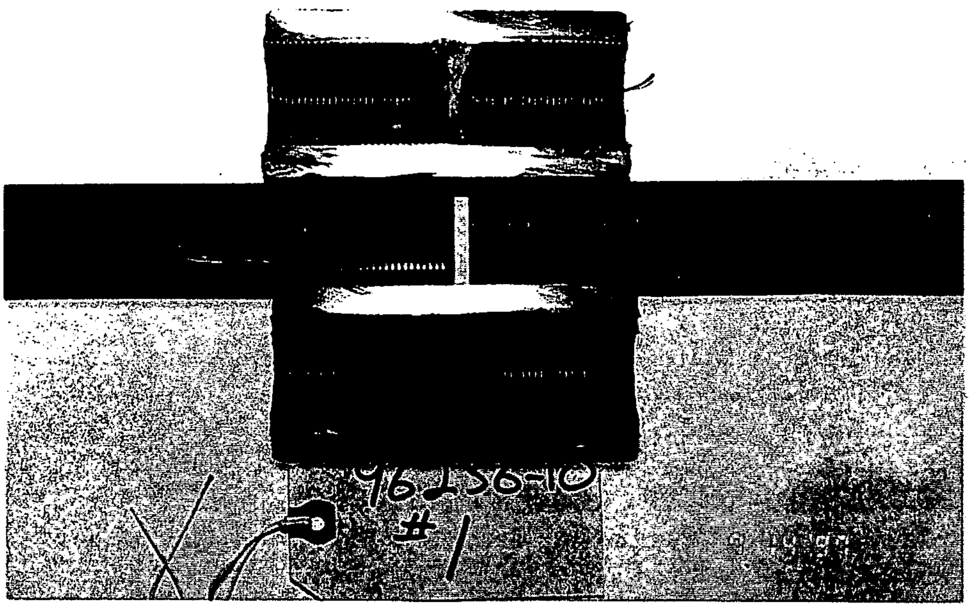


Interior and Exterior Veiw of the Grip Nut
FIGURE A59.

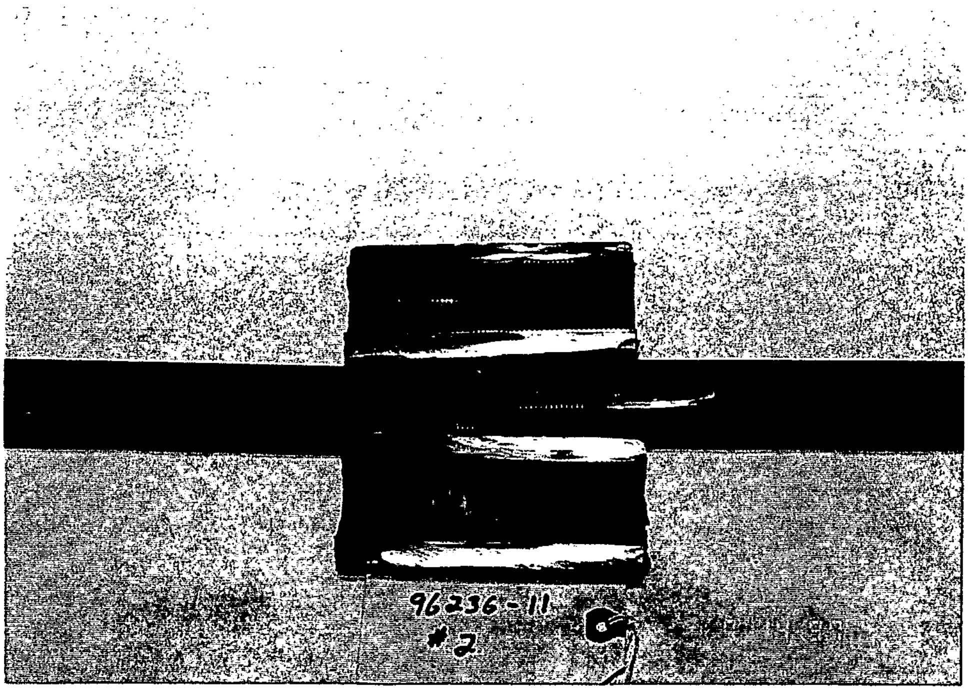
Condition of the Bar Surface Under the Grip Nut
(Score Mark From Nut Removal)
FIGURE A60.



Cutting a Bar Coupling for Inspection
FIGURE A61.

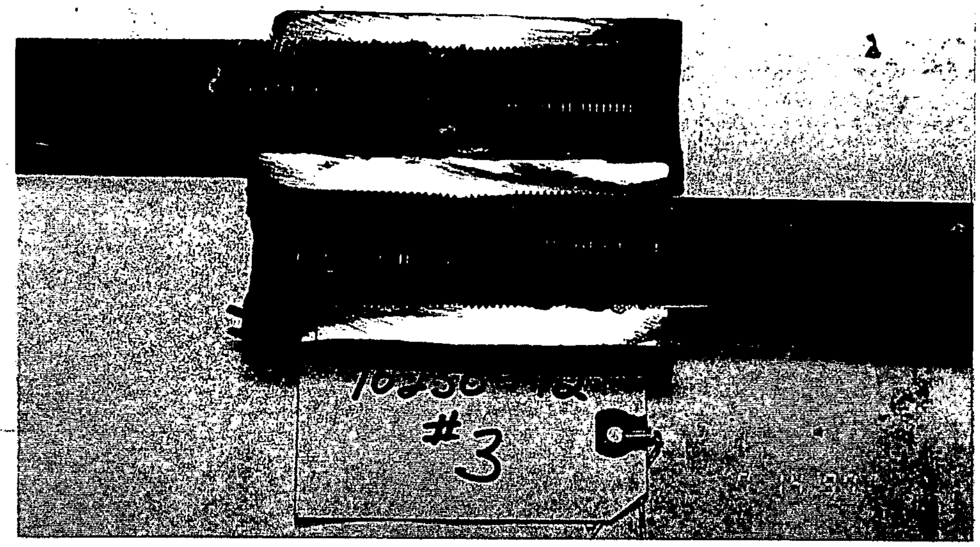


Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No. 1
FIGURE A62.



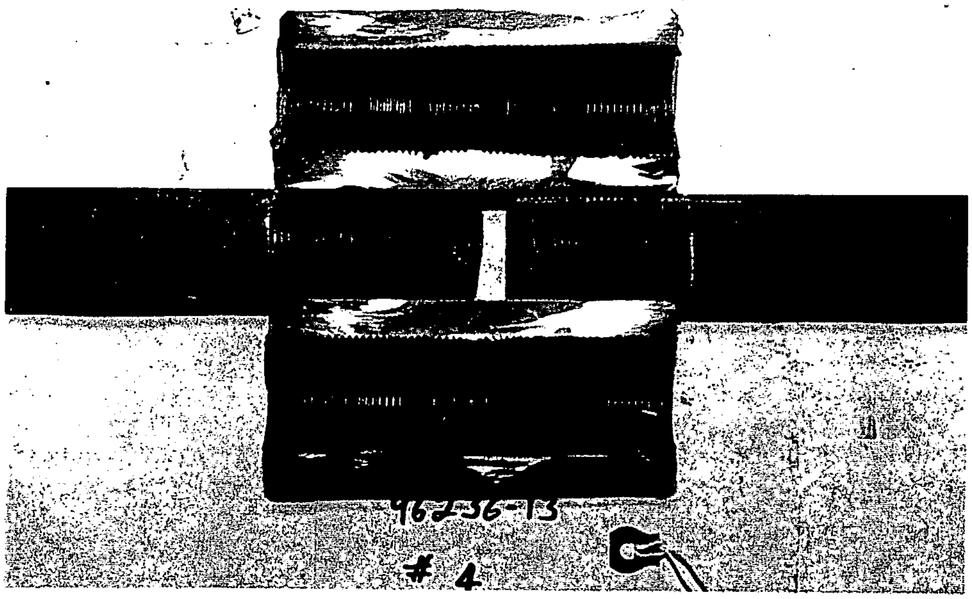
Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No.2

FIGURE A63.



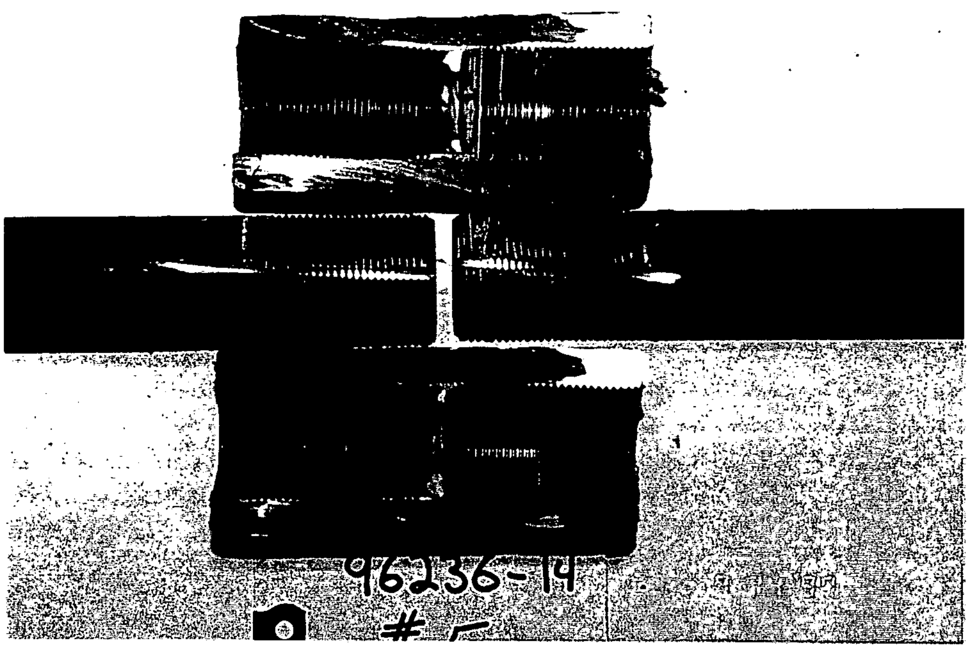
Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No.3

FIGURE A64.



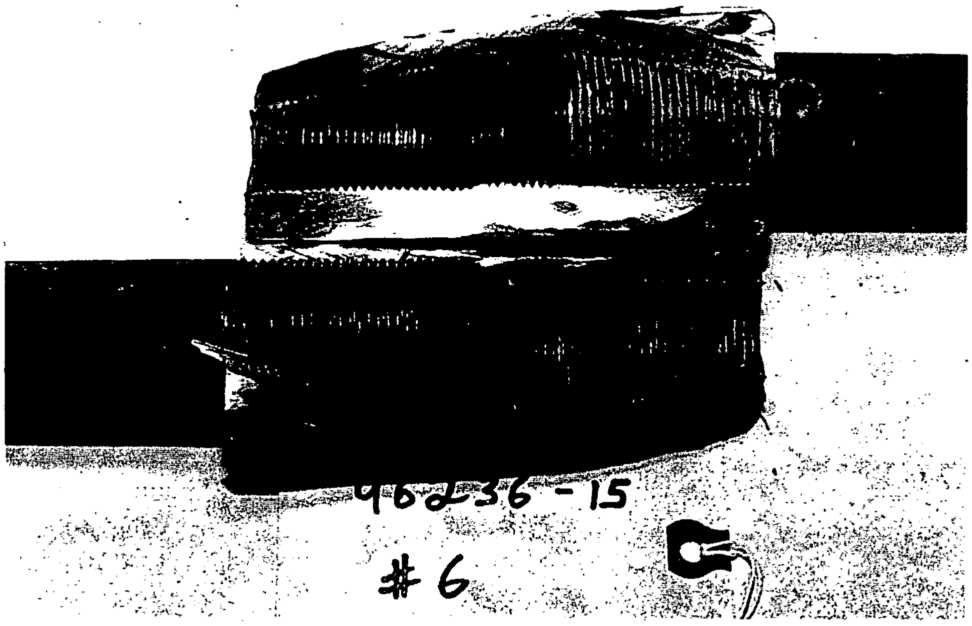
Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No.4

FIGURE A65.



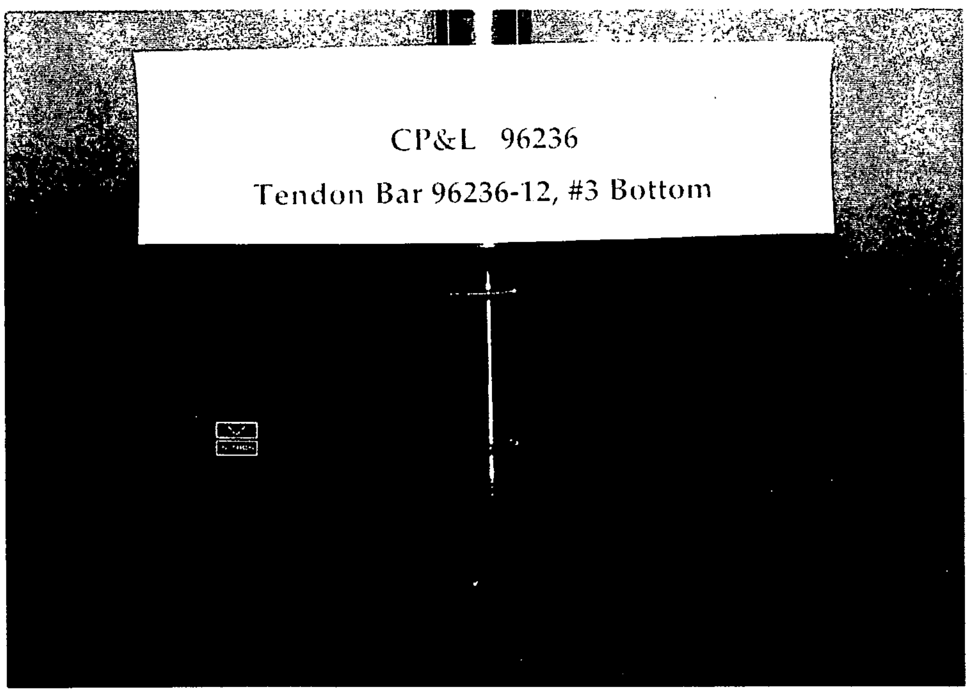
Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No.5

FIGURE A66.



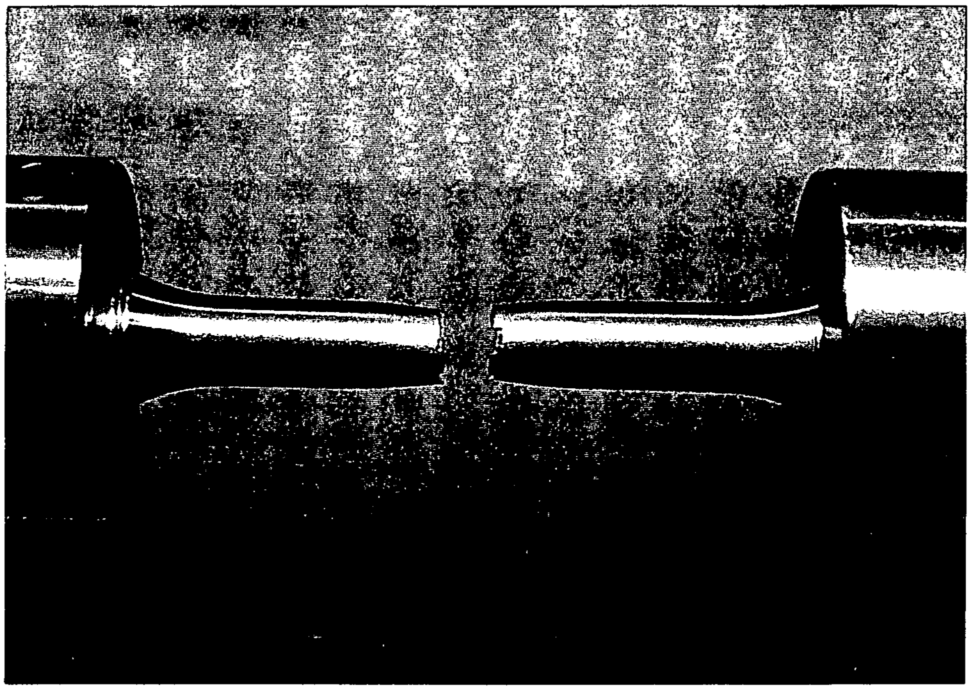
Coupling After Cutting Operation. View Shows Condition of the Threaded Surface of Bar No.6

FIGURE A67.

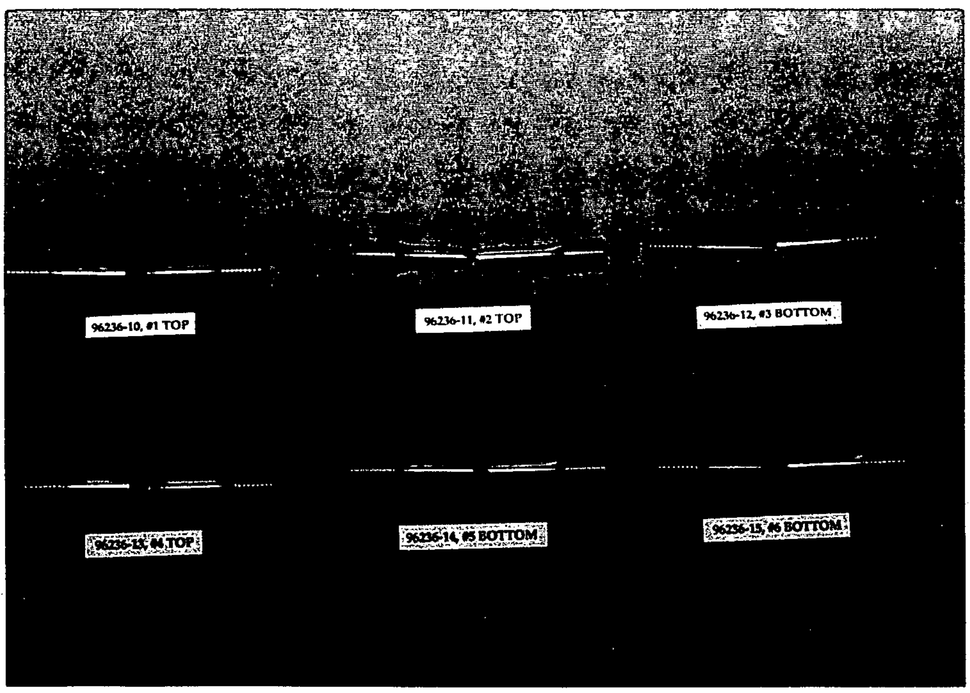


Strain Guage Mounted on Test Coupon in Tensile Loading Configuration

FIGURE A68.



Test Coupon Upon Failure in Tension
FIGURE A69.



View of Six Tendon Bars Following Tensile Loading Analysis
FIGURE A70.

APPENDIX B

CALIBRATION AND LABORATORY DATA

Tensile and hardness testing of tendon specimens were performed on June 25, 1997 and August 26, 1997. The testing was performed in accordance with Altran's material testing procedure TP 11.02 Rev. 1 and ASTM E8.

The extensiometr is calibrated before each test

Model No.: INSTRON 2620-825
Serial No. : 10237
Travel Length: ± 5 mm
Gage Length: 12.5 mm/50 mm

The extensiometer was calibrated on June 25, 1997 using the precision calibrator and the calibration data are given in Table 1. The extensiometer is attached to a pre calibrated precision calibrator. The precision calibrator is manually set to read different displacement distances while the extensiometer output is simultaneously recorded from the digital read-out unit on the INSTRON 8500 controller. The extensiometer used for these tests satisfies the accuracy required by the ASTM E8.

TABLE 1

Setting (mils)	Digital Readout (mils)
0	0.0
30	30.0
60	60.0
90	90.0
120	120.0
150	150.0
180	180.0
190	190.0
180	180.0
150	150.0
120	120.0
90	89.9
60	59.9
30	30.0
0	0.0

Conducted By: Joyce Riley

Signature: Joyce Riley
Date: 9/19/97

The calibration was repeated on August 26, 1997 before testing an additional tendon for tensile strength and data are presented in table 2.

TABLE 2

Setting (mils)	Digital Readout (mils)
0	0
12.5	12.5
25.0	25.0
37.5	37.5
50.0	50.0
62.5	62.5
75.0	75.0
87.5	87.5
100.0	100.0
87.5	87.5
75.0	75.0
62.5	62.5
50.0	50.0
37.5	37.5
25.0	25.0
12.5	12.5
0	0

Conducted By: Au ~~Hui~~ Hua

Signature: [signature]
Date: 9/9/97

CALIBRATED INSTRUMENTS AND EQUIPMENT USED FOR WORK UNDER PROJECT 97149

The below listed calibrated instruments were used in the performance of laboratory examinations and testing under project 97149, "Inspection and Evaluation of Containment Prestressed tendon 25-year Surveillance Block".

INSTRUMENT	ID NO.	DATE Calibrated	DATE Calibration Due	Operator
Load Cell	UK 20	7-11-96	7-11-97	Riley
Caliper	7144266	7-19-96	7-19-97	Riley
Caliper	7144266	8-26-97	8-26-98	Christie
Micrometer	2446022	6-12-97	6-12-98	Riley
Precision Calibrator	ML003	6-12-97	6-12-98	Riley
Wilson Rockwell Hardness Tester	94023101	3-25-97	3-25-98	Christie

Altran Materials Engineering
Mechanical Testing

CP&L Tendons - Tensile Testing

Test type: Tensile

Operator name: JR

Sample Identification: CPL3
Interface Type: 8500 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Ramp Rate (in/min): .0300
Second Speed (in/min): .1200
Extensometer switch value: 1.0000% offset

Instron Corporation
Series IX Automated Materials Testing System 1.19
Test Date: 25 Jun 1997

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 75
Switch-over point (in): .0600

Dimensions:

	Spec. 1	Spec. 2
Diameter (in)	.50050	~~.50400~~ .501 QR
Ext. gauge len (in)	2.0000	2.0000
Spec gauge len (in)	2.3000	2.3000

Specimen Number	Sample ID:	Load at offset Yield 1 (lbs)	Stress at 0.2% Yield (ksi)	Load at Peak (lbs)	Stress at Peak (ksi)	Modulus (ManYoung) (psi)
1	1T	27350.	139.0	30620.	155.6	30260000.
* 2	2T	25830.	129.5	29890.	149.8 / 151.6	30270000.

* Data Needs to be re-calculated using correct diameter QR 6/25/97

The stress-strain data are shown in the Figures 2 and 3.

Altran Materials Engineering
Mechanical Testing

CP&L Tendons - Tensile Testing

Test type: Tensile

Operator name: hiu au

Sample Identification: S3B
Interface Type: 8500 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Ramp Rate (in/min): .0300
Second Speed (in/min): .1200
Extensometer switch value: 1.0000% offset

Instron Corporation
Series IX Automated Materials Testing System 1.19
Test Date: 20 Aug 1997

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 75
Switch-over point (in): .0600

Dimensions:

	Spec. 1
Diameter (in)	.49100
Ext. gauge len (in)	2.0000
Spec gauge len (in)	2.3000

Specimen Number	Sample ID:	Load at offset Yield 1 (lbs)	Stress at 0.2% Yield (ksi)	Load at Peak (lbs)	Stress at Peak (ksi)	Modulus (ManYoung) (psi)
1	s3b	24400.	128.9	28860.	152.4	33590000.

The stress-strain data are shown in the Figure 4.

Altran Materials Engineering
Mechanical Testing

CP&L Tendons - Tensile Testing

Test type: Tensile

Operator name: JR

Sample Identification: CPL4
Interface Type: 8500 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Ramp Rate (in/min): .0300
Second Speed (in/min): .1200
Extensometer switch value: 1.0000% offset

Instron Corporation
Series IX Automated Materials Testing System 1.19
Test Date: 25 Jun 1997

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 75
Switch-over point (in): .0600

Dimensions:

	Spec. 1
Diameter (in)	.50400
Ext. gauge len (in)	2.0000
Spec gauge len (in)	2.3000

Specimen Number	Sample ID:	Load at offset Yield 1 (lbs)	Stress at 0.2% Yield (ksi)	Load at Peak (lbs)	Stress at Peak (ksi)	Modulus (ManYoung) (psi)
1	4T	25730.	129.0	30430.	152.5	32000000.

The stress-strain data are shown in the Figure 5.

Altran Materials Engineering
Mechanical Testing

CP&L Tendons -- Tensile Testing

Test type: Tensile

Operator name: JR

Sample Identification: CPL1 *←
Interface Type: 8500 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Ramp Rate (in/min): .0300
Second Speed (in/min): .1200
Extensometer switch value: 1.0000% offset

Instron Corporation
Series IX Automated Materials Testing System 1.19
Test Date: 25 Jun 1997

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 75
Switch-over point (in): .0600

Dimensions:

	Spec. 1	Spec. 2
Diameter (in)	.50000	.50000
Ext. gauge len (in)	2.0000	2.0000
Spec gauge len (in)	2.3000	2.3000

Specimen Number	Sample ID:	Load at offset Yield 1 (lbs)	Stress at 0.2% Yield (ksi)	Load at Peak (lbs)	Stress at Peak (ksi)	Modulus (ManYoung) (psi)
* 1	3B	24170.	123.1	30000.	152.8	31350000.
2	5B	26340.	134.2	30830.	157.0	30750000.

* Extensometer readings for Sample 3B are incorrect. Only look @ Load. JR 6/25/97

The stress-strain data are shown in the Figure 6.

Altran Materials Engineering
Mechanical Testing

CP&L Tendons - Tensile Testing

Test type: Tensile

Operator name: JR

Sample Identification: CPL2
Interface Type: 8500 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Ramp Rate (in/min): .0300
Second Speed (in/min): .1200
Extensometer switch value: 1.0000% offset

Instron Corporation
Series IX Automated Materials Testing System 1.19
Test Date: 25 Jun 1997

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 75
Switch-over point (in): .0600

Dimensions:

	Spec. 1
Diameter (in)	.50200
Ext. gauge len (in)	2.0000
Spec gauge len (in)	2.3000

Specimen Number	Sample ID:	Load at offset Yield 1 (lbs)	Stress at 0.2% Yield (ksi)	Load at Peak (lbs)	Stress at Peak (ksi)	Modulus (ManYoung) (psi)
1	6B	27720.	140.1	30950.	156.4	31820000.

The stress-strain data are shown in the Figure 7.