AFWAL-TR-81-4019
Volume II

AIRCRAFT ANTENNA CORROSION CONTROL

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INTRODUCTION

Antennas have been determined to be the most corrosion prone components in the Navy's airborne electronic systems. Corrosion of antenna installations affects structural integrity and causes degradation of transmitted and recieved signals and undesirable random and static electrical discharges in sensitive electrical and electronic communication and armament systems. A considerable amount of maintenance time spent on antenna systems are to correct damage caused by corrosion. In an attempt to alleviate this problem an AERMIP (Aircraft Equipment Reliability Improvement Program) was funded to provide aircraft antenna corrosion prevention/control improvements. In the first phase of this program the major causes of corrosion and related antenna failures were identified. These results[1] were reported at the last Tri-Service Conference in 1978.

In the next phase of this program improved corrosion preventive materials and processes for aircraft antennas were proposed. Representative antenna installations were selected for a fleet evaluation of these maintenance procedures. A test plan was developed that provided the guidelines for conducting the fleet evaluations to assess the effectiveness of these materials and processes. Under Commander, Air Force Pacific (COMNAVAIRPAC) and Commander, Air Force Atlantic (COMNAVAIRLANT) sponsorship and in coordination with the appropriate Fleet Wings, the test plan maintenance procedures and material applications were applied to various types of aircraft antennas. The test period covered 180 days.

Aircraft antennas can be classified into four types: whip, long wire, rigid and flush/dome. Figures 1 through 6 provide illustrations of the different antenna types. The installation depicted in Figure 4 shows the use of a gasket between the antenna and airframe skin. It should be noted that not all rigid (or blade) type antennas use this gasket.

The antenna installations selected for evaluations along with the fleet maintenance activities which performed the maintenance procedures are listed in Table I. The main basis of selection was that the antennas should represent the different types each with its own distinctive corrosion problems. For example, the P-3 HF Long Wire antenna is subject to corrosion and arcing due to water intrusion into the tensioner assembly and the insulator; the H-46 HF radio antenna has a whip antenna mounted on the lower skin that has a particular problem due to water entrapment around the electrical attachment inside of the fuselage; and the A-7 Lower TACAN/IFF antenna has a major problem due to the presence of water and other fluids in a bathtub-like area where the coaxial lead penetrates the fuselage skin to the antenna. Similarly, the H-3 No. 1 UHF/Comm Normal (lower) and Alternate (upper) antennas are skin mounted and require a conductive gasket between the antenna base and the skin. These antennas are subject to the same moisture intrusion as the A-7 aircraft, yet the A-7 installation requires no conductive gasket. The H-3 Doppler has a particularly bad problem because that portion of the antenna interior to the aircraft is located in the fuselage low point area and, therefore, subject to a variety of standing fluids.

Table II lists the corrosion maintenance data for the selected antenna. Data was obtained from the Naval Maintenance Support Office (NAMSO), Aviation

Type Equipment History Inquiry Report, NAMSO 4790-A2098-01, for a one year period, 1 January through 31 December 1978. The list contains aircraft, antenna nomenclature, total maintenance actions reported with the no defect actions eliminated, total related corrosion maintenance actions and corrosion percentage. The numbers are based on the corrective maintenance actions performed at the first two levels of maintenance; the organizational or squadron level and the intermediate level. Data for the third or depot level conducted by the Naval Air Rework Facilities cannot be obtained in the NAMSO data system. The numbers reflect the magnitude of the corrosion problem in these antennas. The corrosion maintenance actions attributable to corrosion damage range from 11 to 18%.

AIRCRAFT CORROSION CONTROL MAINTENANCE PROCEDURES EVALUATION

The fleet evaluation was designed to get inputs from the using technicians relative to the use (application/removal) as well as the durability and effectiveness of the corrosion preventive materials and procedures.

Selections of materials for this fleet level corrosion control were based on the following considerations:

1. There should be no detrimental effects on the operation of systems or components.

2. They should possess demonstrated effective corrosion preventive properties.

3. They should be easily utilized in the fleet environment.

4. Insofar as possible, they should be materials that presently are available in the Naval Aviation supply system.

GENERAL ANTENNA MOUNTING PROCEDURE

During the implementation of the test program these procedures were applicable to any of the rigid type antenna bases (blade, whip, or long wire mast base). The step-by-step actions for cleaning, application of corrosion preventives and sealing of these antenna bases were:

a. Removed dirt, oil, and grease from contact surfaces of the antenna and aircraft skin using cleaning cloth dampened with dry cleaning solvent.

b. Removed minor surface corrosion with an abrasive mat

c. On areas where the corrosion products were abrasively removed, applied Chemical Conversion Coating, MIL-C-81706, Class 3, to the bared surface. The class 3 material was used because it provides a thinner coating with lower electrical resistivity.

A-7 TACAN/IFF ANTENNA MOUNTING PROCEDURES

This procedure is applicable to the A-7 aircraft lower TACAN/IFF antenna, and was evaluated on two A-7E aircraft at the Naval Air Station, Lemoore, California.

Since the A-7 lower TACAN/IFF antenna installation did not require a conductive gasket, the following mounting procedures were used:

a. Removed anodize on screw countersink areas of antenna base in order to provide good electrical conductivity from the base to the screws.

b. Applied Chemical Conversion Coating, MIL-C-81706, Class 3, on bared countersink areas.

c. Applied an even coating of Corrosion Preventive Compound, MIL-C-16173, Grade 4, on both the aircraft skin surface and the flat side of the antenna base which mates against the aircraft skin. The Grade 4 material is a soft, tacky to the touch, coating when it dries and has been used for many years as a general preservative on naval aircraft.

d. Conducted electrical resistance test to check for a good grounding connection. The grounding specification requires the resistance not to exceed 0.1 ohms. (The milliohmmeter reading for these antenna installations were both 0.02 ohms.)

e. Applied a fillet of corrosion inhibited polysulfide sealant, MIL-S-81733, Type II, around the outside of the antenna base on one aircraft and a fillet of MIL-S-8802 polysulfide sealant without inhibitors on the antenna on the other aircraft to form a watertight seal.

f. Covered the fastener heads with Corrosion Preventive Compound, MIL-C-16173, Grade 4.

H-3 AIRCRAFT #1 UHF NORMAL AND ALTERNATE ANETNNA

The H-3 aircraft #1 UHF antennas require a conductive gasket; therefore, the base-to-skin mounting procedure was as follows:

a. Placed a heavy coating of Corrosion Preventive Compound, MIL-C-16173, Grade 4, around the lower coax cable and on the outside of the coax connector so that this corrosion preventive compound would be inside of the gasket circle when the antenna base was mated to the fuselage skin.

b. Installed the antenna base as described in paragraphs a and b of the A-7 TACAN/IFF ANTENNA MOUNTING PROCEDURE.

c. Conducted electrical resistance test to check for a good ground connection. (The milliohmmeter reading on these antenna installations were all 0.01 ohms.)

d. Continued the installation procedures as described in paragraphs e and f of the A-7 TACAN/IFF ANTENNA MOUNTING PROCEDURE.

AIRCRAFT ANTENNA COAXIAL CONNECTORS

Corrosion inside of an antenna coaxial connector is a principal cause of antenna performance degradation (Figure 7). Therefore, the cleaning and preserving of the antenna connectors is important to reduce effects of

moisture intrusion. Throughout the test program the cleaning and preserving of these connectors were accomplished during the various installations by the following procedures:

a. With the connector sections mated, corrosion was removed with an abrasive mat.

b. Connectors were opened and internal sections were cleaned.

c. The internal areas were sprayed with a water displaying corrosion preventive compound MIL-C-81309, Type III. The MIL-C-81309 material forms an ultra thin tacky (soft) film that is designed so that it is displaced by the wiping action of a sliding electrical contact, yet the film is self healing (reforms) in non-contact areas after displacement. The resultant lack of disruption to DC continuity through the male/female type of connections due to a MIL-C-81309, Type III, film has been well established.[3,4]

d. The connectors were then mated and a coating of another water displacing corrosion preventive compound, MIL-C-85054[5], was applied to the exterior surface of the connector. This material dries to a relatively thick (1 to 2 mils) hard, clear finish and has been used successfully on naval aircraft to protect exterior skin surfaces in areas where paint has chipped or cracked leaving exposed bare metal.

P-3 AIRCRAFT LONG WIRE/DIRECTION FINDER (DF) SENSING ANTENNA CORROSION PREVENTION PROCEDURE

At the Naval Air Station, Moffett Field, two P-3C aircraft were selected for the Long Wire Antenna Test procedure. This test was performed to develop a means of minimizing a moisture intrusion problem in the antenna insulator. The following installation procedures were used for corrosion prevention on the P-3C aircraft long wire/DF antenna:

a. Removed dirt, oil and grease from the long wire/DF attachment components with Dry Cleaning Solvent, P-D-680.

b. Removed surface corrosion on the antenna mast cable shackle, clevis bolts, etc., with an abrasive mat.

c. Cleaned by wiping with Cleaning Cloth, dampened with Cleaning Compound Solvent, MIL-C-81302. This step removes any petroleum residue and other materials left by the use of the abrasive mat.

d. With the long wire/DF antenna installed, applied a coating of Corrosion Preventive Compound, MIL-C-85054, Type I, over the attaching hardware.

e. Applied Adhesive Sealant, RTV 3140, clear, MIL-A-46146, where the wire feeds into the insulator.

f. Applied Adhesive Sealant, RTV 3140, clear, MIL-A-46146, where the wire feeds into the take-up tension assembly, and over the tension take-up assembly alignment slot.

H-46 AIRCRAFT LONG WIRE/DIRECTION FINDER (DF) SENSE ANTENNA CORROSION PREVENTION INSTALLATION PROCEDURE

The H-46 aircraft Long Wire/Direction Finder (DF) Sense Antenna is a whip antenna mounted on the lower skin and has a corrosion problem due to water entrapment around the antenna electrical attachment inside of the fuselage. This antenna is subject to two types of corrosion damage:

a. Corrosion and arcing due to water intrusion into the insulator assembly.

b. Corrosion around the base of the mast due to steel screws through aluminum parts and water seepage between the base and the skin.

The following corrosion prevention test plan procedures were used on an H-46 aircraft to evaluate techniques to minimize the foregoing problems.

a. Preparation of the individual antenna parts involved removal of surface corrosion on the mast cable shackle, clevis bolts, etc., with an abrasive mat.

b. Removed dirt, oil and grease from long wire/DF attachment components with Dry Cleaning Solvent, PD-680.

c. Cleaned by wiping with Cleaning Cloth, dampened with Cleaning Compound Solvent, MIL-C-81302.

d. The corrosion preventive procedures for mounting the antenna mast are described in the GENERAL ANTENNA BASE MOUNTING PROCEDURE.

e. With the long wire/DF antenna installed, applied a coating of Corrosion Preventive Compound, MIL-C-85054, over the attaching hardware.

f. Applied Adhesive Sealant, RTV 3140, clear, MIL-A-46146, where the wire feeds into the insulator.

H-3 UHF-VHF/ADF (ARA-25) ANTENNA

The principal cause of maintenance requirements on this antenna is traditionally due to a water intrusion problem. Therefore, a special sealing procedure for the ADF antenna was evaluated along with the normal antenna installation anti-corrosion procedures. The following procedures were performed:

a. With antenna removed, removed grease, oil and dirt from the aircraft mounting areas with Cleaning Cloth, dampened with Dry Cleaning Solvent, PD-680.

b. Removed surface corrosion from the ADF antenna with an abrasive mat.

c. Cleaned the corrosion controlled antenna and aircraft mounting areas and areas to be sealed with MIL-C-81302.

d. Assembled the antenna, but omitted installation of the extruded rubber dust cover channel. Sealed the circumference of the mated dust cover and antenna cavity to the casting with Sealing Compound, MIL-S-81733, Type II. Also sealed around the circumference of the mated plastic plate to the antenna cavity, as well as sealing on top of the external fasteners of the dust cover.

e. Before installing the antenna, coated the inside lip, where the antenna is mounted, as well as the surrounding area with Corrosion Preventive Compound, MIL-C-85054.

f. After the sealant was cured, installed the antenna and applied Corrosion Preventive Compound, MIL-C-85054, over the antenna mounts.

g. Cleaned and preserved electrical connectors in accordance with the procedure in the AIRCRAFT ANTENNA COAXIAL CONNECTORS paragraph.

h. Sealed the exterior circumference of the antenna and aircraft mating surface with Sealing Compound, MIL-S-81733.

FLEET EVALUATION RESULTS

Throughout the evaluation the designated fleet squadrons submitted reports describing the results pertaining to the specific antenna procedures applied to their particular aircraft. The following general summary of the submitted reports is provided:

a. Throughout the 180-day evaluation, all the test items were reported from excellent to satisfactory, and none showed evidence of corrosion or problems with the materials used.

b. All reports indicated that the solvents, cleaning materials, etc., had no effect on the sealants or corrosion preventive materials applied to the test items.

c. Throughout the evaluation period, there was only one reported failure. This was on the ADF (ARA-25) antenna on the SH-3H aircraft. The report indicated this failure was discovered during troubleshooting of a discrepancy of the UHF/DF system. During the ADF antenna removal approximately three ounces of water was noted to run out from the antenna area. No corrosion, however, could be detected on the antenna exterior. The technician noted that there was no indication that the presence of this water was the cause of the functional failure of the ADF antenna.

Specific test results included the following:

a. In the evaluation of sealants as applied around the bases of antennas, the two assigned A-7E lower TACAN/IFF antennas were removed (Figure 8) with no difficulty in the removal due to the sealant applied around the circumference of the bases. The inspection of the sealants indicated that MIL-S-8802 and MIL-S-81733 both are effective in resisting deterioration due to solvents, detergents, cleaning materials, etc. Upon removal of the antenna, a combination of fluids (hydraulic oil and water) were present; however, the Corrosion Preventive Compound, MIL-C-16173, Grade 4 prevented these fluids from affecting the antenna and the aircraft skin mounting area. There were no visible

signs of corrosion. When the antenna connectors were disconnected they were in the same material condition as when they were connected at the beginning of the evaluation period. There was no evidence of external connector corrosion. As the photos (Figure 9) show, the antenna coaxial connector appears to be clean after the six months tests even though the photo clearly shows that fluids, foreign matter, etc. from the inside of the aircraft are all around the base of the connector.

b. The P-3C evaluation results indicate that the procedures of applying Adhesive Sealant, RTV 3140, clear, MIL-A-46146, to the HF Long Wire antenna insulator wire connection ends were beneficial for preventing moisture from entering the insulator in this area. The use of Corrosion Preventive Compound, MIL-C-85054, Type I, over the attaching hardware was also effective in preventing corrosion in these areas. However, the procedure for applying the Adhesive Sealant, RTV 3140, clear, MIL-A-46146, over the tensioner (Figure 10), alignment slot was not adequate. The sealant appeared to be lifted from the alignment slot area.

c. The H-3 test plan procedures applied to the Doppler AN-APN-182, No. 1 UHF/COMM (normal and alternate) and the ARA-25 antennas were very satisfactory in preventing corrosion attack in these areas. The corrosion preventive compounds, sealants and method of applying these materials appear to be a very effective way of protecting these normally corrosion-prone areas. The Doppler antenna mounting area had no evidence of corrosion, even though upon removal there was water, hydraulic fluids, etc., present due to the lack of proper drainage.

Evaluation of results on the No. UHF/COMM normal (lower fuselage) and alternate (upper fuselage) antenna anti-corrosion procedures utilized on the antenna base and aircraft structure mating area indicated that the preventive methods employed did preclude moisture from entering the critical base and coaxial connector areas - even though the No. 1 UHF lower fuselage antenna was generally saturated with fluids. The same situation also applied to the ARA-25 antenna.

SPECIAL ANTENNA COAXIAL (COAX) CONNECTOR TESTING

Coax lines are used for the transmission of RF energy in the frequency range from 30 MHz to 3GHz, although there is some overlap with waveguide RF transmission which is used for frequencies above 300 MHz. This means, however, that most of the NAV/COM equipment utilizes coax lines and, therefore, coax connectors where a transmission line mates to an antenna. By far, the principal cause for rejection of NAV/COM antennas is corrosion degradation within the coax antenna connector.

Traditionally no preservatives have been used inside of a coax connector because of fears that any foreign material would alter the characteristic capacitance created by the spacing and insulation between the inner and outer conductors. This characteristic is particularly critical in those lines for which changes in capacitance is used as a sensor in the system - such as in a capacitive type of fuel quantity indicating system. Any change in the dielectric between the inner and outer conductor also can affect the impedance of an antenna line (connector).

Special tests with relatively sensitive measuring equipment were made to determine the electrical (RF transmission) effects incurred by the introduction

of MIL-C-81309, Type III, Water Displacing Corrosion Preventive Compound into coax connectors between sections of coax line. The tests were conducted using TDR (Time Domain Reflectometry) and FDR (Frequency Domain Reflectometry) equipment to sweep a coax assembly over a frequency range of 2 to 11 GHz. Two runs were made on the line/connector assembly with no corrosion preventive applied to display the repeatability of the test when no change is introduced to the test item. Following that, runs were made with MIL-C-81309, Type III, Class 2, applied to both sections (male and female) of the connector.

No attenuation of signal or change in characteristic impedance resulted from the presence of MIL-C-81309 material in the coaxial connectors over the frequency range measured.

Concurrent with the foregoing electrical testing, the effectiveness of MIL-C--81309, Type III, in this application was tested by fleet activities. Reports received from fleet activities throughout the evaluation period revealed no problems with antenna performance or maintenance associated with coax connectors. The disassembly of the connectors at the end of the test period revealed no evidence of corrosion inside of the coax connectors. In the case of the connectors on the A-7, corrosion inside of connectors has been such a problem that there is a requirement at every 28 days for the connectors to be opened and cleaned due to this internal corrosion problem. For the connectors involved in this evaluation, however, none were opened and cleaned or otherwise maintained during the six-month evaluation period - yet, all were clean and free of corrosion when inspected at the end of the evaluation.

CONCLUSIONS

1. The 180 day fleet evaluation was an overwhelming success. The maintenance personnel who were implementing the new procedures on the designated aircraft found them to be effective in cleaning and removing corrosion products and experienced no difficulty in applying the prescribed sealants and water displacing corrosion preventive compounds. When the antennas were removed at the completion of the evaluation all sites were free of corrosion.

2. The introduction of MIL-C-81309, Type III, Class 2, Corrosion Preventive Compound material into antenna coaxial connectors during the fleet evaluation, as well as the test conducted with the TDR (Time Domain Reflectometry) and FDR (Frequency Domain Reflectometry) equipment, demonstrated no detrimental effects to the antenna systems. Also, the use of Corrosion Preventive Compound, MIL-C-85054, as a moisture barrier on the exterior of coaxial connectors provided the fleet with a very effective corrosion preventive procedure.

3. Standardized corrosion control materials and procedures can be effectively used by fleet level activities for better corrosion protection of antennas.

REFERENCES

(1) Shaffer, I. S., Carrato, A. F., and Hoffner, J. A., "Aircraft Antenna Corrosion Proceeding of the 1978 Tri-Service Conference on Corrosion," pp 325-332.

(2) Wieczorek, R. M. and Ketcham, S. J., "Qualification Testing of Corrosion Inhibitive Sealants under MIL-S-81733B," Report no. NADC-78264-60, Naval Air Development Center, Warminster, PA Jan 1979

(3) Knight, W., "Use of Water Displacing Corrosion Preventive Compound (MIL-C-81309A) on Aircraft Electrical Connectors," Report No. MA-7109, Naval Air Development Center, Warminster, PA Feb 1971

(4) Soroka, J., "Failure Analysis Techniques for Electronic Devices and Components," Report No. NADC-78091-60, Naval Air Development Center, Warminster, PA 1980

(5) Pilla, G. J., and De Luccia, J. J., "A Corrosion Preventive Compound for Aerospace," Metal Progress, May 1980, pp 57-59.

TABLE I. ANTENNAS USED IN FLEET EVALUATION

Aircraft	Nomenclature	Performing Maintenance Activity
A-7	Lower TACAN/IFF	NAS Lemoore, CA
H-3	No. 1 UHF/COMM (Normal)	NAS North Island, CA
H-3	No. 1 UHF/COMM (Alternate)	NAS North Island, CA
P-3	Long Wire DF Sensing	NAS Moffett Field, CA
H-46	Long Wire DF Sensing	NAS North Island, CA
H-3	Receiving Transmitter (Doppler)	NAS North Island, CA

TABLE II. ANTENNA CORROSION CORRECTIVE MAINTENANCE

Aircraft	Nomenclature	Total Maintenance Actions	Total Corrosion Maintenance Actions	Percent Corrosion
A-7	Lower TACAN/IFF	281	240	85%
H-3	No. 1 UHF/Comm (normal)	155	103	66%
H-3	No. 1 UHF/Comm (alternate)	58	33	57%
P-3	Long Wire DF Sensing	186	21	11%
H-46	Long Wire DF Sensing	133	28	21%
H-3	Receiver Transmitter (Doppler)	653	139	21%

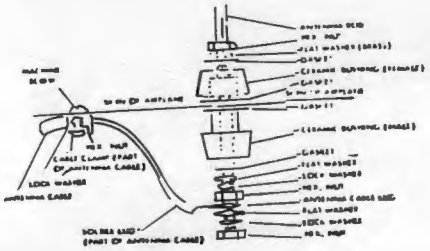

Figure 1.
Typical Whip Antenna

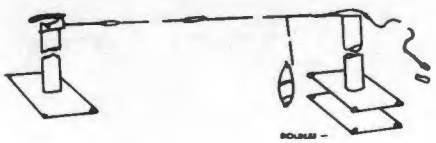

Figure 2.
Typical Long Wire Antenna

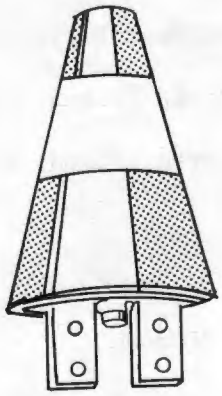

Figure 3.
Typical Rigid Antenna

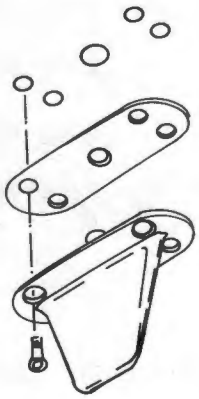

Figure 4.
Typical Rigid Antenna
(with Gasket)

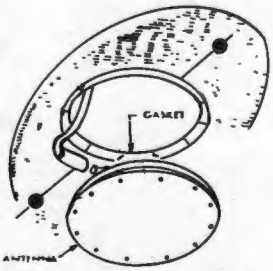

Figure 5.
Typical Flush
Mounted Antenna

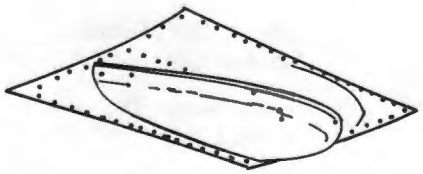

Figure 6.
Typical Dome Mounted
Antenna

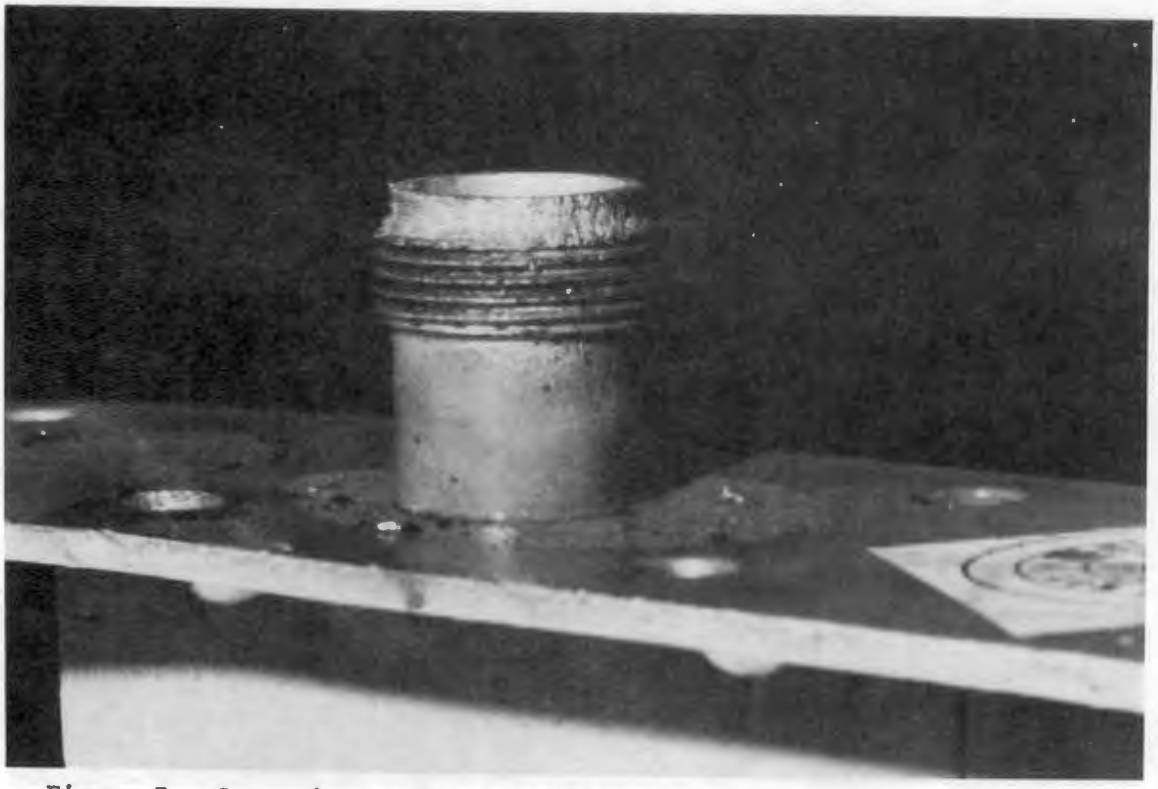

Figure 7. Corrosion on Lower TACAN/IFF Antenna Coaxial Connector

Figure 8. Sealed A-7 Lower TACAN/IFF Antenna

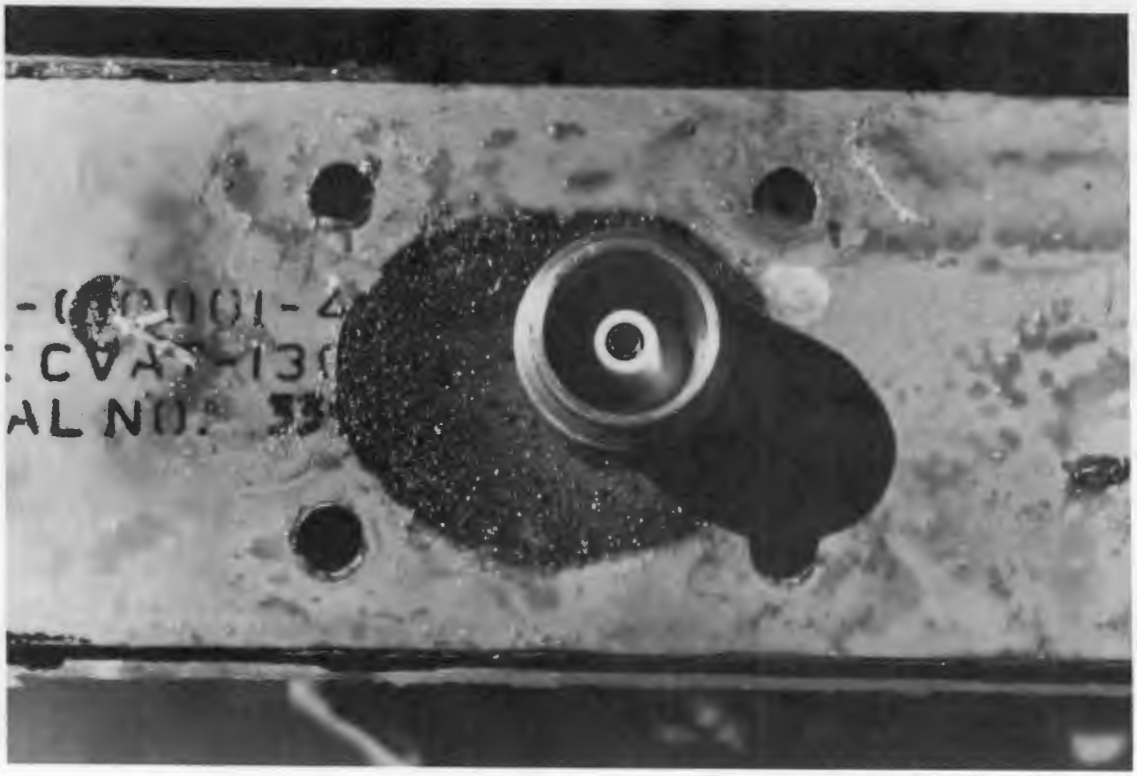

Figure 9. A-7 Lower TACAN/IFF Antenna Coaxial Connector

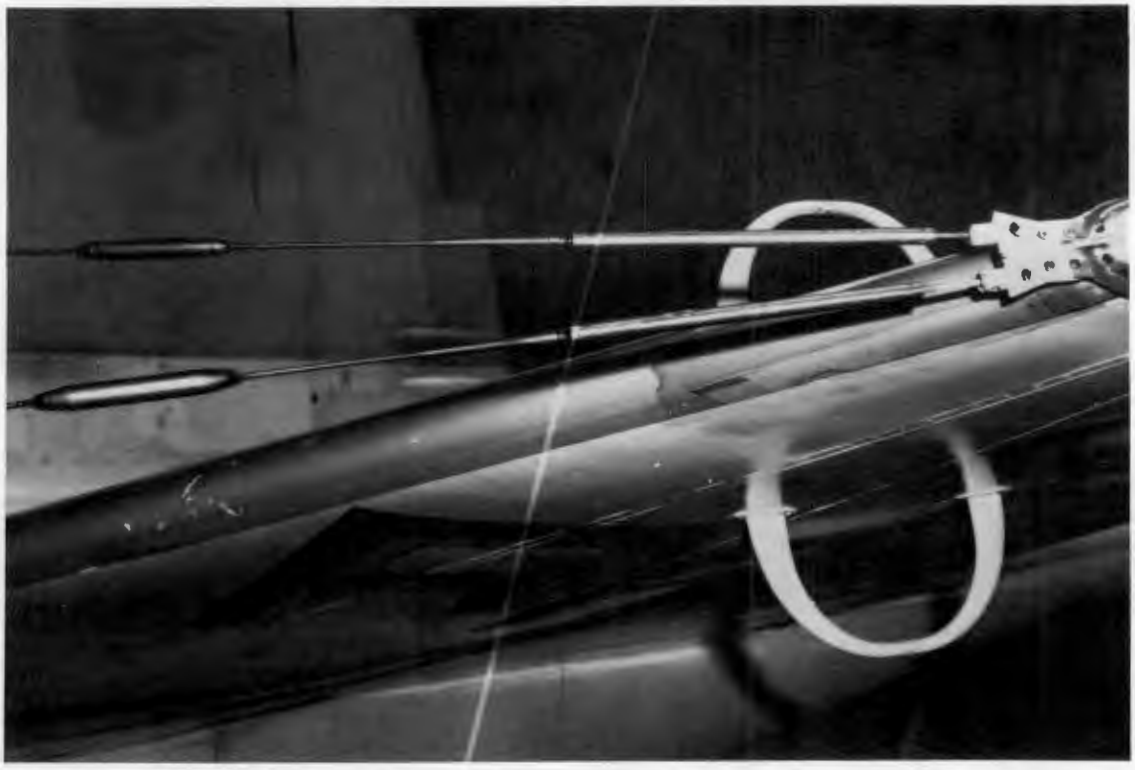

Figure 10. P-3 HF Long Wire Tensioner