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SUBJECT: Forwards special rept re Unit 1 Reactor Bldg Tendon #7, providing results of engineering review,performed to justify continued svc of Units 1 & 2.

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Vice President

December 31, 1997

U.S. Nuclear Regulatory Commission
Attention Document Control Desk
Washington, DC 20555

Subject: Duke Power Company
Oconee Nuclear Station, Unit 1
Docket No. 50-269
Reactor Containment Building
Tendon Surveillance #7

Pursuant to Oconee Nuclear Station Technical Specification 3.6.7.2.c, please find attached a copy of a special report regarding Oconee Unit 1 Reactor Building Tendon Surveillance #7. The purpose of this special report is to provide the results of an engineering review which was performed to justify continued service of the Units 1, 2, and 3 Reactor Building tendons.

During conduct of the Unit 1 tendon surveillance per Technical Specification 4.4.2, some precursor conditions of abnormal tendon degradation were observed. These conditions were higher than normal water content in tendon filler grease, presence of free water, grease leakage from the reactor building, lower than expected tendon elongation, and low filler grease reserve alkalinity. The engineering evaluation concluded that these precursor conditions did not result in loss of tendon prestress forces, and that the examined tendons were capable of performing their intended safety function during their projected inservice lifetimes.

As described in recent correspondence with the staff, including Technical Specification Amendment 225, 225, 222, for Units 1, 2, and 3, respectively, Tendon Surveillance #7 for Oconee Unit 1 was conducted using the newly approved methodology prescribed by Regulatory Guide 1.35 Revision 3.

If there are any questions you may contact D. A. Nix at (864) 885-3634.

Very truly yours,

W. R. McCollum, Jr.
Site Vice-President

Attachment

A001

070070

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OCONEE UNIT 1
Seventh Tendon Surveillance
Technical Specification 3.6.7.2.c Special Report

1.0 Introduction:

During the Unit 1 End-of-Cycle 17 refueling outage, Oconee performed Tendon Surveillance #7 in accordance with Technical Specificaton 4.4.2, "Reactor Building Structural Integrity". During this surveillance, conditions were observed which, according to Technical Specification 4.4.2.2 and 4.4.2.4, are considered indications of potential abnormal degradation of the reactor building. Technical Specification 4.4.2 resulted in the examination, testing, and inspection of 3 randomly selected vertical tendons, 5 randomly selected hoop tendons, and 3 randomly selected dome tendons. The vertical tendons were 23V16, 23V7, and 45V6. The horizontal tendons were 46H94, 31H70, 24H54, 24H77, and 26H81. The dome tendons were 1D14, 2D32, and 2D43. In addition, one previously designated surveillance tendon from each group, 23V14 (vertical), 53H10 (horizontal), and 2D28 (dome), was selected for examination, testing, and inspection. Dome tendon 3D28 was substituted for 2D28 due to personnel safety concerns involved with examination of tendon 2D28. The selected tendons were inspected in accordance with Technical Specification 4.4.2, Regulatory Guide 1.35 Revision 3, and implementing procedures. The inspection, examination, and testing activities included inspections for corrosion, analysis of grease and water samples, and determination of tendon lift-off forces. In addition, for tendons 23V16, 24H77, and 1D14, a single wire was removed, inspected, and tested for strength.

The following conditions were observed which resulted in the need for further engineering evaluation and special reporting per Technical Specificaton 3.6.7.2.c:

1) Free water was discovered in two of the four vertical tendons selected for surveillance. A change in the physical appearance of filler grease in these tendon sheaths was also observed. According to Technical Specification 4.4.2.2.d.1, filler grease should have no free water present and there should be no changes in the physical appearance of the filler grease.

2) Grease samples were taken and analyzed from all tendons selected for surveillance. For five of the tested tendons, the reserve alkalinity could not be shown to be greater than zero. For one tested tendon, the water content was greater than 10%. According to Technical Specification 4.4.2.2.d.5, reserve alkalinity should be greater than zero and water content should not be greater than 10% (by dry weight).

3) Elongation of three tendons was measured per Technical Specifications 4.4.2.2.b and 4.4.2.2.c. The elongation of these tendons differed by more than 10% from that recorded during the original installation. Per Technical Specification 4.4.2.2.c, the measured elongation corresponding to a specific load should not differ by more than 10% from that recorded during initial installation.

4) Replacement filler grease was pumped into the tendon sheaths of the tested tendons. The net amount of filler grease injected exceeded the net duct volume by more than 5% for twelve tendons. Per Technical Specification 4.4.2.2.d.2, the amount of grease replaced should not be greater than 5% of the net duct volume when injected at +/- 10% of the specified installation pressure.

5) Grease leakage was observed during the visual examination of the exterior surface of the reactor building. Per Technical Specification 4.4.2.4, this condition can be considered as evidence of abnormal degradation of the reactor building.

Each of these conditions have been satisfactorily evaluated for indication of degradation or potential degradation of the reactor building. No degradation of the reactor building was concluded to have occurred. Detailed descriptions of the observed conditions and the evaluations are provided in the following sections of this report.

2.0 Evaluations

2.1 Free Water/Change in Physical Appearance of Filler Grease

During removal of the lower tendon cap from tendons 23V14 and 23V16, free water discharged at pressure from around the stud holding the tendon cap to the stressing washer. The lower cap was removed and contaminated grease and water continued to drain from the tendon sheath. The filler grease which drained from the sheath was tan in color. As a result of the discovery of free water in these tendon sheaths, additional tendon lower caps were inspected for the presence of free water. Free water was discovered in 26 of the 175 remaining lower caps. Two additional tendons, 23V20 and 23V22, were selected from these 26 tendons for a comprehensive Technical Specification-type inspection, filler grease analysis, and testing of lift-off forces.

The water found in tendon sheaths 23V14 and 23V16 was sampled for pH analysis. The pH of the water was determined to be 8.31 for tendon 23V14 and 8.83 for tendon 23V16. These pH values are slightly basic and are considered to be non-corrosive. Sufficient water for pH analysis could not be obtained from tendons 23V20 or 23V22.

The anchorage components, stressing washers, shims, and bearing plates, were examined for corrosion, corrosion level, and grease coverage. Tendons 23V14, 23V20 and 23V22 had good grease coverage, but some surface corrosion (with no pitting) was observed on the buttonheads and stressing washers. Some pitting was noted on the bearing plates, but was generally outside the cap. In addition, for tendon 23V16, pitting less than 0.003 inches deep was observed on the stressing washers and buttonheads, and some surface corrosion was noted on the wires. However, there was no significant reduction in wire cross sectional area. Photographs are

provided in Figures 1-3 to illustrate these conclusions. No corrosion was observed on the wires of any tendon on the field (lower) end, despite the presence of standing water in this part of the sheath. The water had no free surface for oxygen replenishment, and the oxygen originally contained in the water had apparently been scavenged by corrosion activity on other surfaces such as the tendon sheath. Table I provides a summary of corrosion levels and grease coverage on the bearing plate, shims, buttonheads, and stressing washer.

Tendon 23V16 was detensioned and a single wire was removed for inspection and testing. The wire was selected at random, cut at the bottom, and removed from the top. No corrosion was present at any point along the removed wire. The wire was tested for strength in accordance with Technical Specification 4.4.2.2.b.2. The ultimate strength exceeded 240,000 psi for all samples. Tendon 23V14 had been previously inspected six times and had three wires removed. None of these three wires showed any signs of corrosion.

Tendons were tested for lift-off forces and found to be above the Minimum Required Values for functionality and at or above the Predicted Values for the 27th year of service. Table II provides a summary of as-found conditions, lift-off forces, and Predicted and Minimum required lift-off values.

When tendon 23V16 was retensioned, elongations were measured during retensioning. The elongation versus force relationship is described in detail in Section (3.0) of this report. The measured elongations did not indicate wire breakage or reduction of cross-sectional area.

Based on the following information;

1) tendon components and removed wire exhibited minimal or no corrosion,
2) elongation values indicated no wire breakage or reduction of area, and,
3) lift-off values were acceptable and above the predicted values,

it is concluded that the free water in the sheaths and change in physical appearance of the filler grease has not caused degradation of the tendon wires, and there is no indication of abnormal degradation of the Reactor Building.

2.2 Loss of Reserve Alkalinity/ Excessive Water Content

The reserve alkalinity of tendon filler material sampled from tendons 2D28(shop end), 3D28 (field end), and 26H81(shop end), was reported as less than 2. The reserve alkalinity of tendon filler material sampled from tendons 46H94 (shop and field ends), 45V6 (field end), and 23V14 (field end) was reported as less than 0. The low reserve alkalinity indicates a loss of one protective feature

of the filler material. Additionally, filler grease from Tendon 23V14 contained 18.40% water, which is greater than the 10% limit specified by Technical Specification 4.4.2.2.

The lift-off forces for tendons 3D28, 26H81, 46H94, 45V6, and 23V14 were found to be above the Minimum Required Values for functionality and at or above the Predicted Values for the 27th year of service. Table II contains a summary of as-found conditions, lift-off forces, and predicted and minimum required lift-off values.

NRC Information Notice 91-80 provides the recommendation to avoid lift-off testing of tendons which have anchor head threads of questionable integrity due to occupational safety concerns. Since the anchor head threads in tendon 2D28 were of questionable integrity based on visual observation, this tendon was not lift-off tested for personnel safety reasons. Tendon 3D28 was appropriately substituted for tendon 2D28. The tendon anchor head threads are only used for lift-off testing and do not perform a safety-related function. Therefore, the reactor building structural integrity is not affected by the questionable integrity of the anchor head threads on tendon 2D28.

Tendon 3D28 had slight pitting (<0.003 inches) on the shop end buttonheads. Tendon 26H81 had minor or no corrosion with no pitting. Tendon 46H94 had no corrosion with bright metal surfaces on both ends. Tendon 45V6 had some surface corrosion (reddish brown color with no pitting) on the buttonheads on the field(lower) end. Tendon 23V14 had some surface corrosion (reddish brown color with no pitting) on the buttonheads and stressing washers. In addition, tendons 23V14 and 3D28 had been previously inspected six times and had three and two wires removed respectively, with none showing any signs of corrosion.

Based on the lack of or minimal corrosion of the tendon components and the lift-off values being above the predicted values, it is concluded that the reserve alkalinity of the filler grease has not caused degradation of the tendon wires, and there is no indication of abnormal degradation of the Reactor Building. No elongation measurements were taken on any of these tendons. New replacement filler grease with reserve alkalinity >35 was pumped into these tendon sheaths.

2.3 Elongation Not Within 10% of Installed Values

The elongation of three tendons, 23V16, 1D14, and 24H77, were measured during retensioning of the tendons in accordance with Technical Specification 4.4.2.2.c. The tendons were stressed to 80% of ultimate strength during original installation. Technical Specification 4.4.2.2.c limits the overstress to 70% of ultimate strength. Therefore, the tendons were only overstressed sufficiently to reinstall the shims. The elongation results were recorded at the following pressures:

1) the pressure required to bring the tendon into a slightly stressed condition to remove slack and seat the buttonheads,
2) the seating pressure,
3) two intermediate pressures between the seating pressure (2) and the slightly stressed condition (1), and,
4) the overstress pressure required to install the shims and not to exceed 70% of ultimate strength.

From these data points, a linear relationship was found to exist between the seating pressure and the pressure at the overstressed condition. This relationship was used to extrapolate the elongation which would have resulted from stressing the tendon to 80% of ultimate strength, which is the only point at which elongations were measured during installation.

Tendon	End	Extrapolated Elongation	Original Elongation	% Decrease
23V16	Shop	4.88	6.25	22
	Field	3.30	6.19	47
1D14	Shop	3.32	4.25	22
	Field	2.66	4.25	37
24H77	Shop	4.80	4.88	2
	Field	3.96	4.69	16

From this analysis, the elongation in all cases would have been less than that observed during installation, if the tendon had been stressed to 80% of ultimate strength, and ranged from 2% to 47% less than was measured originally. While this differs by greater than the 10% Technical Specification limit, it differs in a direction which suggests an increase in the spring constant of the tendons. This is not to suggest that the spring constant actually increased, which would not be physically possible. Friction forces along the tendon would tend to reduce the effective tendon length and would therefore reduce the observed elongation. However, since the measured elongation with respect to applied force has not increased, it can be concluded that there has not been any decrease in tendon wire cross-sectional area. A reduction in area would indicate possible corrosion or breakage of tendon wires. Measured lift-off values for these tendons were also acceptable. The acceptable lift-off forces provides additional evidence that the condition of these tendons is acceptable and that these elongations are not an indication of abnormal degradation of the Reactor Building.

2.4 Excessive Filler Grease Voids

Tendons sheaths were refilled with new Visconorust 2090P-4 filler grease. The net volume of grease installed exceeded the net duct volume by greater than 5% on 12 of the tendons tested in accordance

with technical specifications, and on tendons 23V20 and 23V22, which were tested under an expanded scope. The tendons and percent of net volume of filler grease installed are tabulated in Table II.

Installation pressure for the replacement grease varied from 50-100 psig for the horizontal and dome surveillance tendons to 100-150 psig for the vertical surveillance tendons. The applied pressure was the required pressure to achieve a full tendon sheath. The original installation pressure is not known, but is believed to have been 100 psig based on tendon surveillance procedures used for the first scheduled surveillance. However, it is evident that the void volume of these tendon sheaths exceeded 5% of the net duct volume.

The lift-off forces for all tendons having voids greater than 5% of the net duct volume were found to be above the Minimum Required Values for functionality. In addition, the lift-off forces for these tendons were at or above the Predicted Values for the 27th year of service.

Tendons 23V16, 24H77, and 1D14 were each detensioned. In addition, a wire was removed from these three tendons for testing and inspection. The wires were selected at random, cut at the bottom and removed from the top. No corrosion was present at any point along the wire(s) removed. The wire was tested for strength in accordance with Technical Specification 4.4.2.2.b.2. The test results indicated that the ultimate strength exceeded 240,000 psi for all samples. During retensioning of these tendons, elongations were measured. These elongation measurements indicated that there was no reduction of cross sectional area or wire breakage.

During past tendon surveillances, tendons 23V14, 53H10, and 3D28 had been previously inspected six times and had three, two, and two wires removed respectively. None of these wires showed any signs of corrosion.

2.5 Grease Leakage on the Exterior of the Reactor Building

The effect of grease penetration into containment concrete has been previously evaluated. It was concluded that tendon protection grease has no detrimental effects on concrete. This evaluation is described in a letter dated November 7, 1996, from Duke to the NRC.

3.0 Remedial Actions:

As a result of these tendon surveillance results, additional vertical tendon inspection is ongoing. These ongoing inspections are composed of inspection of the anchorage components and tendon wires for corrosion, the presence of free water, discolored grease, and lack of grease coverage. In addition, the gaskets, tendon caps, copper washers, concrete surfaces, or any other conditions which could permit water intrusion or loss of filler grease are being

investigated, repaired, replaced, or modified as necessary. No additional lift-off testing is planned for Unit 1 other than Technical Specification required testing.

Vertical tendon sheaths which were discovered to have free water, or tan/milky filler grease, will be drained as completely as possible and the grease will be disposed of as waste. Tendon sheaths containing grease which appears to be acceptable will also be drained. The filler grease which is not visually rejected will be reused. New filler grease will be installed in cases where a sufficient volume of used grease is not available. Used grease from multiple tendon sheaths may be combined for reuse, however, new and used grease will not be combined or used in the same sheath. The source tendon sheaths for all reused grease will be documented and recorded. When a vertical tendon is randomly selected for future Technical Specification surveillance, the sampling and testing of filler grease will be of old or new grease, but not a mixture.

The root cause of the presence of free water and excessive void volumes in the vertical tendon sheaths is being evaluated. Possible sources of free water are:

- rainwater bypass of the upper cap gaskets,
- rainwater intrusion around the cap hold down studs,
- groundwater infiltration through the concrete below grade, and,
- rainwater infiltration through the concrete dome (very unlikely),

The cause of excessive void volumes in the filler grease is partially attributable to the 6% shrinkage factor inherent in the filler grease. There are undocumented reports of vertical tendon leaks from their lower caps into the tendon gallery. This potential cause is still being investigated. Hoop and dome tendon caps are not reported to have experienced leakage of significant magnitude to cause the reduction in filler grease observed. Leakage from the sheath through the concrete also does not appear to be sufficient to account for the reduction in filler grease observed.

Additional remedial actions will be performed on Unit 1, as necessary, after the root cause evaluations are complete.

In addition, the Units 2 and 3 reactor building vertical tendon lower caps will be checked for the presence of free water by February, 1998. Additional remedial actions will be taken on Units 2 and 3 based on the results of the Units 2 and 3 tendon cap inspections. These additional remedial actions would occur during the upcoming outages for Units 2 and 3. These refueling outages are planned for Unit 2 in the Spring of 1998 and for Unit 3 in the Fall of 1998.

4.0 Conclusions:

Free water, changes in physical appearance of filler grease, loss of filler grease reserve alkalinity, voids in the filler grease, and smaller than expected tendon elongations, have been evaluated for any indication of abnormal degradation or potential for abnormal degradation of the Unit 1 reactor building. These evaluations have concluded that no abnormal degradation has occurred. Remedial actions are being taken to eliminate or minimize the existence of these or other precursor conditions, and to prevent recurrence of such conditions. Considering the lack of significant corrosion after 27 years of stressed life of the tendons, despite the conditions previously described and evaluated, it is concluded that no potential abnormal degradation of the reactor building(s) has occurred or will occur as a result of these conditions.

The Units 2 and 3 reactor buildings have not yet been examined per the new Regulatory Guide 1.35 methodology. However, the Units 2 and 3 reactor buildings are of similar materials, construction, and design as the Unit 1 reactor building. As a result, similar tendon surveillance results and conclusions are expected for Units 2 and 3 as compared to Unit 1. Nevertheless, to validate this hypothesis, some limited surveillance activities are planned on Units 2 and 3 as described above, prior to the next scheduled tendon surveillances on these units.

TABLE I CORROSION LEVELS					
Tendon	End	Bearing Plate	Buttonheads	Shims	Stressing Washer
45V6	Shop	C	A	A	A
	Field	C	B	A	A
23V7	Shop	C	B	A	B
	Field	C	B	A	A
23V14	Shop	C	B	A	B
	Field	C	B	A	B
23V16	Shop	B	C	A	C
	Field	C	C	A	C
23V20	Shop	C	B	A	B
	Field	C	B	A	B
23V22	Shop	C	B	A	B
	Field	C	B	A	B
46H94	Shop	C	A	A	A
	Field	C	A	A	A
53H10	Shop	D	A	A	A
	Field	C	A	A	A
31H70	Shop	C	A	A	A
	Field	C	A	A	A
24H54	Shop	C	A	A	A
	Field	C	A	A	A
24H77	Shop	C	B	A	B
	Field	C	B	A	B
26H81	Shop	C	A	A	B
	Field	C	A	A	B
1D14	Shop	C	A	A	B
	Field	C	A	A	B
2D32	Shop	C	A	A	A
	Field	C	A	A	A
3D28	Shop	C	C	A	B
	Field	C	B	A	A
2D43	Shop	C	A	A	B
	Field	C	B	A	B

Corrosion Level Legend

A Bright metal, no visible oxidation
B Reddish Brown color, no pitting
C 0.0 inches<Pitting<0.003 inches
D 0.003 inches<pitting<0.006 inches
E 0.006 inches<pitting<0.010 inches
F Pitting>0.010 inches

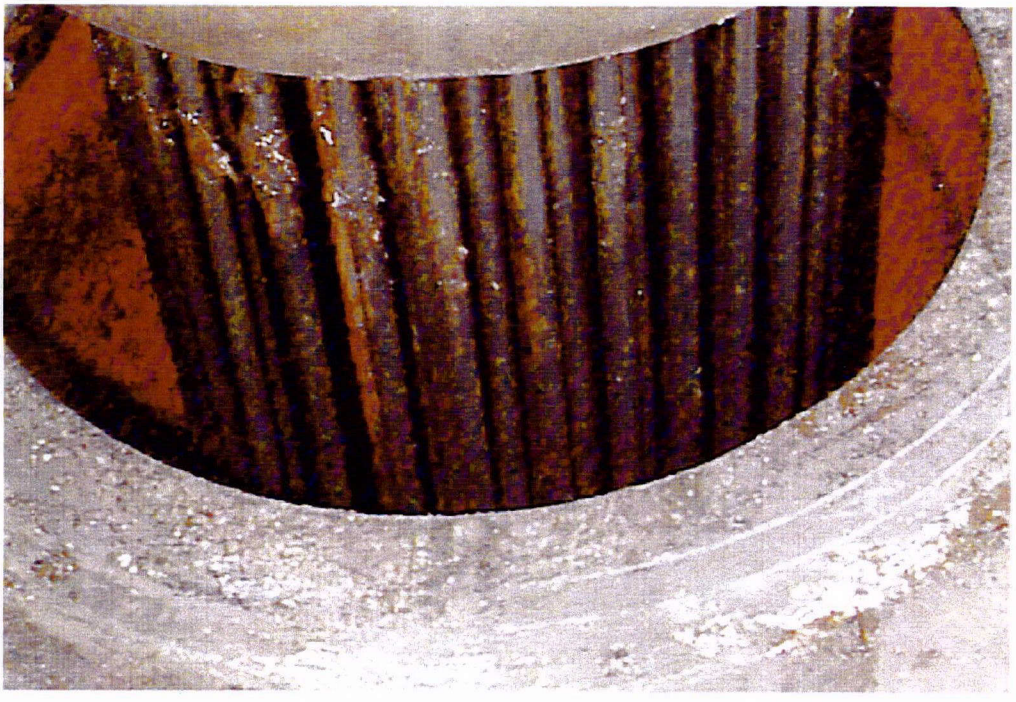
TABLE II
AS FOUND CONDITIONS AND LIFT-OFF FORCES

Tendon	End	Reserve Alkalinity (limit>0)	Water Content (% by Weight) (limit<10)	Free Water Found (gal)	Net Installed Grease Volume (% of Net Duct Volume) (limit<5)	Tested Value (kips)	Predicted (kips)	MRV (kips)
45V6	Shop	NS	NS	-0-	<5%	707	632	615
	Field	-2.33	<0.2%	-0-		NT	632	615
23V7	Shop	NS	NS	-0-	<5%	681	632	615
	Field	2.67	<0.2%	-0-		NT	632	615
23V14	Shop	NS	NS	-0-	34%	704	632	615
	Field	-8.17	18.40%	4+		NT	632	615
23V16	Shop	NS	NS	-0-	Not complete	694	632	615
	Field	1.97	7.52%	20+		632	632	615
23V20*	Shop	NS	NS	-0-	8%	694	632	615
	Field			1+		NT	632	615
23V22*	Shop	NS	NS	-0-	10%	694	632	615
	Field			3+		NT	632	615
46H94	Shop	-1.68	0.28%	-0-	31%	669	587	565
	Field	-0.675	<0.2%	-0-		632	587	565
53H10	Shop	17.9	1.79%	-0-	47%	673	587	565
	Field	NS	NS	-0-		666	587	565
31H70	Shop	4.23	<0.2%	-0-	24%	601	587	565
	Field	2.56	<0.2%	-0-		637	587	565
24H54	Shop	2.65	<0.2%	-0-	41%	645	587	565
	Field	2.54	<0.2%	-0-		643	587	565
24H77	Shop	3.66	<0.2%	-0-	15%	607	587	565
	Field	4.01	<0.2%	-0-		656	587	565
26H81	Shop	3.1	<0.2%	-0-	17%	591	587	565
	Field	<2	<0.2%	-0-		619	587	565
1D14	Shop	5.52	0.39%	-0-	20%	709	604	577
	Field	6.53	<0.2%	-0-		694	604	577
2D32	Shop	2.08	<0.2%	-0-	26%	733	604	577
	Field	1.64	0.75%	-0-		709	604	577
3D28	Shop	<2	0.41%	-0-	56%	706	604	577
	Field	4.58	0.29%	-0-		706	604	577
2D43	Shop	3.7	<0.2%	-0-	23%	720	604	577
	Field	4.74	<0.2%	-0-		709	604	577

NS = Not Sampled | NT = Not Tested | = Outside Tech Spec Limits

*=Not a Tech Spec Tendon

FIGURE 1
Surface Corrosion on Wires



Note: Orange color on trumpet is primer. Wire left of center was observed to have most corrosion. Corrosion was present only on the side toward the viewer. Surface is rough, raised approximately 1/16" over adjacent surface.

FIGURE 2
View of Underside of Stressing Washer

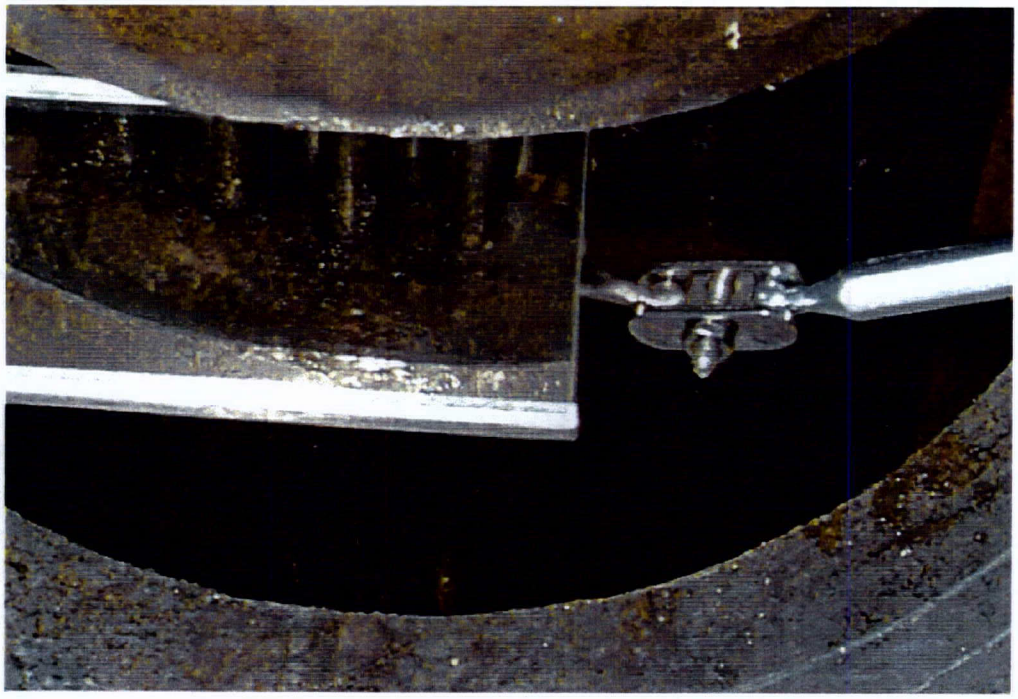


FIGURE 3
View of Underside of Stressing Washer