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U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Materials Chemistry Division
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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
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INTRODUCTION

The increase of underground telephone cable installation by the telephone industry throughout the United States has created a demand for comprehensive and reliable information with respect to the corrosion of shielding materials. In order to obtain such corrosion data on both currently accepted and proposed experimental cable systems, the National Bureau of Standards and the Rural Electrification Administration initiated a six-year underground corrosion program. The program was initiated in 1968 with the burial of thirty-one cable systems in selected soil environments. A paper summarizing the results for specimens buried for one year was given at the 18th International Wire and Cable Symposium [1]. During the period since the first report and the present time, many additional systems utilizing metals or plastic coated metals have been incorporated into the program. Other papers summarizing the results obtained for these materials and the additional systems after burial for periods of up to six years were presented at the Corrosion/74 [2] and Corrosion/76 Symposia [3]. This paper (the fifth report) contains additional data for some of the systems included in the earlier reports. Table 1 describes the various cable systems included in this report.

SOILS AT THE TEST SITES

The chemical and physical properties of the soils at the test sites are given in table 2. The chemical properties listed show that the soils differ widely with respect to their composition and the concentrations of soluble salts they contain. The pH of the soils ranges from extreme acidity (4.0) to high alkalinity (8.8). The electrical resistivity of the soils ranges from 55 ohm-cm, which is approximately that of sea water, to 30,000 ohm-cm, indicating the absence of soluble salts. The physical conditions of the soils range from well aerated to very poorly aerated.

These widely differing soil environments allow for a comprehensive soil corrosion program. The soils included are moderately corrosive (Sites B and D) to very corrosive (Sites A, C, E, and G) toward ferrous and other metals. The soils cover a wide range of soil properties, with respect to corrosion, found throughout the United States. Furthermore, it is possible to correlate corrosion data from these six soils with data previously obtained from 128 test sites in which the National Bureau of Standards has conducted extensive investigations on the underground corrosion of metals and alloys [3]. Descriptions of the soils at the six test sites are as follows:

Sagemoor sandy loam (Site A) is a well-drained alkaline soil and is typical of that found in vast areas of eastern Washington and Oregon. The site is located on the Yakima Indian Reservation near Toppenish, Washington. The soil is consistent in composition to a depth of at least seven feet and supports abundant growth of sage brush.

Hagerstown loam (Site B) is a well-drained soil representative of the majority of well-developed soils found in the eastern part of the United States. The site is located at the Loch Raven Reservoir of the Baltimore City

Water Department. The soil consists of a brown loam about one foot deep, underlain by a reddish-brown clay that extends five feet or more to underlying rock. Practically all of the materials that have been investigated in the extensive NBS soil corrosion tests since 1922 have been exposed at this site and, therefore, it can serve as a reference site for the correlation of data obtained for specimens in the present program with data obtained from the earlier tests.

Clay soil (Site C). This site is located in a large clay pit on level land at the U.S. Coast Guard Receiving Center at Cape May, New Jersey. The soil consists of a plastic gray clay to a depth of twelve inches. This is underlain by a poorly drained, very heavy plastic clay to which the specimens are exposed.

Lakewood sand (Site D) is a white, loose sand with some black streaks occurring in places and supports an abundant growth of beach grasses. The site is located in a well-drained rolling area on the property of the U.S. Coast Guard Electronic Engineering Station at Wildwood, New Jersey. The area is not subject to overflow from the ocean except under unusual flood conditions.

Coastal sand (Site E) is a typical white, coastal beach sand with a high content of black sand that occurs in streaks. This sand is similar to Lakewood sand except that at this site the sand is continuously saturated with salt water. The site is located on the Two-mile Beach on the property of the U.S. Coast Guard Electronic Engineering Station, Wildwood, New Jersey.

Tidal marsh (Site G) is a soil typical of the poorly-drained marsh soils that are found along the Atlantic and Gulf coasts and is charged with hydrogen sulfide. The site is located along a creek that empties into the Chesapeake Bay at Lexington Park, Maryland, on the property of the U.S. Naval Air Training Center.

TEST PROCEDURE

In order to expose the shield material to the environment and to simulate conditions which may occur in field installations of telephone cables, specimens were prepared as shown in figure 1. Specimens used in this study were polyethylene jacketed cable lengths [approximately fourteen inches (35.6 cm) long] containing metallic or plastic coated metal shields. With a few exceptions, the shield was exposed by stripping the outer polyethylene protective jacket at two areas, one each approximately four inches (10.2 cm) from either end of the cable length, creating a window and a ring. The window was an exposed area along the length of the cable approximately two inches (5 cm) long x 0.5 inch (1.3 cm) wide, while the ring was an exposed area 0.5 inch (1.3 cm) wide around the circumference of the cable. In addition, some of the systems were electrically coupled to copper strips by mechanically bonding the strip to electrical wires which were in turn mechanically bonded to the shield at the ends of the cable. Coupling the shield to copper thus created a galvanic cell between the copper and the shield material. This was done to simulate field conditions in which dissimilar metal shields may be coupled either to existing cable systems having copper shields or to copper ground rods. The ends of the specimens were sealed with a sealing compound and wrapped with vinyl tape to prevent entry of moisture at the end areas.

With a few exceptions, six specimens of each system were buried at each of the six soil sites. All specimens were buried at a depth of approximately three to four feet (0.9 to 1.2 m) below the ground line in trenches two feet (0.6 m) wide.

Each year a replicate specimen was withdrawn from each of the burial sites for cleaning and examination.

Five areas on each of the specimens were examined and rated numerically in accordance with table 3. These areas were the exposed window, the exposed ring, the jacketed surrounding area one-half inch around the exposed window, the jacketed surrounding area one-half inch around the exposed ring, and the remainder of the jacketed shield. In the case of composite and clad materials, the outer, middle, and inner shields were rated individually.

RESULTS

The results obtained from the evaluation of cable specimens exposed for periods up to six years in various underground soil environments are summarized in tables 4 through 9. It should be noted that at the time of this report specimens of Site A had not been recovered since the underground corrosion removals of 1979 and that the results indicated are those of the fourth NBS report, NBSIR 81-2243 [4]. Specimens of selected systems with varying degrees of corrosion are shown in figures 2 through 37. The words "tacky" and "semi-tacky" are used to describe the filling compound used in the exposed specimens. Specimens with filling compounds were tacky at the time of installation. As previously noted, areas of the shields were given numerical ratings to indicate the extent of degradation due to corrosion. These ratings are described in table 3. A rating of ten indicates that the shield was unaffected by corrosion, while a rating of zero indicates severe corrosion sufficient to cause longitudinal electrical discontinuity (ELD) of the shield. When the shield exhibited ELD at all areas measured, it was considered to be destroyed. It was noted that degradation of some specimens exposed for shorter periods of time was much more severe than that observed on similar specimens exposed for greater periods of time. This may be partially explained by the methods used in preparation of the specimens. If the cut through the outer jacket made to expose the window and ring was deep enough to penetrate the shield, it could allow corrosion of the inner shield materials. On the other hand, if the depth of cut was such that only the outer jacket was slit, then the integrity of the shield materials could be maintained. The various systems and their performance in the six soil environments in which the specimens were exposed are described below.

System 56. This system consisted of a 3-mil (0.1 mm) Type 430 stainless steel outer shield bonded to a 3-mil (0.1 mm) 1100 aluminum alloy inner shield with a clear flooding compound on the core side.

Specimens of this system were exposed at Sites A, B, C, E, and G only.

Delamination of the outer and inner shields was noted on nearly all of the specimens examined.

There was no degradation of the outer or inner shields of specimens exposed for six years at Site A and five years at Site D or of the outer shield on specimens buried for up to six years at Site C and four years at Site E. The outer shield was ELD or near ELD at the unjacketed window and/or ring areas on specimens exposed for four and six years at Site G. The inner shields were perforated due to localized corrosion after burial for four and six years at Site C and three, four, and six years at Site E. In general, the inner shield was at or near ELD on specimens exposed from two to six years at Site G.

The filling compound was still tacky except where corrosion was observed.

System 57. This system is the same as System 56 except that the system was coupled to copper.

Specimens of this system were exposed at Sites A, C, D, E, and G only.

As noted for System 56, there was delamination of the outer and inner shields on nearly all specimens examined.

In general there was no degradation of the outer shield on specimens buried for up to six years at Sites A, C, D, and E. Localized pitting corrosion was noted on the outer shield of one specimen exposed for one year at Site A. The outer shields were perforated due to corrosion at unjacketed window or ring areas on specimens buried at Site C for five and six years.

There was no degradation of the inner shield on specimens buried from two to six years at Site A and one year at Site C. For the specimens buried at Site C for four to six years, the inner shield was ELD or near ELD at jacketed and unjacketed areas. The inner shield of specimens buried at Site D for three and five years and at Site E for two and three years were ELD at the unjacketed window, while all areas exposed at Site E on the inner shield for six years were ELD. Similarly, the inner shield of specimens exposed at Site G was ELD at all examined areas, while only the window and ring areas were ELD on the outer shield for the same exposed time.

The filling compound was tacky except at areas where the shields were corroded.

System 58. This system consisted of a 3-mil (0.1 mm) Type 304 stainless steel outer shield with a 4-mil (0.1 mm) vapor deposited aluminum alloy coating on the inner shield.

Specimens of this system were exposed at Sites A, C, E, and G only.

The outer shield was unaffected by corrosion at Sites A and E for up to six years. Nil or superficial corrosion was noted on specimens from Site C for up to three years of exposure. The outer shield at Site C buried for six years was noted as having superficial corrosion at all areas examined, while all areas examined on the inner shield were ELD or near ELD. Corrosion in varying degrees was noted on the outer shield after being buried up to six years at Site G. However, the inner shield at the same site was ELD at all areas examined. The specimen at Site E was not installed for the six year exposure because of a lack of material.

System 59. This system is the same as System 58 except that the system was coupled to copper.

Specimens of this system were exposed at Sites A, C, E, and G only.

Coupling this system to copper accelerated corrosion of both shields. With few exceptions, corrosion was superficial or nil on the outer shield exposed up to five years at Sites A and C, and six years at Site E. Specimens buried for five and six years at Site G were perforated due to corrosion on the outer shield at all areas examined, while the inner shield was ELD for specimens exposed for two to six years. All areas of the inner shield were also ELD for specimens buried for two to six years at Site E.

System 60. This system consisted of a 3-mil (0.1 mm) Type 304 stainless steel shield with a 2-mil (0.05 mm) vapor deposited aluminum coating on the outer and core sides of the shield.

Specimens of this system were buried at Sites A, C, E, and G only.

There was no apparent corrosion of the stainless steel on any of the specimens buried for up to five years at these sites. With very few exceptions, the stainless steel shield was unaffected by corrosion at all areas examined for specimens buried for up to six years at Sites A, C, and E. The stainless steel shield for specimens from for the six year exposure at Site G was perforated at and adjacent to the window area as well as at the jacketed areas examined. The vapor deposited aluminum coated outer shield was near ELD at all areas except for the area adjacent to the ring on the specimen buried up to five years at Site A, while the vapor deposited aluminum inner shield showed slight corrosion at all areas. Both inner and outer vapor deposited aluminum shields of specimens buried for five and six years at Site C were at or near ELD, while companion specimens at Site G were ELD for two through six years at all areas examined. The outer aluminum shield at and adjacent to the window and/or ring areas of specimens buried for four years at Site E were ELD. The inner aluminum shield at the jacketed areas was ELD for the same exposure time. The specimen at Site E was not installed for the six year exposure because of a lack of material.

System 61. This system is the same as System 60 except that the system was coupled to copper.

Specimens of this system were buried at Sites A, C, E, and G only.

Coupling this system to copper accelerated corrosion on the inner and outer vapor deposited aluminum coating at all four sites. In general, the stainless steel shield specimens exposed at Sites A and E for up to five years were unaffected by corrosion. However, the stainless steel shield specimens exposed at Site G for up to six years were perforated due to corrosion at nearly all areas examined. With few exceptions, the stainless steel shields exposed at Site C for two, four, and six years were unaffected by corrosion. Perforation due to severe corrosion on the inner aluminum shields exposed at Site A was observed, while ELD or near ELD of the outer aluminum shield of specimens buried up to five years was evident. Specimens exposed for two through six years at Sites C, E, and G were ELD at all areas on the inner and outer aluminum shield examined.

System 62. This system consisted of a 50-pair, 22-gauge air core cable having an 8-mil (0.2 mm) aluminum shield with a copolymer coating on both sides of the shield. There was no window or ring on specimens of this system. The conductors were removed from the cable leaving a hollow shell.

The performance of this system was excellent after exposure for five years at Sites A and C and for four years at Site B. Specimens exposed up to six years at Sites D and E were unaffected by corrosion with the exception of the specimens exposed for four years. Perforation due to localized pitting corrosion was noted for specimens exposed at Site G for two and four years, while companion specimens exposed for three and five years were unaffected by corrosion. Specimens from Sites C and G showed minor degradation after exposure for six years.

System 63. This system consisted of a 16-pair, 22-gauge cable having an 8-mil (0.2 mm) uncorrugated aluminum alloy shield bonded on both sides to a polyolefin polymer. The shield was bonded to the jacket. There was no window or ring on specimens of this system. The conductors were removed from the cable leaving a hollow shell.

No corrosion was observed on specimens buried for five years at Site A and for six years at Sites B, C, D, and E. The shields of specimens buried for two, four, and five years at Site G were perforated due to corrosion, while companion specimens exposed for one, three, and six years were unaffected by corrosion. Slight dissipation was noted at the sheared ends of the specimens.

System 64. This system consisted of a 25-pair, 18-gauge cable having an 8-mil (0.2 mm) uncorrugated aluminum alloy shield bonded on both sides to a 2-mil (0.05 mm) polyolefin polymer. The shield was bonded to the jacket. There was no window or ring on specimens of this system. The conductors were removed from the cable leaving a hollow shell.

Specimens exposed for four years at Site B, five years at Site A, and six years at Sites D and E were unaffected by corrosion. Only four specimens were buried at Site B due to a lack of sufficient material to allow for a five and six year exposure. Pitting corrosion which resulted in perforation of the shield was observed on the specimens buried for four years at Site C and specimens exposed for four, five, and six years at Site G. The shield of the specimen from Site C buried for six years showed minor degradation. Slight dissipation at the sheared ends of the specimens was observed at all sites.

System 65. This system consisted of a 25-pair, 24-gauge cable having an 8-mil (0.20 mm) uncorrugated aluminum alloy shield bonded on both sides to a polyolefin polymer. The shield was bonded to the jacket. There was no window or ring on specimens of this system. The conductors were removed from the cable leaving a hollow shell.

There was no apparent corrosion on specimens of this system after exposure for five years at Site A and for six years at Sites B, C, D, E, and G.

System 66. This system is the same as System 65 except that the shield was coupled to copper.

Specimens of this system were exposed at Sites A, B, C, D, and E only.

These specimens were unaffected by corrosion after exposure for up to five years at Site A and for up to six years at Sites B, C, D, and E.

System 67. This system consisted of 4-mil (0.1 mm) aluminum foil [3 3/4 in. x 8 in. (9.5 cm x 20.3 cm)] coated on both sides with a 6-mil (0.15 mm) ethylene acrylic acid copolymer.

Specimens of this system were exposed at Sites A, B, C, and D only.

There was no apparent degradation of specimens of this system after exposure for two years at Site A and for four years at Sites B, C, and D. (Specimens buried for two years at Sites B and D and for three years at Site C were not recovered.)

System 68. This system consisted of 4-mil (0.1 mm) aluminum foil [3 3/4 in. x 8 in. (9.5 cm x 20.3 cm)] coated on both sides with a 6-mil (0.15 mm) polyester film.

These specimens were exposed at Sites A, B, C, and D only.

Specimens of this system were unaffected by corrosion after exposure for three years at Site A and up to four years at Sites B, C, and D.

System 69. This system consisted of 4-mil (0.1 mm) aluminum foil [1 1/2 in. x 12 in. (3.8 cm x 30.4 cm)] coated on both sides with a 5.5 mil (0.14 mm) polyester film.

These specimens were exposed at Sites A, B, C, and D only.

Corrosion of specimens of this system was nil for up to three years at Site A and for up to four years at Sites B, C, and D. (Specimens exposed for one and three years at Site D and for three years at Sites B and C were not recovered.)

System 70. Specimens of this system (Table 1) were exposed at Sites A, B, C, and D only.

Corrosion was nil for specimens buried for up to two years at Site A and up to four years at Sites B, C, and D. Severe corrosion was observed for the specimen exposed at Site A for three years. More than 25 percent of the metal shield was dissipated due to corrosion. There was no window or ring on specimens of this system.

Systems 71 and 72 were buried plant housings and are not included in this report.

System 73. In general, the inner and outer shield of specimens of this system (Table 1) exposed for one year at all sites were unaffected by corrosion. Degradation of the outer black plate steel shield was severe at the unjacketed window and ring areas on the specimen buried at Site B for up to three years. The shield was near ELD at the unjacketed ring area for specimens buried for three years. The outer shield of specimens exposed at Site A for two years and at Sites C and D for two and three years was severely corroded at the unjacketed window and/or ring areas. Perforation due to corrosion at the window areas of the outer shield of specimens exposed for two years at Site E was noted. In general, the inner aluminum alloy shield was unaffected by corrosion except at Site G where ELD or near ELD was observed at or adjacent to ring areas on specimens exposed for three years. The outer shield exposed for three years at Site G was ELD at all areas examined, except for the jacketed areas.

The filling compound was tacky except at corroded areas.

System 74. This system was the same as System 73 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated corrosion of the shields at unjacketed areas. With few exceptions corrosion on the inner shields of specimens buried up to three years at all sites was nil or superficial. Specimens at Site B were ELD or near ELD for the first three years of exposure at the window and/or ring areas, while the adjacent window and ring areas were severely corroded. Severe degradation was noted at the window and/or ring areas exposed for one, two, and three years at Sites D and E. Of the specimens buried at Site G all areas examined on the inner shield were ELD after two and three years of exposure. The outer shield at the window area was ELD on specimens exposed at Site G for one, two, and three years, while the ring and adjacent ring area was ELD on specimens buried for two and three years.

The filling compound was still tacky except at corroded areas.

System 75. The inner aluminum alloy shield on specimens of this system (Table 1) exposed for up to three years at all sites was unaffected by corrosion. The outer steel shield on specimens buried at Sites C, E, and G for one year, Sites A and B for up to two years, and Site D for up to three years was also unaffected by corrosion. Corrosion was superficial or nil on specimens buried at Sites D and E for three years.

With one exception, corrosion at all areas examined on both shields was nil on specimens buried for one to three years at Site C. The outer shield exposure showed slight corrosion at all areas examined after two years of exposure at the same site. At Site G the window area was near ELD for the specimen buried for two years and near ELD at the ring area after three years exposure.

The filling compound was still tacky except at corroded areas.

System 76. Same as System 75 except that the shields were coupled to copper.

Coupling the shields to copper accelerated the corrosion of the outer shield in all of the soils in which the specimens were exposed. No degradation was observed on the inner aluminum alloy shield of the specimens buried for up to three years. With one exception, the outer steel shield was corroded to varying degrees at unjacketed areas on all specimens exposed for up to three years. Corrosion at these areas was most severe on specimens buried at Sites C, E, and G. The outer shield of the specimens buried for two years at Site G was ELD at the window and ring areas. Both ring and jacketed areas were ELD after exposure at this site for three years. The outer shield of the specimen buried for one year at Site A was unaffected by corrosion.

The filling compound was still tacky except at corroded areas.

System 77. The aluminum alloy inner shield on specimens of this system (Table 1) were unaffected by corrosion after exposure for up to three years in all soils with the exception of one specimen at Site G. There was no degradation of the outer steel shield of specimens buried for one year at Sites A, B, and D. After exposure for three years, corrosion of the outer shield was superficial or nil at jacketed areas for all specimens except for those exposed at Sites B and C. Corrosion of the outer shield was observed at the window and ring areas of all specimens buried for two and three years in all soils. Perforation due to localized pitting corrosion was noted at window and ring areas on specimens buried at Sites A and D for two years and at Sites B, C, and E for up to three years on the outer shield. The specimens exposed at Site G for two and three years were ELD at and adjacent to the window and/or ring areas.

The filling compound was still tacky except at corroded areas.

System 78. Same as System 77 except that the shields were coupled to copper.

Coupling the shields to copper accelerated corrosion of the outer shield in all of the soils and of the inner shield at Sites C and G. The inner shields of specimens buried for three years at Sites B and D were unaffected by corrosion. Corrosion of the inner shield on specimens buried at Sites C and G occurred at the window and/or ring areas. For specimens buried at Site G for up to three years , the inner shield was ELD or near ELD at window and ring areas and severely corroded at jacketed areas. In general, severe corrosion was observed on the outer shield at the window and ring areas on all specimens of this system. Of the specimens buried for two and three years at Sites B, C, and G, the outer shield was at or near ELD at the unjacketed window and ring areas. Corrosion of the outer shield was severe at the window and ring areas on specimens of this system buried for two years at Sites A and D and three years at Site E.

The filling compound was still tacky except at corroded areas.

System 79. Except for the specimens of this system (Table 1) buried at Site G, there was no degradation of the inner aluminum alloy shield on any of the specimens buried up to three years. Severe corrosion was noted on the inner shield at the window and ring areas on specimens exposed for up to three years at Site G. In general, corrosion of the outer steel shield occurred at or adjacent to the unjacketed window and ring areas. Perforation due to corrosion at the jacketed and adjacent window areas was observed after exposure for one year at Site E. At the same site, the window and ring areas on the outer steel shield were perforated due to corrosion for specimens exposed for two and three years. The specimen buried for up to three years at Site G was at or near ELD at or adjacent to window and ring areas.

The filling compounds were still tacky at all uncorroded areas, while corroded areas were noted as dry.

System 80. Same as System 79 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated corrosion of the shields. With a few exceptions, there was little or no corrosion on either shield at jacketed areas of specimens buried at Sites A and C for two years and Sites D and E for three years. The inner aluminum alloy shield was perforated due to corrosion at unjacketed window and ring areas on specimens buried up to three years at all sites. Specimens exposed for three years at Sites B, C, and G were ELD at the window and ring areas on the outer steel shield and were ELD on both shields of specimens exposed at Sites C and G for the same time. All areas examined on the inner and outer shields for specimens buried at Site G for two and three years were ELD and were considered destroyed.

The filling compounds were still tacky at all uncorroded areas, while corroded areas were noted as dry.

System 81. There was no corrosion of the inner aluminum alloy shield for specimens of this system (Table 1) after exposure for one and two years at Sites A and G and up to three years at Sites B, C, D, and E. Corrosion of the steel outer shield in varying degrees was noted at unjacketed window and/or ring areas of specimens exposed up to three years at Sites B, C, D, and E. The inner and outer shields at the unjacketed window and ring areas of the specimens were ELD after the third year of exposure at Site G. However, only the inner shield was ELD at the adjacent ring after the same amount of time.

System 82. Same as System 81 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated corrosion of the outer steel shield at window and ring areas in all of the soils. The inner and outer shields at jacketed areas exhibited little or no corrosion after exposure at Sites A and B for up to two years and at Sites C, D, and E for up to three years. Severe corrosion was observed on the outer steel shield at the window and/or ring areas of specimens buried at Site A for two years and at Sites D and E for up to three years. The outer shield at the window and ring areas was severely corroded after exposure of one year at Site B as were the adjacent window and ring areas of the outer shield after exposure for three years. Specimens buried for two and three years at Site B and one year at Site G were ELD at the window and ring areas, while specimens exposed at the same site for two and three years were ELD at all areas examined and were considered destroyed.

The filling compound was semi-tacky to dry for all specimens.

System 83. With few exceptions specimens of this system (Table 1) were unaffected by corrosion. Specimens exposed at Site C were perforated due to corrosion on the outer steel shield at the window and ring areas for specimens exposed up to two years and severely corroded at the same areas after three years. The aluminum alloy inner shield of specimens exposed for two years at Site G showed slight corrosion at the adjacent window areas, while severe corrosion was observed at the window and ring areas of specimens buried at the same site for the same amount of time. Perforation was noted at the window and ring areas of the outer shield for specimens exposed at Site G for two years and at the adjacent ring area of specimens exposed for up to three years. The window area of the outer shield was near ELD on the specimen buried for three years at Site G.

The filling compound was semi-tacky to dry for all specimens.

System 84. Same as System 83 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated the corrosion of the outer corrugated steel shield of specimens buried in five of the six soils. The specimen at Site A was unaffected by corrosion after an exposure of two years. Varying degrees of corrosion were noted at the unjacketed window and ring areas on the outer shield of specimens buried up to three years. Perforation due to corrosion was observed at the unjacketed window and/or ring areas for specimens exposed at Sites B, C, and E for up to three years, and at Site D for two and three years. The outer shield of the specimen exposed for two years at Site G was ELD at the unjacketed window and ring areas. However, ELD was observed on both shields at the same areas of specimens exposed at Site G for three years. All inner shield areas except the adjacent window area were ELD after exposure for three years at Site G.

The filling compounds were semi-tacky to dry for all specimens.

System 85. With few exceptions specimens of this system (Table 1) were noted as having superficial or nil degradation on the inner aluminum alloy shield exposed up to three years in all soils. The inner shield at the unjacketed ring area was near ELD on the specimen buried at Site G for one year. Companion specimens buried for two and three years at the same site were severely corroded at all areas examined and were considered destroyed. The corrugated steel outer shield was unaffected by corrosion on specimens at Site A buried for two years. Perforation due to severe corrosion was noted at the unjacketed window and/or ring areas on the outer shields of specimens exposed for three years at Sites B, C, D, and E. Slight degradation of the inner shield at and adjacent to the window of the specimen exposed at Site C was observed for the three year exposure.

The filling compound was semi-tacky to dry for all specimens.

System 86. Same as System 85 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated corrosion of the shields, particularly at the unjacketed areas. The inner aluminum alloy shield of the specimen buried for two years at Site C was ELD at all areas examined. The companion specimen exposed for three years at the same site was ELD at and adjacent to window and/or ring areas. Severe corrosion of both shields was noted on specimens buried up to three years at Site G. The inner shield on the specimen exposed for one year at Site G was perforated due to corrosion at all areas examined, while corrosion on the outer steel shield at jacketed areas was negligible. Specimens buried at the same site were ELD on the outer shield at the unjacketed window and ring areas after one year exposure. Both shields were ELD at all area examined for specimens exposed at Site G for two and three years and were considered destroyed. With few exceptions for the specimens buried in the other four sites for three years, both shields were perforated to severely corroded at all areas examined.

The filling compound was semi-tacky to dry for all specimens.

System 87. There was no degradation of the corrugated aluminum alloy inner shield on specimens of this system (Table 1) buried up to three years in four of the six soils. The inner shield of the specimen exposed for two years at Site G was perforated due to corrosion at all areas examined, while the companion specimen exposed for three years was ELD at all areas on both the inner and outer shield and was considered destroyed. Perforation due to localized pitting corrosion at the window and ring areas on the steel outer shield was noted for specimens exposed at Site A for one and two years and at Site D for two and three years. Companion specimens at Sites B, C, and E buried up to three years were perforated or severely corroded at or adjacent to window and ring areas.

The filling compound was semi-tacky to dry for all specimens.

System 88. Same as System 87 except that the shields were coupled to copper.

Coupling specimens of this system to copper accelerated the corrosion of the black plate steel outer shield at the window and ring areas after an exposure of up to three years in all soils. In general, the performance of the outer shields at unjacketed areas was fair to very poor for specimens buried at the six sites. Corrosion of the corrugated aluminum alloy inner shield was nil at all areas examined for up to three years in four of the six soils. The inner shield of the specimen buried for three years at Site C was ELD at all areas examined. Both shields of specimens exposed at Site G for two and three years were ELD at all areas rated, and were considered destroyed.

The filling compound was semi-tacky to dry on all specimens.

System 89. This system consisted of a 100-pair, 22-gauge semi-conducting cable having a 5-mil (0.1 mm) corrugated copper alloy shield and a low density polyethylene jacket.

Corrosion on the specimens of this system was nil or negligible in all of the soils after exposure for two years.

System 90. Same as System 89 except that the shield was coupled to copper.

Coupling specimens of this system to copper had little or no effect on the corrosion behavior of the copper alloy shield.

System 91. This system consisted of a 3-mil (0.1 mm) corrugated 1006 low carbon steel outer shield bonded to a 3-mil (0.1 mm) corrugated 4022 aluminum alloy inner shield.

Corrosion of either shield at the jacketed areas was not appreciable for specimens buried for one year at Site D or two years at Site B. Severe corrosion was observed on the outer shield at the window and/or ring areas of specimens exposed for up to two years at Sites B, C, and E. ELD or near ELD was noted on the window and ring areas on both shields of specimens exposed for two years at Site D. The inner and outer shields were at or near

ELD at the window and ring areas on specimens exposed for one and two years at Site E. The specimen at Site A was ELD at all areas examined after one year of exposure, and the same was observed for the specimen at Site G after two years of exposure. All three specimens were considered destroyed at these sites.

System 92. Same as System 91 except that the shields were coupled to copper.

Specimens of this system were exposed at Sites A, B, and G only.

Coupling this system to copper accelerated corrosion of both shields. Corrosion of varying degrees was noted on the inner aluminum alloy shield for specimens buried at Site B for two years. The outer shield was at or near ELD at the window and ring areas for specimens exposed at Site B for two years and at or near ELD on the inner and outer shield of specimens at Site E buried for one and two years. The shields of specimens were ELD and considered destroyed after burial for one year in all three soils and after two years at Site G.

System 93. This system consisted of a 3-mil (0.1 mm) corrugated 1006 low carbon steel inner shield bonded to a 3-mil (0.1 mm) corrugated 4022 aluminum alloy outer shield.

Specimens of this system were exposed at Sites A, B, C, D, and E only.

With one exception there was no appreciable degradation of the outer aluminum alloy shield after exposure for one year at these sites. The outer shield of the specimen exposed for one year at Site A was perforated at all areas examined, while the inner shield was ELD at all areas except under the jacket. Corrosion of the inner and outer shield varied from superficial to moderate at all areas examined after burial for up to two years at Sites B, C, D, and E.

System 94. Same as System 93 except that the shields were coupled to copper. Specimens of this system were exposed at Sites A and B only.

Coupling specimens of this system to copper accelerated corrosion of both shields. Both the inner and outer shields of specimens exposed for one and two years at these sites were ELD at all areas examined and were considered destroyed.

System 95. This system consisted of a 25-mil (0.6 mm) uncorrugated seamless aluminum alloy outer shield and a 112-mil (2.8 mm) solid copper alloy center conductor, with a high density polyethylene jacket.

Specimens of this system were exposed at Sites B, D, E, and G only. With one exception corrosion was nil or superficial in all of the soils after exposure for one year. The specimen buried at Site G was ELD at the unjacketed window and ring areas and experienced severe corrosion at the area adjacent to the unjacketed window.

System 96. Same as System 95 except that the shields were coupled to copper.

Specimens of this system were exposed at Sites B, D, E, and G only.

Coupling specimens of this system to copper accelerated corrosion of the shields in all soils buried for one year. In general, there was little or no degradation of the specimen buried at Site B nor was there degradation at the jacketed areas of specimens at Sites D and E. The unjacketed areas on specimens buried in Sites D and E were perforated due to pitting corrosion, and the specimen exposed at Site G was ELD at all areas examined and was considered destroyed. The specimen from Site D was exposed without a window.

System 97. Specimens of this system (Table 1) were exposed at Sites B, D, E, and G only.

With one exception, specimens of this system were unaffected by corrosion during their first year of exposure. The shield of the specimen from Site G was severely corroded at the unjacketed ring area and near ELD at the unjacketed window area.

The filling compounds were still tacky.

System 98. Same as System 97 except that the shields were coupled to copper.

Specimens of this system were exposed at Sites B, C, E, and G only.

Coupling specimens of this system to copper accelerated corrosion of the aluminum alloy shield at the window and ring areas in all soils buried for one year. The specimen exposed at Site E was perforated due to localized pitting corrosion at the window and ring areas. After burial of one year at Site G, the shield of the specimen was near ELD at the area adjacent to the window while the window, ring, and adjacent ring areas were ELD.

The filling compound was still tacky at all areas.

System 99. Specimens of this system (Table 1) were exposed at Sites B, D, E, and G only.

Corrosion was nil for specimens buried for one year with the exception of one. At Site G, the tin-free steel outer shield of the specimen developed severe corrosion at the unjacketed window area and perforation due to localized pitting corrosion at the unjacketed ring area.

The filling compound was still tacky.

System 100. Same as System 99 except that the shields were coupled to copper.

Specimens of this system were exposed at Sites B, D, E, and G.

Coupling specimens of this system to copper accelerated corrosion of the tin-free steel outer shields in most sites. After exposure for one year at Sites B, D, and G the unjacketed window and ring areas were perforated due to corrosion. All other areas examined at all sites were unaffected by corrosion.

The filling compound was still tacky at all areas.

System 101. Specimens of this system (Table 1) were exposed at Sites B, D, E, and G.

There was no degradation on the uncorrugated aluminum alloy inner shield on any of the specimens buried for one year. In general, slight rust stain was noted on specimens exposed at Site B on the tin-plated steel outer shield at jacketed and unjacketed seamed areas. The outer shield of the specimen buried at Site G was perforated by corrosion at all areas examined.

The filling compound was semi-tacky except at corroded areas where it was dry.

System 102. Same as System 101 except that the shields were coupled to copper.

Specimens of this system were exposed at Sites B, D, E, and G only.

Coupling specimens of this system to copper accelerated corrosion of the corrugated tin-plated steel outer shield. All areas examined on the aluminum alloy inner shield were unaffected by corrosion. Degradation of either shield at Site D was superficial or nil for the first year of exposure. Severe corrosion was observed at the window and ring areas of the specimens buried at Site B. The specimen at Site G was ELD at the window area due to corrosion on the outer jacket, and corrosion at all areas rated on this specimen was moderate to severe.

The filling compound was still tacky except at corroded areas which were dry.

System 103. Specimens of this system (Table 1) were exposed at Sites B, D, and E only. Corrosion of both shields was nil or superficial after one year of burial in the three soils with the exception of one specimen. The outer shield at the unjacketed window area of the specimen showed slight localized pitting corrosion after exposure at Site B.

The filling compounds were still tacky.

System 104. Specimens of this system (Table 1) were exposed at Sites B, D, and E only. After an exposure of one year at three sites, the specimen degradation of the inner and outer shields was nil or superficial with the exception of one specimen. Slight localized pitting corrosion was noted on the low carbon steel inner shield at the unjacketed window area for the specimen recovered from Site E.

The filling compound was still tacky.

System 105. Specimens of this system (Table 1) were exposed at Sites B, D, and E only. Specimens buried at all three sites were unaffected by corrosion after one year of burial.

The filling compounds were still tacky.

SUMMARY AND DISCUSSION

The data presented describes the performance of various cable systems after exposure for up to six years in different soil environments. Forty-eight (48) different shielding systems (using metal or plastic coated metals) were investigated under some very adverse conditions.

With a few exceptions, direct burial telephone cable specimens containing the various metallic shielding protective systems were fabricated with portions of the outer jackets damaged in order to simulate that which could occur in actual field installations. In addition some of the systems were electrically coupled to copper strips, thus creating a galvanic cell between the copper and the non-copper shield materials. This was done to simulate field conditions where the shield may be coupled to existing cable systems having copper shields or to copper ground rods.

Six soil environments were employed which have chemical and physical properties representative of a wide range of soils that may be encountered in the United States in actual field installations. Some are moderately corrosive and some are very corrosive toward ferrous and other metals or alloys.

The data show that of the cable specimens buried for up to six years, few were resistant to corrosion in all of the soils in which they were exposed.

The performance of Systems* 56 and 57 after exposure for six years was excellent in alkaline soil. Specimens of System 56 buried in Lakewood sand showed no corrosion after five years of exposure. Specimens of System 56 exposed for six years were fair in clay soil and coastal sand, while specimens of System 57 buried in the same soils were poor, as were the specimens exposed in a tidal marsh. Specimens of Systems 56 and 57 were not installed in Hagerstown loam.

*Systems are described in table 1.

Specimens of System 58 exposed for five years were good in an alkaline soil. However, the specimens of System 59 buried for the same amount of time and in the same soil were poor. Corrosion of System 60 after four years in coastal sand was very poor and the same was true for specimens exposed in alkaline soil for five years. Similarly, specimens of System 58 in coastal sand buried for five years and System 61 in alkaline soil were noted as very poor. After exposure for six years, specimens of Systems 58, 59, 60, and 61 were very poor in clay soil and tidal marsh as were specimens of Systems 59 and 61 buried for the same time in coastal sand. Specimens of Systems 58, 59, 60, and 61 were not installed in Hagerstown loam and Lakewood sand.

After exposure for five years in an alkaline soil, six years in clay and Lakewood sand, and four to six years in Hagerstown loam, there was little or no degradation due to corrosion on specimens of Systems 62, 63, 64, 65, and 66. Similarly, there was no degradation on specimens of System 65 after exposure for up to six years in a tidal marsh. The performance of Systems 62, 63, and 64 exposed in a tidal marsh was, in general, fair. Specimens of System 66 were not buried in this soil.

Specimens of Systems 67, 68, and 69 buried for three years in an alkaline soil and four years in Hagerstown loam, clay, and Lakewood sand were unaffected by corrosion. Specimens of System 70 exposed for three years in an alkaline soil were poor, while specimens buried in Hagerstown loam, clay, and Lakewood sand were excellent. Systems 67, 68, 69, and 70 were not installed in coastal sand or tidal marsh.

After exposure for three years in coastal sand, corrosion of System 73 was generally rated as good. Specimens of Systems 73 and 74 (same as System 73 except coupled to copper) buried in alkaline soil were poor to very poor. Similarly, companion specimens of the same systems exposed for three years in Hagerstown loam, clay, Lakewood sand, coastal sand, and a tidal marsh, were poor to very poor.

Specimens of System 75 buried for two years in an alkaline soil and three years in clay, Lakewood and coastal sand, showed little or no corrosion, while the specimens exposed in a tidal marsh were poor. System 75 exposed in Hagerstown loam and System 76 exposed in Lakewood sand were good after three years of exposure. System 76 (same as System 75 except coupled to copper) was generally fair to poor in Hagerstown loam, clay, and coastal sand exposed for three years.

The performance of System 77 exposed for two years in an alkaline soil was good, while System 78 (same as System 77 except coupled to copper) was poor to very poor. Specimens of System 77 buried for three years in Hagerstown loam were fair while specimens of System 78 under the same conditions were judged to be poor to very poor. Systems 77 and 78 were poor to very poor in clay soil, Lakewood sand, coastal sand, and tidal marsh after an exposure of three years.

Of the specimens of System 79 exposed for two years in an alkaline soil and three years in Lakewood sand there was little or no corrosion observed. System 80 (same as System 79 except coupled to copper) buried for two years in an alkaline soil was fair, as was System 79 exposed for three years in coastal sand. The performance of specimens for System 79 buried for three years in Hagerstown loam and clay soil was fair to poor. The corrosion resistance of System 79 in a tidal marsh was poor to very poor after three years of exposure. The performance of System 80 in Hagerstown loam, clay, Lakewood sand, coastal sand, and tidal marsh was also poor to very poor for the same length of time.

There was no corrosion on System 81 buried in alkaline soil for two years. However, System 82 (same as System 81 except coupled to copper) exposed in the same soil and for the same length of time was observed as poor. Specimens of System 81 exposed in Lakewood and coastal sand for three years were fair. The System 81 specimens buried in Hagerstown loam and System 82 in Lakewood and coastal sand were in general, poor. System 81 in clay soil and tidal marsh was very poor as were the specimens of System 82 in Hagerstown loam and clay soil. Specimens of System 82 exposed in a tidal marsh for three years were considered destroyed.

Systems 83 and 84 were unaffected by corrosion after being exposed for two years in an alkaline soil. System 83 remained unaffected after three years in Hagerstown loam, Lakewood and coastal sand. Specimens of System 84 (same as System 83 except coupled to copper) buried in Lakewood and coastal sands for three years were good while companion specimens in Hagerstown loam were noted as fair. Both systems were poor to very poor in clay soil and tidal marsh after being buried for three years.

Of the specimens of System 85 exposed in an alkaline soil for two years, no corrosion was observed. However, System 86 (same as System 85 except coupled to copper) buried in the same soil for the same time was fair as were the specimens in coastal sand after two years and in Lakewood sand after three years. Specimens of System 85 in Hagerstown loam and clay soil were observed as poor after exposure for three years. Severely corroded specimens of System 86 were found in Hagerstown loam, clay, Lakewood, and coastal sand buried for three years. Both systems were destroyed due to exposure after exposure for three years in a tidal marsh.

The corrosion of Systems 87 and 88 buried for two years in an alkaline soil was moderate as were the specimens of System 87 in Lakewood sand after three years. Coastal sand specimens of System 87 were good, while System 88 (same as System 87 except coupled to copper) was very poor. Corrosion resistance of both Systems was poor to very poor after being buried for three years in Hagerstown loam and clay soil. Severe corrosion of Systems 87 and 88 exposed in a tidal marsh was noted and the specimens were considered destroyed after three years of exposure.

The performance of specimens of Systems 89 and 90 buried in an alkaline soil for one year and two years in all other soil environments showed little or no corrosion attack. Systems 91 and 92 in Hagerstown loam and System 91 in clay soil, Lakewood and coastal sand, were very poor after an exposure of two years. Specimens of both Systems 91 and 92 were considered destroyed after exposure in alkaline soil for one year and tidal marsh for two years. There were no specimens of System 92 installed in clay soil, Lakewood, or coastal sand.

Specimens of System 93 buried for two years in Hagerstown loam, clay, Lakewood and coastal sand were observed as generally good. The one year exposure of System 93 in an alkaline soil was very poor. Specimens of System 94 (same as System 93 except coupled to copper) buried in the same soil for one year and buried in Hagerstown loam for two years were destroyed due to corrosion. Specimens for System 93 were not installed in a tidal marsh, nor was System 94 installed in clay soil, Lakewood sand, coastal sand, and tidal marsh.

Except for Systems 96, 100, and 102, Systems 95 through 105 showed little or no corrosion in Hagerstown loam, Lakewood and coastal sand after one year of exposure. In general, Systems 95 through 105 buried in tidal marsh for one year were noted to be poor to very poor. Corrosion resistance was fair to good on System 96 in Lakewood and coastal sand, System 100 in

Hagerstown loam, coastal sand, and tidal marsh, and System 102 in coastal sand. Little or no corrosion was observed for specimens of System 96 in Hagerstown loam and for Systems 100 and 102 in Lakewood sand. The specimens of System 102 buried in a tidal marsh were very poor, while specimens of System 96 were destroyed after exposure for one year in the same soil.

The following should not be considered for use because of the relatively poor performance in one or more of the less aggressive soils: Systems No. 56, 58, 60, 61, 73, 77, 79, 81, 85, 87, 91, and 93.

When Systems No. 57, 59, 74, 76, 78, 80, 82, 84, 86, 88, 92, 94, 96, and 102 were coupled to copper, their performance was poor to very poor in one or more of the soils. For most of the materials studied in this investigation, the copper strip coupled to the shield caused an appreciable acceleration of corrosion to the shield over that observed when the material was not coupled to copper. The copper behaved as the cathode in a galvanic cell where the dissimilar metal shield was the anode. The result was dissipation of the shield by sacrificial corrosion in addition to the normal corrosion occurring in the particular soil environment.

Some exceptions to the above were noted where some specimens fabricated with stainless steel shields were coupled to copper, i.e., Systems No. 57 and 59. For these specimens, the copper was anodic to the stainless steel outer shield and cathodic to the inner aluminum shield. With the exception of one specimen, there was little or no degradation of the copper strips buried in any of the soils; however, some green patina was observed at areas on all of the copper strips.

REFERENCES

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[2] W. F. Gerhold, J. P. McCann, and W. E. Williamson, "Corrosion of Underground Telephone Cable Shielding Materials in Soil Environments After Exposure for Four Years," paper presented at NACE Corrosion/74, Chicago, IL, March 1974.

[3] W. F. Gerhold and J. P. McCann, "Corrosion Evaluation of Underground Telephone Cable Shielding Materials," paper #31 presented at NACE Corrosion/76, Houston, TX, March 1976.

[4] W. F. Gerhold and J. L. Fink, "Corrosion Evaluation of Underground Telephone Cable Shielding Materials," Department of Commerce, NBSIR 81-2243, April 1981.

Tables

Figure Captions

Figure 1	Preparation of specimens for cable exposure tests.
Figure 2	System 95 exposed for one year.
Figure 3	System 101 exposed for one year.
Figures 4 & 5	Systems 73, 75, 77, 79, 81, 85, and 87 exposed at Site A for two years.
Figures 6 & 7	Systems 74, 78, 80, 82, 86, and 88 exposed at Site A for two years.
Figures 8 thru 33	Selected Systems between Systems 73 and 88 exposed for three years.
Figures 34 & 35	System 56 exposed for six years.
Figures 36 & 37	System 57 exposed for six years.

Table 1. Description of Various Systems Included in the Soil Corrosion Study of Telephone Cable Shielding Materials.

System	Description
56	3-mil (0.08 mm) Type 430 stainless steel outer shield bonded to a 3-mil (0.08 mm) 1100 aluminum alloy inner shield with a clear flooding compound on the core side.
57	Same as System 56, except that the system was coupled to copper.
58	3-mil (0.08 mm) Type 304 stainless steel with 4-mil (0.10 mm) vapor deposited aluminum on the outer surface.
59	Same as System 58, except that the shield was coupled to copper.
60	3-mil (0.08 mm) Type 304 stainless steel with 2-mil (0.05 mm) vapor deposited aluminum on the outer and core sides of the shield.
61	Same as System 60, except that the shield was coupled to copper.
62	50-pair, 22-gauge air core cable having an 8-mil (0.20 mm) aluminum alloy shield with a copolymer coating on both sides of the shield. Cable core was removed.
63	16-pair, 22-gauge cable having an 8-mil (0.20 mm) uncorrugated aluminum alloy shield bonded on both sides to a polyolefin polymer. Shield was bonded to the jacket.
64	25-pair, 18-gauge cable having an 8-mil (0.20 mm) uncorrugated aluminum alloy shield bonded on both sides to a 2-mil (0.05 mm) polyolefin polymer. Shield was bonded to the jacket.
65	25-pair, 24-gauge cable having an 8-mil (0.20 mm) uncorrugated aluminum alloy shield bonded on both sides to a polyolefin polymer. Shield was bonded to the jacket.
66	Same as System 65, except that the shield was coupled to copper.
67	4-mil (0.10 mm) aluminum foil [3 3/4 in. x 8 in. (9.52 cm x 20.32 cm)] coated both sides with a 6-mil (0.15 mm) ethylene acrylic acid copolymer.
68	4-mil (0.10 mm) aluminum foil [3 3/4 in x 8 in. (9.52 cm x 20.32 cm)] coated both sides with a 6-mil (0.15 mm) polyester film.
69	4-mil (0.10 mm) aluminum foil [1 1/2 in. x 12 in. (3.81 cm x 30.48 cm)] coated both sides with a 5.5 mil (0.14 mm) polyester film.
70	25-pair, 24-gauge cable having a 6-mil (0.15 mm) corrugated copper alloy outer shield (nominal chemical composition: 97.5 percent Cu, 2.5 percent Fe, 0.02 percent P) and an inner shield of 4-mil (0.10 mm) aluminum alloy coated on both sides with a 5.5-mil (0.14 mm) polyester film. Outer shield was bonded to the jacket. This was a filled cable having a clear flooding compound.

Table 1 (continued)

System	Description
73	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated black plate steel outer shield and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer. This was a filled cable having a clear flooding compound over the core and inner shield and another type of clear flooding compound over the outer shield.
74	Same as System 73, except that the shields were coupled to copper.
75	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated steel outer shield, coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield, coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer. This was a filled cable having a clear flooding compound over the core and inner shield and another type of clear flooding compound over the outer shield.
76	Same as System 75, except that the shields were coupled to copper.
77	25-pair, 22-gauge cable having a 6-mil (0.20 mm) corrugated steel outer shield and an 8-mil (0.20 mm) corrugated aluminun alloy inner shield coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer. This was a filled cable having a clear flooding compound over the core and inner shield and another type of clear flooding compound over the outer shield.
78	Same as System 77, except that the shields were coupled to copper.
79	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated steel outer shield and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield. This was a filled cable having a clear flooding compound over the core and inner shield and another type of clear flooding compound over the outer shield.
80	Same as System 79, except that the shields were coupled to copper.
81	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated steel outer shield coated on both sides with 2-mil (0.05 mm) ethylene acrylic acid copolymer and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield coated on both sides with 2-mil (0.05 mm) ethylene acrylic acid copolymer. This was a filled cable with amorphous polypropylene applied over the core, inner shield, and outer shield.
82	Same as System 81, except that the shields were coupled to copper.
83	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated steel outer shield coated on both sides with 2-mil (0.05 mm) ethylene acrylic acid copolymer and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield coated on both sides with ethylene acrylic acid copolymer. This was a filled cable with amorphous polypropylene applied over the core, inner shield, and outer shield.

Table 1 (continued)

System	Description
84	Same as System 83, except that the shields were coupled to copper.
85	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated steel outer shield and an 8-mil (0.20 mm) corrugated aluminum alloy shield. This was a filled cable with amorphous polypropylene applied over core, inner shield, and outer shield.
86	Same as System 85, except that the shields were coupled to copper.
87	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated black plate steel outer shield and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer. This was a filled cable with amorphous polypropylene applied over core, inner shield, and outer shield.
88	Same as System 87, except that the shields were coupled to copper.
89	100-pair, 22-gauge semi-conducting cable having a 5-mil (0.13 mm) corrugated copper alloy shield and a low density polyethylene jacket.
90	Same as System 89, except that the shield was coupled to copper.
91	3-mil (0.08 mm) corrugated 1006 low carbon steel outer shield bonded to a 3-mil (0.08 mm) corrugated 4022 aluminum alloy inner shield.
92	Same as System 91, except that the shields were coupled to copper.
93	3-mil (0.08 mm) corrugated 1006 low carbon steel inner shield bonded to a 3-mil (0.08 mm) corrugated 4022 aluminum alloy outer shield.
94	Same as System 93, except that the shields were coupled to copper.
95	25-mil (0.64 mm) uncorrugated seamless aluminum alloy outer shield and a 112-mil (2.84 mm) solid copper alloy center conductor with a high density polyethylene jacket.
96	Same as System 95, except that the outer shield was coupled to copper.
97	25-mil (0.64 mm) uncorrugated seamless aluminum alloy outer shield and a 112-mil (2.84 mm) solid copper alloy center conductor. This was a filled cable having a flooding compound of polyisobutylene between jacket and outer shield, with a high density polyethylene jacket.
98	Same as System 97, except that the outer shield was coupled to copper.

Table 1 (continued)

System	Description
99	25-pair, 22-gauge cable having a 6-mil (0.15 mm) corrugated tin free steel outer shield, coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer and an 8-mil (0.20 mm) corrugated aluminum alloy inner shield, coated on both sides with a 2-mil (0105 mm) ethylene acrylic acid copolymer. This was a filled cable having a clear flooding compound over the core and inner shield, and another type of clear flooding compound over the outer shield.
100	Same as System 99, except that the shields were coupled to copper.
101	6-mil (0.15 mm) corrugated tin plated steel outer shield coated on both sides with a 2-mil (0.05 mm) ethylene acrylic acid copolymer and a 25-mil (0.64 mm) uncorrugated seamless aluminum alloy inner shield (outer conductor) having a 98-mil (2.49 mm) solid copper alloy center conductor with a black polyethylene inner and outer jacket.
102	Same as System 101, except outer shield was coupled to copper.
103	25-pair, 22-gauge cable having a corrugated aluminum alloy outer shield bonded to a corrugated low carbon steel inner shield coated only on the inner shield. This was a filled cable having a clear flooding compound on the outer and inner shields.
104	25-pair, 22-gauge cable having a corrugated aluminum alloy outer shield bonded to a corrugated low carbon steel inner shield. This was a filled cable having a clear flooding compound on the outer and inner shields.
105	25-pair, 22-gauge cable having a corrugated aluminum alloy outer shield bonded to a corrugated low carbon steel inner shield coated on both the outer and inner shields. This was a filled cable having a clear flooding compound on the outer and inner shields.

Table 2. Properties of Soils at Test Sites

Site Ident.	Soil	Location	Internal drainage of test site	Resistivity[1] (ohm - cm)	pH	TDS[2]	Composition of water extract (parts per million) Ca	Mg	Na + K as Na	CO_3	HCO_3	SO_4	Cl	NO_3
A	Sagemoor sandy loam	Toppenish, WA	Good	400	8.8	7,080	108	23	1,960	0.0	5,002	216	330	6
B	Hagerstown loam	Loch Raven, MD	Good	5,200	5.8	[3]	--	--	--	--	--	--	--	--
C	Clay	Cape May, NJ	Poor	300	4.0	14,640	540	754	2,242	0.0	0.0	6,768	3,529	118
D	Lakewood sand	Wildwood, NJ	Good	30,000	7.3	[3]	--	--	--	--	--	--	--	--
E	Coastal sand	Wildwood, NJ	Poor	55	7.1	11,010	302	329	3,230	0.0	55	1,333	5,765	31
G	Tidal marsh	Lexington Park, MD	Poor	300	7.1	11,580	140	165	2,392	0.0	0.0	1,709	3,259	37
							(Milligram equivalents per 100 grams of soil)							
A	---	---	---	---	---	---	0.54	0.19	8.50	0.0	8.20	0.45	0.93	0.01
B	---	---	---	---	---	[3]	---	---	---	---	---	---	---	---
C	---	---	---	---	---	---	2.70	6.18	9.51	0.0	0.0	14.0	9.94	0.19
D	---	---	---	---	---	[3]	---	---	---	---	---	---	---	---
E	---	---	---	---	---	---	1.51	2.70	13.9	0.0	0.09	2.36	16.2	0.05
G	---	---	---	---	---	---	0.70	1.35	10.2	0.0	0.0	2.56	9.18	0.06

[1]Resistivity determinations made at the test site with Shepard Canes
[2]TDS, total dissolved solids--residue dried at 105 °C
[3]Analyses not made for soils at sites B and D because of the very low concentrations of soluble salts in these soils

Table 3. Rating Code for the Corrosion Evaluation of Shields in Cable Specimens

Rating	Performance	Degree of Corrosion
10	Excellent	Unaffected. No indication of corrosion.
9	Excellent	Superficial rust or etching on surface.
8	Very Good	Uniform metal attack, rust, and/or slight localized pitting.
7	Good	Appreciable pitting over the surface, but no perforations through metal shield. Some minor delamination or dissipation of metallurgically or plastic-bonded metals leaving cathodic metal intact.
6+	Good	Localized pitting: only one perforation in shield by pitting.
6	Good	Localized pitting: two to five perforations in shield by pitting.
5	Fair	Many localized pits causing perforation of shield; < 5 percent of shield dissipated by corrosion; extensive delamination of metallurgically bonded metals.
4	Poor	Severe corrosion: pitting to perforation of shield; five to ten percent of shield dissipated by corrosion; severe corrosion of anodic part of metallurgically bonded metals.
3	Poor	Severe corrosion: pitting to perforation of shield; ten to twenty-five percent of shield dissipated by corrosion.
2	Very Poor	Severe corrosion: more than twenty-five percent of shield dissipated by corrosion; shield still has electrical continuity along the cable.
1	Very Poor	Severe corrosion: shield is close to electrical discontinuity (ELD) due to perforation in shield and dissipation of metal by corrosion.
0	Very Poor	Severe corrosion: shield is electrically discontinuous (ELD) due to dissipation of metal by corrosion.

Table 4. Performance of Shields in Cable Specimens Buried Up to Six Years in Sagemoor Sandy Loam (Site A)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
56	1	10	10	10	10	10	
	2	10	10	10	10	10	
	3	10	10	10	10	10	
	4	10	10	10	10	10	
	5	10	10	10	10	10	
	6	10	10	10	10	10	
57	1	10(4)	10(5)	10	10(5)	10(5)	10
	2	10	10	10	10	10	10
	3	10	10	10	10	10	10
	4	10	10	10	10	10	10
	5	10	10	10	10	10	10
	6	10	10	10	10	10	9
58	1	10(5)	10(5)	10(0)	10(5)	10(7)	
	2	10(5)	10(4)	10(0)	10(5)	10(5)	
	3	10(5)	10(5)	10(0)	10(7)	10(7)	
	4	10(10)	10(10)	10(5)	10(7)	10(7)	
	5	10(7)	10(7)	10(7)	10(7)	10(7)	
59	1	10(0)	10(2)	10(2)	10(0)	10(3)	9
	2	10(0)	10(2)	6(10)	10(0)	10(1)	9
	3	9(0)	9(2)	9(0)	10(0)	9(2)	10
	4	9(5)	9(4)	9(0)	9(7)	9(5)	9
	5	9(5)	10(4)	9(5)	9(3)	9(5)	10
60	1	0(10)5	0(10)5	0(10)0	0(10)5	0(10)3	
	2	0(10)8	1(10)8	0(10)0	1(10)7	0(10)7	
	3	0(10)4	1(10)3	0(10)0	0(10)2	0(10)5	
	4	1(10)5	2(10)7	0(10)0	1(10)7	1(10)7	
	5	1(10)7	1(10)8	1(10)7	1(10)7	7(10)8	
61	1	0(10)1	0(10)0	0(10)1	0(10)3	0(10)5	9
	2	1(10)5	1(10)5	0(10)0	0(10)2	0(10)3	10
	3	0(10)0	1(10)4	0(5)0	0(10)2	1(10)2	10
	4	0(10)5	0(10)4	0(10)1	0(10)5	0(10)5	10
	5	0(10)0	0(10)3	0(10)0	0(10)0	0(10)3	9

Table 4 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
62	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
63	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
64	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
66	1			10			10
	2			10			9
	3			10			Missing
	4			10			10
	5			10			Missing
67	1			10			
	2			10			
	3			10			
68	1			10			
	2			10			
	3			10			
69	1			10			
	2			10			
	3			10			
70	1			10			
	2			10			
	3			3			

Table 4 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
73	1	9(10)	9(10)	9(10)	9(10)	9(10)	
	2	4(10)	2(10)	9(10)	8(10)	8(10)	
74	1	2(9)	1(9)	9(10)	5(9)	3(9)	10
	2	4(10)	2(10)	9(10)	8(10)	8(10)	10
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	8(10)	8(10)	10(10)	10(10)	10(10)	
76	1	10(10)	10(10)	10(10)	10(10)	10(10)	10
	2	8(10)	6+(10)	10(10)	10(10)	10(10)	10
77	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	6(10)	6(10)	10(10)	10(10)	10(10)	
78	1	10(10)	10(10)	10(10)	10(10)	10(10)	10
	2	4(10)	1(10)	10(10)	10(8)	10(8)	10
79	1	10(10)	6(10)	10(10)	10(10)	10(10)	
	2	9(10)	10(10)	10(10)	10(10)	10(10)	
80	1	10(10)	5(6)	9(10)	10(10)	9(10)	10
	2	4(4)	4(4)	10(10)	10(5)	10(10)	10
81	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
82	1	6(10)	5(10)	10(10)	10(10)	10(10)	10
	2	4(2)	3(5)	9(10)	8(10)	8(10)	10
83	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
84	1	Not recovered					
	2	10(10)	10(10)	10(10)	10(10)	10(10)	10
85	1	9(10)	9(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
86	1	5(10)	6(10)	10(10)	10(10)	10(10)	10
	2	5(10)	5(10)	10(10)	10(10)	10(10)	10
87	1	9(10)	9(10)	10(10)	10(10)	9(10)	
	2	6(10)	5(10)	10(10)	10(10)	10(10)	
88	1	6(10)	5(10)	8(10)	8(10)	8(10)	10
	2	8(10)	5(10)	10(10)	8(10)	10(10)	10

Table 4 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
89	1	9	9	10	10	10	
90	1	9	9	10	10	9	10
91	1	Destroyed					
92	1	Destroyed					
93	1	5(0)	5(0)	5(4)	5(0)	5(0)	
94	1	Destroyed					

Table 5. Performance of Shields in Cable Specimens Buried Up to Six Years in Hagerstown Loam (Site B)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
62	1			10			
	2			10			
	3			10			
	4			10			
63	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
64	1			10			
	2			10			
	3			10			
	4			10			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
66	1			10			10
	2			10			10
	3			10			10
	4			10			Missing
	5			10			Missing
	6			10			9
67	1			10			
	2	Not recovered					
	3			10			
	4			10			
68	1			10			
	2			10			
	3			10			
	4			10			
69	1			10			
	2			10			
	3	Not recovered					
	4			10			

Table 5 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
70	1			10			
	2			10			
	3			10			
	4			10			
73	1	2(10)	2(10)	10(10)	9(10)	9(10)	
	2	4(10)	3(10)	9(10)	8(10)	8(10)	
	3	2(10)	1(10)	8(10)	8(10)	8(10)	
74	1	0(10)	1(10)	9(10)	9(10)	5(10)	10
	2	3(10)	2(10)	9(10)	8(10)	10(10)	10
	3	0(10)	1(10)	8(10)	2(10)	3(10)	9
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
	3	6+(10)	6+(10)	10(10)	10(10)	10(10)	
76	1	5(10)	5(10)	10(10)	5(10)	5(10)	10
	2	5(10)	5(10)	10(10)	5(10)	10(10)	10
	3	3(10)	4(10)	10(10)	5(10)	7(10)	10
77	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	5(10)	6(10)	10(10)	8(10)	8(10)	
	3	4(10)	6+(10)	8(10)	8(10)	9(10)	
78	1	2(10)	2(10)	10(10)	9(10)	9(10)	10
	2	1(10)	1(10)	10(10)	8(10)	8(10)	10
	3	0(10)	0(10)	6(10)	2(10)	2(10)	10
79	1	6(10)	5(10)	10(10)	10(10)	10(10)	
	2	5(10)	5(10)	9(10)	8(10)	8(10)	
	3	4(10)	3(10)	8(10)	8(10)	8(10)	
80	1	2(10)	2(10)	9(10)	9(10)	10(10)	10
	2	2(6+)	1(9)	8(9)	8(10)	9(10)	10
	3	0(4)	0(4)	5(10)	4(10)	5(10)	10
81	1	9(10)	5(10)	9(10)	9(10)	9(10)	
	2	3(10)	4(10)	9(10)	9(10)	9(10)	
	3	4(10)	9(10)	5(10)	6(10)	6+(10)	
82	1	2(10)	2(10)	9(10)	9(10)	9(10)	9
	2	1(10)	1(10)	9(10)	8(10)	8(10)	10
	3	1(10)	1(10)	8(10)	2(10)	2(10)	9

Table 5 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
83	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
	3	10(10)	10(10)	10(10)	10(10)	10(10)	
84	1	5(10)	5(10)	10(10	10(10)	8(10)	10
	2	6(10)	6(10)	10(10)	10(10)	10(10)	10
	3	3(10)	5(10)	10(10)	10(10)	10(10)	9
85	1	9(10)	4(10)	9(10)	4(10)	9(10)	
	2	6(10)	4(10)	10(10)	8(10)	9(10)	
	3	4(10)	4(10)	8(10)	8(10)	8(10)	
86	1	3(9)	3(9)	10(9)	9(9)	9(9)	10
	2	2(10)	1(10)	10(10)	8(10)	10(10)	10
	3	1(6)	2(6)	9(6)	8(6)	9(6)	10
87	1	5(10)	5(10)	9(10)	8(10)	8(10)	
	2	4(10)	4(10)	9(10)	8(10)	8(10)	
	3	3(10)	3(10)	8(10)	6(10)	8(10)	
88	1	3(10)	3(10)	8(10)	8(10)	8(10)	10
	2	2(10)	1(10)	8(10)	8(10)	8(10)	10
	3	2(10)	0(10)	7(10)	7(10)	7(10)	10
89	1	9	9	9	9	9	
	2	9	9	9	9	9	
90	1	9	9	9	9	9	10
	2	9	9	9	9	9	9
91	1	4(5)	3(8)	8(9)	6(9)	7(9)	
	2	0(9)	3(9)	8(9)	7(9)	3(9)	
92	1	Destroyed					
	2	0(4)	0(3)	7(7)	4(6)	0(5)	10
93	1	9(6)	9(7)	9(7)	9(7)	9(7)	
	2	9(7)	9(7)	9(7)	9(7)	9(7)	
94	1	Destroyed					10
	2	Destroyed					10
95	1	9	9	10	10	10	
96	1	8	8	10	8	8	10
97	1	10	10	10	10	10	

Table 5 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
98	1	8	8	10	10	10	10
99	1	10(10)	10(10)	10(10)	10(10)	10(10)	
100	1	5(10)	6(10)	10(10)	10(10)	10(10)	9
101	1	8(10)	8(10)	8(10)	8(10)	8(10)	
102	1	4(10)	4(10)	10(10)	9(10)	9(10)	9
103	1	8	10	10	10	10	
104	1	10	10	10	10	10	
105	1	10	10	10	10	10	

Table 6. Performance of Shields in Cable Specimens Buried Up to Six Years in Clay Soil (Site C)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
56	1	10	10	10	10	10	
	2	10	10	10	10	10	
	3	10	10	10	10	10	
	4	10(2)	10	10	10	10	
	5	10	10	10	10	10	
	6	10(5)	10(5)	10(5)	10(5)	10(5)	
57	1	10	10	10	10	10	9
	2	10(5)	10(5)	10	10(5)	10(5)	Missing
	3	10(5)	10(5)	10	10	10	Missing
	4	10(0)	10	10	10	10	10
	5	10(0)	3(2)	10(0)	10(0)	10(3)	9
	6	6(0)	10(0)	10(0)	9(0)	10(0)	9
58	1	10(5)	10(5)	10(4)	10(7)	10(8)	
	2	10(2)	9(3)	10(4)	10(5)	9(5)	
	3	9(2)	9(5)	10(0)	10(4)	10(7)	
	4	9(5)	7(7)	9(1)	9(5)	9(7)	
	5	8(4)	6+(5)	10(2)	9(5)	6+(5)	
	6	9(1)	9(0)	9(0)	9(0)	9(1)	
59	1	9(3)	10(2)	10(3)	10(5)	10(2)	Missing
	2	10(1)	10(0)	10(0)	10(0)	10(0)	9
	3	10(0)	10(0)	5(0)	10(0)	10(0)	10
	4	10(0)	8(0)	5(0)	9(0)	6+(0)	Missing
	5	9(0)	5(0)	10(0)	9(0)	10(0)	Missing
	6	6+(0)	6+(0)	3(0)	6+(0)	6(0)	5
60	1	4(10)7	6(6)6	4(10)1	5(10)5	5(10)5	
	2	0(10)5	0(10)8	3(10)2	7(10)5	2(10)5	
	3	1(10)7	2(10)7	0(10)0	2(10)5	2(10)8	
	4	0(10)7	0(10)8	4(10)1	2(10)5	3(10)7	
	5	0(10)0	0(10)1	0(10)0	0(10)1	0(10)1	
	6	0(10)0	0(10)0	0(6)0	0(10)0	0(10)0	
61	1	0(10)0	0(10)4	0(10)1	0(10)0	0(10)5	10
	2	0(10)0	0(10)0	0(5)0	0(10)0	0(10)0	9
	3	0(10)0	0(6+)0	0(6)0	0(5)0	0(6)0	Missing
	4	0(10)0	0(10)0	0(10)0	0(10)0	0(10)0	6
	5	0(5)0	0(9)0	0(6+)0	0(9)0	0(9)0	9
	6	0(10)0	0(10)0	0(10)0	0(10)0	0(10)0	3

Table 6 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
62	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			7			
63	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
64	1			10			
	2			10			
	3			10			
	4			5			
	5			10			
	6			7			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
66	1			10			10
	2			10			Missing
	3			10			Missing
	4			10			Missing
	5			10			Missing
	6			10			
67	1			10			
	2			10			
	3	Not recovered					
	4			10			
68	1			10			
	2			10			
	3	Not recovered					
	4			10			

Table 6 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
69	1			10			
	2			10			
	3	Not recovered					
	4			10			
70	1			10			
	2			10			
	3			10			
	4			10			
73	1	9(10)	2(10)	9(10)	9(10)	5(10)	
	2	2(10)	2(10)	8(10)	8(10)	8(10)	
	3	4(10)	2(10)	8(10)	8(10)	8(10)	
74	1	1(10)	1(8)	9(10)	3(10)	2(10)	10
	2	0(0)	0(3)	9(10)	8(8)	8(10)	Missing
	3	0(10)	4(10)	9(10)	3(10)	2(10)	10
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	8(10)	8(10)	8(10)	8(10)	8(10)	
	3	10(10)	10(10)	10(10)	9(10)	10(10)	
76	1	2(10)	2(10)	10(10)	8(10)	6(10)	10
	2	5(10)	4(10)	10(10)	5(10)	5(10)	10
	3	4(10)	4(10)	10(10)	7(10)	5(10)	10
77	1	6(10)	10(10)	10(10)	10(10)	10(10)	
	2	5(10)	4(10)	10(10)	8(10)	8(10)	
	3	3(10)	3(10)	10(10)	8(10)	5(10)	
78	1	2(10)	2(10)	10(10)	9(10)	10(10)	10
	2	0(8)	0(4)	8(10)	1(10)	0(10)	10
	3	0(0)	0(0)	8(4)	3(5)	1(5)	9
79	1	Not recovered					
	2	5(10)	4(10)	10(10)	8(10)	8(10)	
	3	3(10)	5(10)	9(10)	8(10)	8(10)	
80	1	2(5)	2(2)	10(10)	10(10)	10(10)	9
	2	0(0)	0(0)	8(8)	8(1)	8(3)	10
	3	0(0)	0(0)	6+(0)	5(0)	5(1)	9
81	1	9(10)	6+(10)	10(10)	10(10)	10(10)	
	2	Not recovered					
	3	4(10)	2(10)	6+(10)	7(10)	8(10)	

Table 6 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
82	1	2(10)	1(5)	10(10)	9(10)	10(10)	Missing
	2	0(0)	0(1)	9(10)	2(8)	4(8)	10
	3	0(0)	0(0)	9(0)	2(0)	2(2)	9
83	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	6(10)	10(10)	10(10)	10(10)	
	3	2(7)	5(10)	10(10)	5(10)	9(10)	
84	1	6(10)	6(10)	10(10)	10(10)	10(10)	10
	2	5(10)	5(10)	10(10)	10(10)	10(10)	10
	3	2(7)	4(10)	10(10)	4(7)	10(10)	10
85	1	6+(10)	5(10)	9(10)	9(10)	9(10)	
	2	6(10)	4(10)	10(10)	8(10)	9(10)	
	3	4(9)	5(9)	10(10)	8(10)	8(10)	
86	1	0(9)	1(0)	9(9)	9(9)	9(9)	Missing
	2	1(0)	0(0)	10(0)	8(0)	10(0)	Missing
	3	0(0)	1(0)	8(1)	5(4)	3(0)	10
87	1	6(10)	5(10)	9(10)	8(10)	8(10)	
	2	4(10)	3(10)	8(10)	8(10)	8(10)	
	3	5(10)	2(10)	8(10)	8(10)	8(10)	
88	1	2(5)	1(10)	9(10)	0(10)	9(10)	10
	2	1(0)	1(5)	8(10)	8(1)	8(10)	10
	3	0(0)	0(0)	7(0)	7(0)	8(0)	9
89	1	9	9	9	9	9	
	2	8	8	9	9	9	
90	1	9	9	9	9	9	10
	2	8	8	9	9	9	Missing
91	1	0(0)	0(0)	6(6)	6(6)	5(5)	
	2	1(1)	1(4)	5(5)	7(4)	7(5)	
93	1	5(5)	5(5)	6(6)	5(5)	5(5)	
	2	7(7)	6(6)	8(7)	8(7)	8(7)	

Table 7. Performance of Shields in Cable Specimens Buried Up to Six Years in Lakewood Sand (Site D)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
56	1			10			
	2	10	10	10	10	10	
	3	10	10	10	10	10	
	4	10	10	10	10	10	
	5	10	10	10	10	10	
	6	Not recovered					
57	1	Not recovered					
	2	10(5)	10(5)	10	10(5)	10	10
	3	10(0)	10(4)	10	10(5)	10(5)	Missing
	4	10(6)	10(5)	10	10	10	10
	5	10(0)	10(4)	10(5)	10(4)	10(4)	10
	6	Not recovered					
62	1			10			
	2			10			
	3			10			
	4			8			
	5			10			
	6			10			
63	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
64	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			

Table 7 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
66	1			10			Missing
	2			10			Missing
	3			10			Missing
	4			10			Missing
	5			10			10
	6			10			Missing
67	1			10			
	2	Not recovered					
	3			10			
	4			10			
68	1			10			
	2			10			
	3			10			
	4			10			
69	1	Not recovered					
	2			10			
	3	Not recovered					
	4			10			
70	1			10			
	2			10			
	3			10			
	4			10			
73	1	9(10)	6(10)	10(10)	9(10)	9(10)	
	2	8(10)	4(10)	9(10)	8(10)	8(10)	
	3	8(10)	3(10)	8(10)	8(10)	8(10)	
74	1	5(10)	2(10)	9(10)	9(10)	4(10)	10
	2	4(10)	4(10)	8(10)	8(10)	8(10)	10
	3	4(10)	2(10)	8(10)	8(10)	8(10)	10
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
	3	10(10)	10(10)	10(10)	10(10)	10(10)	
76	1	10(10)	6+(10)	10(10)	10(10)	10(10)	10
	2	5(10)	6(10)	10(10)	10(10)	10(10)	10
	3	6+(10)	6+(10)	10(10)	10(10)	10(10)	10
77	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	8(10)	6(10)	10(10)	9(10)	9(10)	
	3	9(10)	9(10)	10(10)	9(10)	9(10)	

Table 7 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
78	1	6(10)	5(10)	10(10)	10(10)	10(10)	10
	2	5(10)	4(10)	10(10)	5(10)	10(10)	10
	3	4(10)	2(10)	10(10)	9(10)	7(10)	10
79	1	6+(10)	6(10)	10(10)	10(10)	10(10)	
	2	8(10)	5(10)	10(10)	9(10)	9(10)	
	3	8(10)	8(10)	10(10)	9(10)	9(10)	
80	1	8(10)	6(10)	10(10)	10(10)	10(10)	10
	2	5(10)	4(10)	10(10)	8(10)	8(10)	10
	3	3(10)	2(10)	9(10)	9(10)	8(10)	10
81	1	9(10)	9(10)	10(10)	10(10)	10(10)	
	2	8(10)	5(10)	10(10)	10(10)	10(10)	
	3	5(10)	4(10)	10(10)	9(10)	9(10)	
82	1	5(10)	5(10)	10(10)	10(10)	10(10)	10
	2	4(10)	2(10)	9(10)	9(10)	9(10)	10
	3	4(10)	2(10)	9(10)	8(10)	9(10)	10
83	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
	3	10(10)	10(10)	10(10)	10(10)	10(10)	
84	1	10(10)	6(10)	10(10)	10(10)	10(10)	10
	2	5(10)	5(10)	10(10)	10(10)	10(10)	10
	3	6(10)	6(10)	10(10)	10(10)	10(10)	10
85	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	7(10)	5(10)	10(10)	10(10)	10(10)	
	3	5(10)	5(10)	10(10)	9(10)	10(10)	
86	1	5(10)	5(10)	10(10)	10(10)	10(10)	10
	2	4(10)	4(10)	10(10)	8(10)	10(10)	10
	3	2(9)	2(6+)	9(6+)	8(9)	9(8)	10
87	1	7(10)	7(10)	9(10)	7(10)	8(10)	
	2	5(10)	5(10)	5(10)	8(10)	8(10)	
	3	5(10)	5(10)	8(10)	8(10)	8(10)	
88	1	6(10)	5(10)	8(10)	8(10)	8(10)	10
	2	2(10)	3(10)	8(10)	8(10)	8(10)	10
	3	2(10)	2(10)	7(10)	8(10)	8(10)	9
89	1	10	9	9	10	10	
	2	9	9	9	9	9	

Table 7 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
90	1	9	9	9	9	10	10
	2	9	9	9	9	9	10
91	1	6(9)	6(9)	9(9)	9(9)	9(9)	
	2	1(1)	0(0)	5(5)	6(6)	6(6)	
93	1	9(7)	9(7)	9(7)	9(7)	9(7)	
	2	8(7)	6+(6+)	8(6)	8(7)	8(7)	
95	1	9	9	10	10	10	
96	1	-	4	9	-	7	
97	1	10	10	10	10	10	
98	1	8	8	10	10	10	10
99	1	10(10)	10(10)	10(10)	10(10)	10(10)	
100	1	10(10)	10(10)	10(10)	10(10)	10(10)	10
101	1	10(10)	10(10)	9(10)	10(10)	10(10)	
102	1	10(10)	10(10)	9(10)	9(10)	9(10)	10
103	1	10	10	10	10	10	
104	1	10	10	10	10	10	
105	1	10	10	10	10	10	

Table 8. Performance of Shields in Cable Specimens Buried Up to Six Years in Coastal Sand (Site E)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
56	1	10	10	10	10	10	
	2	10	10	10	10	10	
	3	10(5)	10(5)	10(7)	10(5)	10(6)	
	4	10(2)	10	10	10(5)	10	
	5	Not recovered					
	6	10(5)	10(3)	10(5)	10(5)	10(5)	
57	1	10(4)	10(4)	10(5)	10(5)	10(5)	9
	2	10(0)	10(5)	10	10(5)	10(5)	10
	3	10(0)	10(4)	10(5)	10(4)	10(4)	Missing
	4	10(4)	10(4)	10(4)	10(4)	10(4)	10
	5	Not recovered					
	6	10(0)	10(0)	10(0)	10(0)	10(0)	9
58	1	10(7)	10(7)	10(7)	10(7)	10(7)	
	2	10(4)	10(4)	10(2)	10(7)	10(7)	
	3	10(4)	10(4)	10(5)	10(5)	10(5)	
	4	10(1)	10(0)	10(1)	10(4)	10(5)	
	5	10(5)	10(5)	10(0)	10(1)	10(3)	
59	1	10(1)	10(2)	10(7)	10(0)	10(7)	10
	2	10(0)	10(0)	10(0)	10(0)	10(0)	9
	3	10(0)	10(0)	6(0)	9(0)	9(0)	9
	4	10(0)	10(0)	10(0)	10(0)	10(0)	9
	5	10(0)	10(0)	5(0)	5(0)	10(0)	9
	6	10(0)	10(0)	10(0)	10(0)	10(0)	9
60	1	2(10)7	2(10)7	8(10)7	4(10)8	5(10)8	
	2	0(10)5	0(10)1	0(10)2	2(10)5	5(10)4	
	3	0(10)5	4(10)7	0(10)4	4(10)5	5(10)8	
	4	0(10)5	0(10)4	3(10)0	0(10)5	2(10)5	
	5	Not recovered					
61	1	0(10)0	0(10)0	0(10)0	0(10)0	0(10)0	10
	2	0(10)1	0(10)0	0(10)0	0(10)0	0(10)0	Missing
	3	0(10)0	0(10)0	0(10)0	0(10)0	0(10)0	10
	4	0(10)0	0(10)0	0(6)0	0(10)0	0(10)0	Missing
	5	0(10)0	0(10)0	0(10)0	0(10)0	0(10)0	10
	6	0(10)0	0(10)0	0(6)0	0(6)0	0(9)	10
62	1			10			
	2			10			
	3			10			
	4			8			
	5			10			
	6			Not recovered			

Table 8 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
63	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
64	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
66	1			10			10
	2			10			Missing
	3			10			10
	4			10			Missing
	5			10			10
	6			10			Missing
73	1	9(10)	9(10)	9(10)	9(10)	9(10)	
	2	0(10)	5(10)	9(10)	9(10)	9(10)	
	3	9(10)	8(10)	8(10)	9(10)	9(10)	
74	1	5(10)	2(10)	9(10)	9(10)	9(10)	10
	2	4(10)	3(10)	8(10)	8(10)	8(10)	10
	3	3(10)	2(10)	9(10)	8(10)	8(10)	10
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	9(10)	9(10)	10(10)	10(10)	10(10)	
	3	10(10)	10(10)	10(10)	10(10)	10(10)	
76	1	5(10)	4(10)	10(10)	2(10)	5(10)	10
	2	10(10)	6(10)	10(10)	10(10)	10(10)	10
	3	5(10)	3(10)	10(10)	5(10)	5(10)	10
77	1	6(10)	6(10)	10(10)	10(10)	10(10)	
	2	10(10)	6(10)	10(10)	9(10)	8(10)	
	3	5(10)	6(10)	10(10)	8(10)	6(10)	

Table 8 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
78	1	3(10)	2(10)	10(10)	9(10)	10(4)	Missing
	2	0(10)	2(10)	9(10)	9(10)	8(10)	10
	3	2(10)	2(10)	10(10)	5(10)	8(10)	10
79	1	9(10)	9(10)	6+(10)	6+(10)	9(10)	
	2	5(10)	6(10)	10(10)	9(10)	10(10)	
	3	5(10)	5(10)	9(10)	8(10)	6+(10)	
80	1	4(10)	4(10)	10(10)	10(10)	10(10)	10
	2	2(10)	2(10)	10(10)	9(10)	10(10)	10
	3	4(10)	3(10)	6+(10)	8(10)	8(10)	10
81	1	5(10)	9(10)	9(10)	10(10)	9(10)	
	2	4(10)	5(10)	10(10)	10(10)	10(10)	
	3	5(10)	5(10)	8(10)	8(10)	6+(10)	
82	1	3(10)	3(10)	9(10)	10(10)	9(10)	10
	2	2(10)	3(10)	8(10)	9(10)	8(10)	10
	3	4(10)	2(10)	8(10)	8(10)	8(10)	10
83	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	10(10)	10(10)	10(10)	10(10)	10(10)	
	3	10(10)	10(10)	10(10)	10(10)	10(10)	
84	1	10(10)	6(10)	10(10)	4(10)	9(10)	10
	2	7(10)	5(10)	10(10)	10(10)	10(10)	10
	3	7(5)	6(10)	10(10)	10(10)	7(10)	10
85	1	9(10)	6(10)	10(10)	10(10)	10(10)	
	2	5(10)	7(10)	10(10)	9(10)	9(10)	
	3	Not recovered					
86	1	5(9)	4(4)	10(9)	9(9)	10(9)	10
	2	4(5)	5(1)	10(5)	8(5)	10(3)	10
	3	2(6+)	2(4)	8(6)	8(6)	9(6)	10
87	1	7(10)	7(10)	6(10)	9(10)	9(10)	
	2	8(10)	8(10)	8(10)	8(10)	8(10)	
	3	6(10)	7(10)	8(10)	8(10)	8(10)	
88	1	5(10)	3(10)	9(10)	8(10)	8(10)	10
	2	4(10)	2(10)	8(10)	8(10)	8(10)	10
	3	3(10)	2(10)	7(10)	8(10)	8(10)	8

Table 8 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
89	1	9	9	9	9	9	
	2	9	9	9	9	9	
90	1	9	9	9	9	9	10
	2	9	9	9	9	9	Missing
91	1	2(2)	0(0)	5(5)	6(6)	6(6)	
	2	1(1)	1(1)	5(5)	5(5)	5(5)	
93	1	8(7)	7(7)	8(7)	6(6)	8(7)	
	2	6(6)	6(6)	8(7)	6+(6+)	6(6)	
95	1	10	10	10	10	10	
96	1	6+	5	8	7	7	10
97	1	10	10	10	10	10	
98	1	6	6+	10	10	10	10
99	1	10(10)	10(10)	10(10)	10(10)	10(10)	
100	1	6(10)	6+(10)	10(10)	10(10)	10(10)	10
101	1	Not recovered					
102	1	7(10)	5(10)	8(10)	8(10)	8(10)	10
103	1	9	9	10	9	9	
104	1	8	9	9	9	9	
105	1	10	10	10	10	10	

Table 9. Performance of Shields in Cable Specimens Buried Up to Six Years in Tidal Marsh (Site G)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
56	1	10	10	10	10	10	
	2	0	10(2)	10(0)	10(0)	10(5)	
	3	10(5)	10(2)	10(5)	10(5)	10(5)	
	4	0(0)	1(0)	10(0)	10(0)	10(0)	
	5	10(0)	10(1)	10(0)	10(0)	10(0)	
	6	0(0)	10(1)	10(0)	5(0)	5(1)	
57	1	9(2)	9(3)	10(5)	9(3)	9(3)	9
	2	0	5(0)	5(0)	4(5)	10(0)	9
	3	0	9(4)	9(5)	5	10(3)	Missing
	4	0	0(4)	0	0	0	Missing
	5	0(0)	2(2)	10(0)	10(2)	10(2)	Missing
	6	0(0)	0(0)	5(0)	3(0)	3(0)	3
58	1	6(0)	6(0)	5(0)	5(0)	6(0)	
	2	9(0)	5(0)	5(0)	6+(0)	5(0)	
	3	9(0)	9(0)	5(0)	6(0)	6+(0)	
	4	6(0)	5(0)	5(0)	5(0)	5(0)	
	5	6(0)	9(0)	8(0)	9(0)	9(0)	
	6	5(0)	6+(0)	6+(0)	6(0)	9(0)	
59	1	9(0)	6+(1)	9(0)	6(0)	10(1)	9
	2	6(0)	6(0)	5(0)	5(0)	6(0)	9
	3	5(0)	9(0)	5(0)	6(0)	6(0)	9
	4	2(0)	6(0)	5(0)	6(0)	0(0)	9
	5	6(0)	5(0)	6(0)	6(0)	6(0)	9
	6	6(0)	4(0)	5(0)	5(0)	5(0)	9
60	1	0(6)0	2(8)5	1(5)0	0(6)0	1(6+)7	
	2	0(10)0	0(6)0	0(5)0	0(9)0	0(6)0	
	3	0(8)0	0(9)0	0(6)0	0(6)0	0(8)0	
	4	0(9)0	0(8)0	0(5)0	0(9)0	0(8)0	
	5	Not recovered					
	6	0(5)0	0(9)0	0(5)0	0(6)0	0(9)0	
61	1	0(5)0	1(8)4	0(5)3	0(5)0	0(6+)0	9
	2	0(5)0	0(6+)0	0(5)0	0(9)0	0(9)0	9
	3	0(6+)0	0(6+)0	0(6)0	0(6)0	0(9)0	9
	4	0(4)0	0(6)0	0(5)0	0(8)0	0(9)0	9
	5	0(4)0	0(8)0	0(6+)0	0(9)0	0(6)0	9
	6	0(6)0	0(8)0	0(5)0	0(6)0	0(5)0	9

Table 9 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
62	1			6+			
	2			5			
	3			10			
	4			5			
	5			10			
	6			7			
63	1			10			
	2			5			
	3			10			
	4			5			
	5			5			
	6			10			
64	1			10			
	2			10			
	3			10			
	4			5			
	5			5			
	6			6			
65	1			10			
	2			10			
	3			10			
	4			10			
	5			10			
	6			10			
73	1	9(10)	9(10)	10(10)	9(10)	9(10)	
	2	0(10)	1(10)	9(10)	8(10)	8(10)	
	3	0(7)	0(0)	8(10)	0(10)	0(1)	
74	1	0(10)	1(5)	9(9)	9(9)	3(5)	10
	2	0(0)	0(0)	8(0)	2(0)	0(0)	10
	3	0(0)	0(0)	8(0)	2(0)	0(0)	9
75	1	10(10)	10(10)	10(10)	10(10)	10(10)	
	2	1(10)	5(10)	10(10)	5(10)	5(10)	
	3	5(10)	1(10)	10(10)	8(10)	2(10)	
76	1	1(10)	10(10)	10(10)	10(10)	10(10)	10
	2	0(10)	0(10)	5(10)	0(10)	4(10)	10
	3	2(10)	0(10)	0(10)	4(10)	2(10)	10
77	1	4(10)	1(10)	10(10)	10(10)	10(10)	
	2	0(10)	0(10)	10(10)	3(10)	0(10)	
	3	0(0)	0(10)	9(10)	2(5)	0(10)	

Table 9 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
78	1	10(2)	10(0)	10(4)	9(0)	10(0)	10
	2	0(0)	0(0)	8(4)	8(0)	3(0)	10
	3	0(0)	0(0)	6(2)	1(0)	2(0)	9
79	1	5(10)	1(2)	9(10)	9(10)	9(10)	
	2	1(3)	2(3)	8(10)	8(10)	8(10)	
	3	0(0)	0(0)	8(0)	5(0)	8(1)	
80	1	0(0)	1(1)	10(10)	6(10)	10(10)	10
	2	Destroyed					10
	3	Destroyed					9
81	1	5(10)	5(10)	10(10)	10(10)	10(10)	
	2	4(10)	5(10)	10(10)	8(10)	10(10)	
	3	0(0)	0(0)	5(5)	4(2)	4(0)	
82	1	1(10)	1(10)	9(10)	9(10)	9(10)	10
	2	Destroyed					10
	3	Destroyed					9
83	1	2(10)	5(10)	10(10)	10(10)	10(10)	
	2	5(3)	5(3)	10(10)	8(8)	4(8)	
	3	1(10)	5(10)	10(10)	5(10)	7(10)	
84	1	7(10)	5(6)	10(10)	10(10)	10(10)	9
	2	0(10)	0(10)	9(10)	2(10)	2(10)	Missing
	3	0(0)	0(0)	10(0)	3(2)	3(0)	8
85	1	5(10)	4(1)	10(10)	10(10)	10(10)	
	2	Destroyed					
	3	Destroyed					
86	1	0(0)	0(1)	9(5)	9(3)	9(2)	10
	2	Destroyed					10
	3	Destroyed					9
87	1	6(10)	3(10)	8(10)	8(10)	8(10)	
	2	0(4)	0(3)	8(5)	8(5)	8(5)	
	3	Destroyed					
88	1	0(0)	0(0)	8(8)	8(4)	8(4)	9
	2	Destroyed					9
	3	Destroyed					9
89	1	9	9	9	9	9	
	2	9	9	9	9	9	

Table 9 (continued)

System	Exposure Time (years)	Exposed Window	Exposed Ring	Under Jacket	1/2 Inch Window	1/2 Inch Ring	Copper Cathode
90	1	9	9	9	9	9	9
	2	9	9	9	9	9	9
91	1	Destroyed					
	2	Destroyed					
92	1	Destroyed					
	2	Destroyed					
95	1	0	0	7	3	7	
96	1	Destroyed					
97	1	1	3	10	10	10	
98	1	0	0	10	2	0	9
99	1	4(10)	6(10)	10(10)	10(10)	10(10)	
100	1	5(10)	5(10)	10(10)	10(10)	10(10)	9
101	1	4(10)	5(10)	6(10)	6(10)	5(10)	
102	1	0(10)	4(10)	5(10)	4(10)	5(10)	9

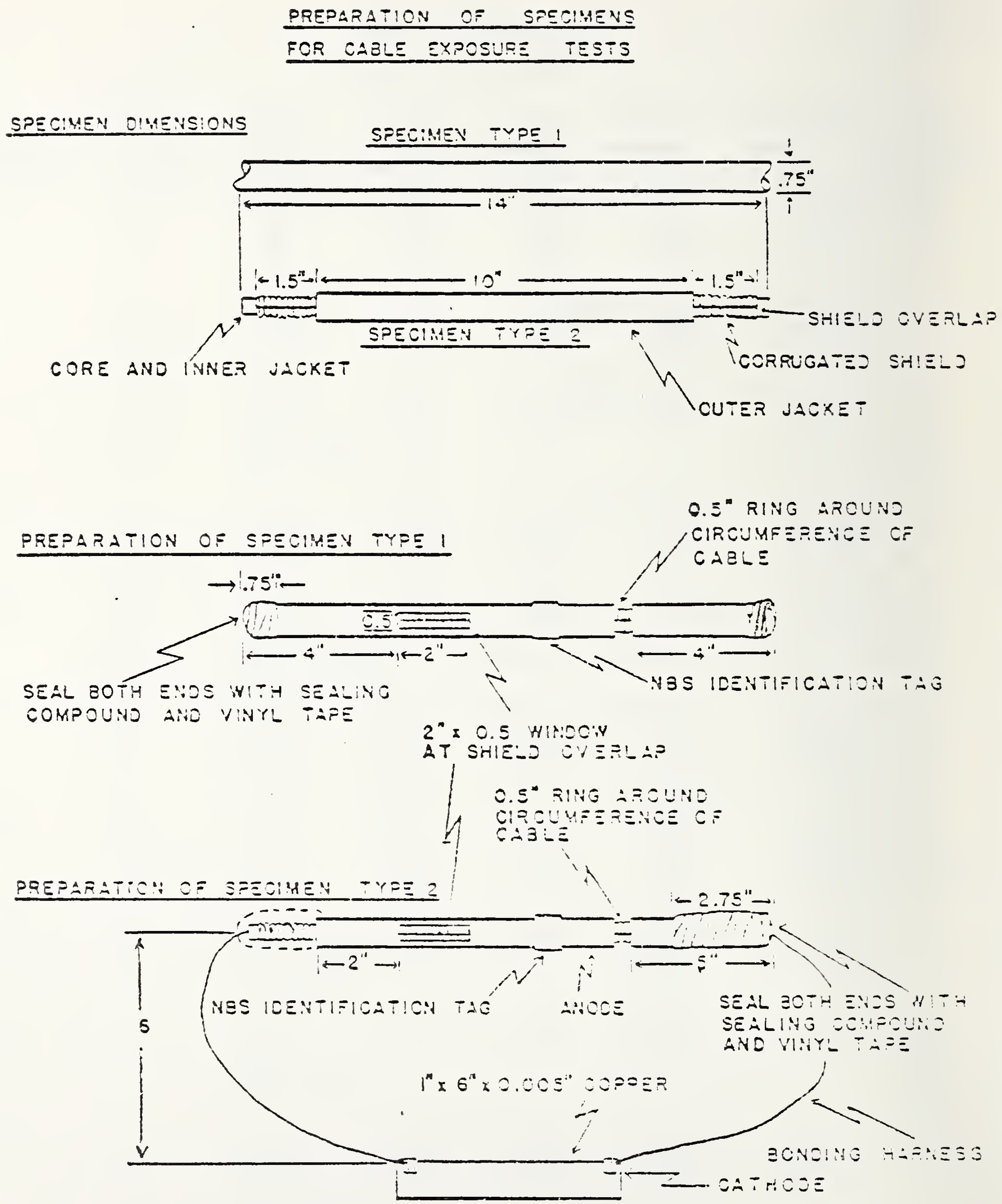

Figure 1 Preparation of specimens for cable exposure tests

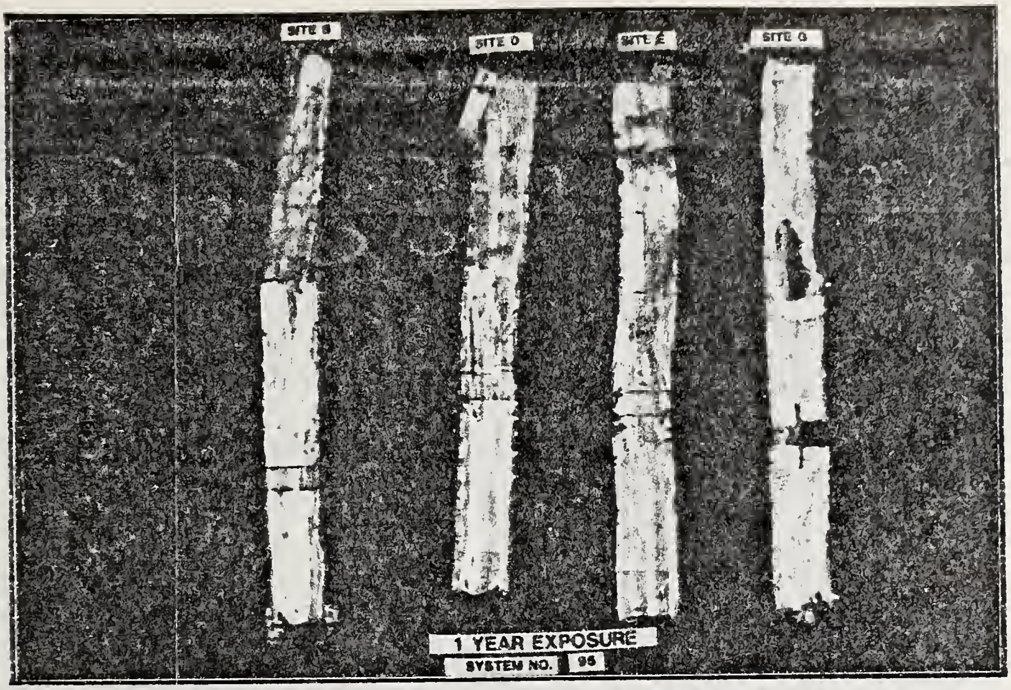

Figure 2. Outer Shield; System 95, Sites B,D,E, and G, left to right, exposed for one year. Severe corrosion at the window and ring areas on the specimen from Site G.

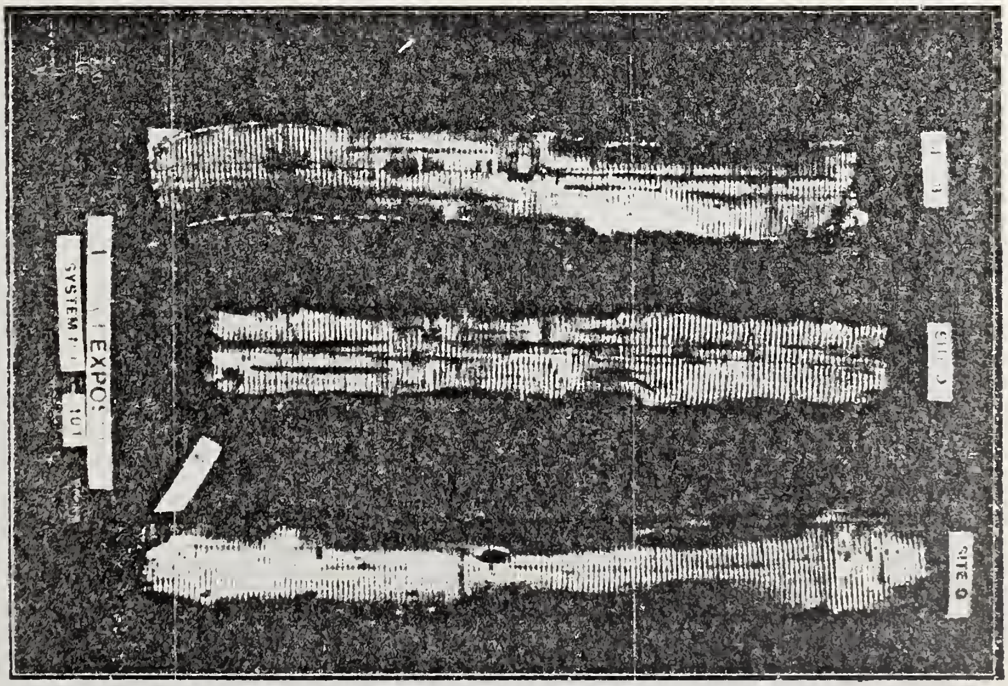

Figure 3. Outer Shield; System 101, Sites B,D, and G, top to bottom, exposed for one year. Dark areas indicate corrosion at the window and ring areas on the specimen from Site G.

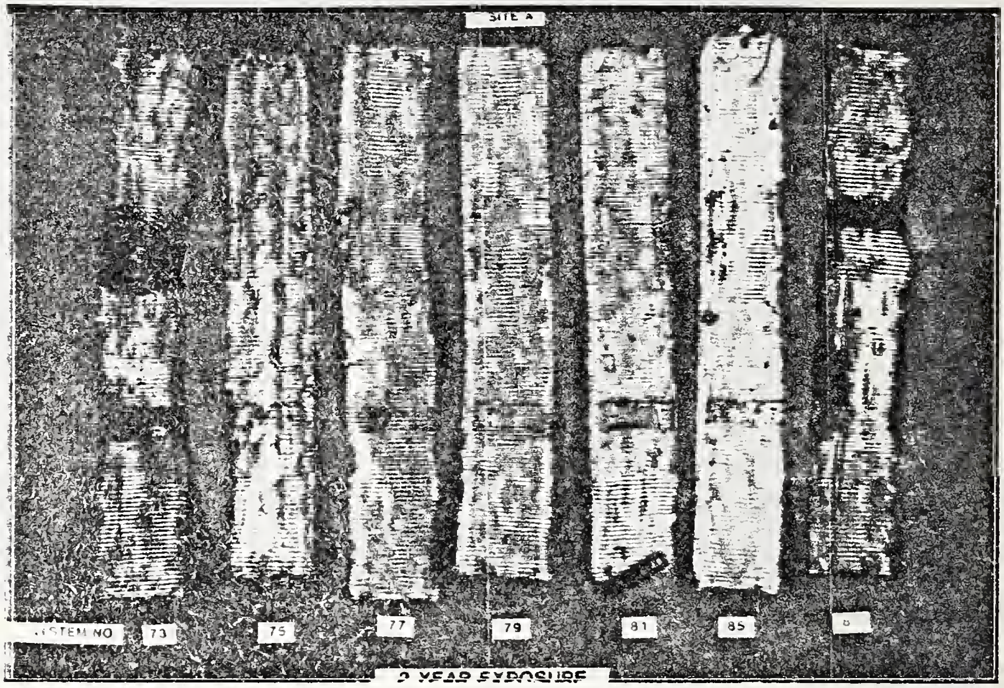

Figure 4. Outer Shield; Systems 73,75,77,79,81,85, and 87, left to right. Exposed at Site A for two years. Dark areas on specimens indicate corrosion.

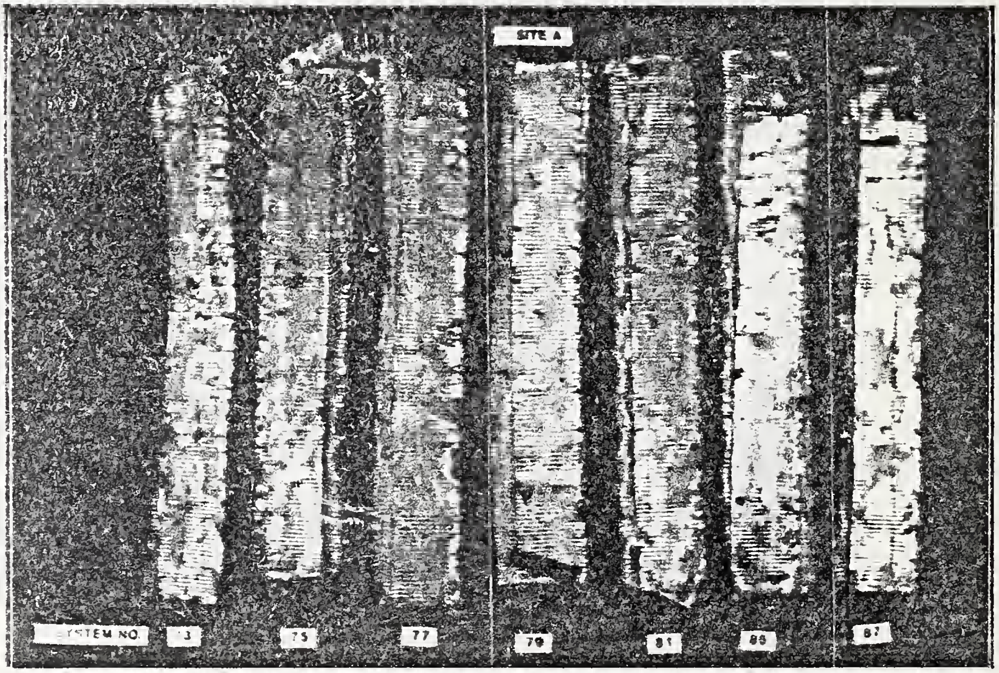

Figure 5. Inner Shield; Systems 73,75,77,79,81,85, and 87, left to right. Exposed at Site A for two years. Corrosion was not apparent.

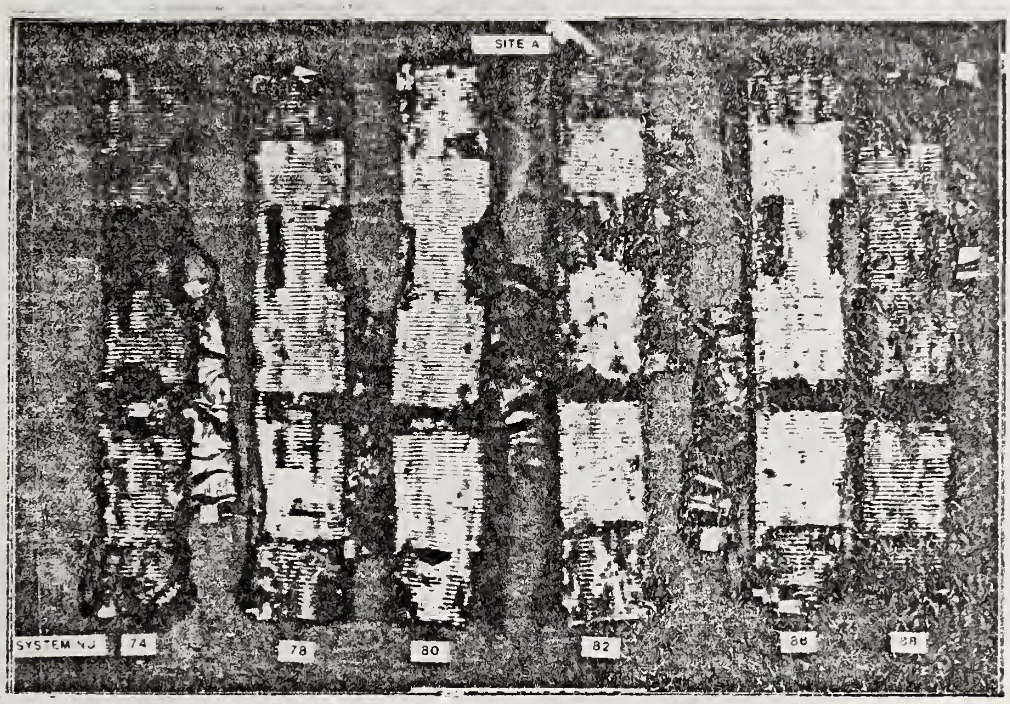

Figure 6. Outer Shield; Systems 74,78,80,82,86, and 88, left to right, exposed at Site A for two years. Dark areas on specimens indicate corrosion. Coupling this system to copper accelerated corrosion.

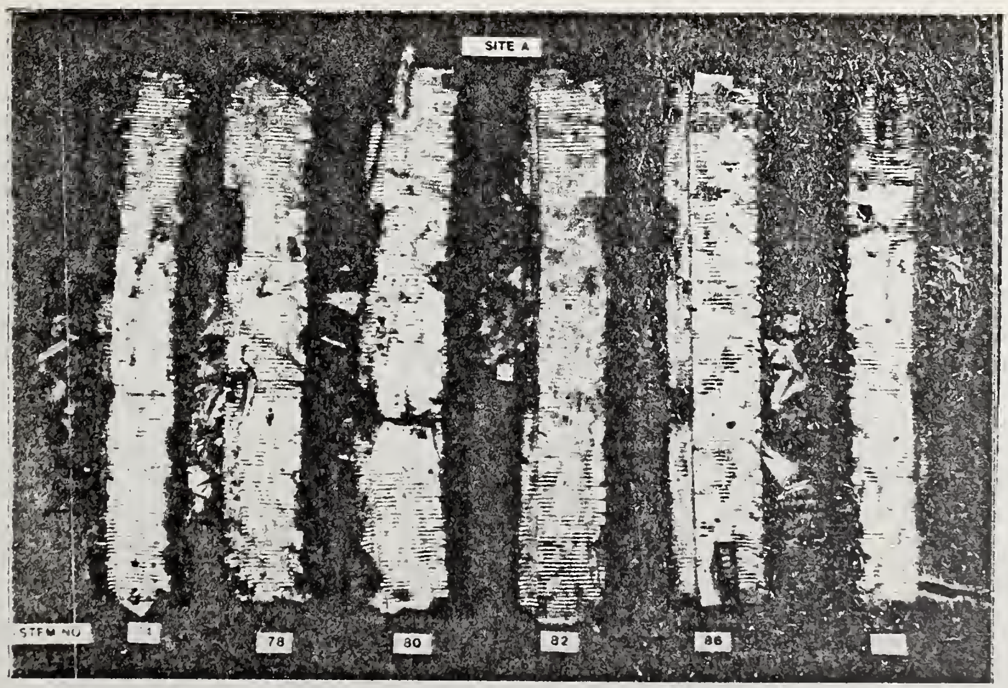

Figure 7. Inner Shield; Systems 74,78,80,82,86, and 88, left to right, exposed at Site A for two years. Degradation on System 80 and 82 at the window and ring areas.

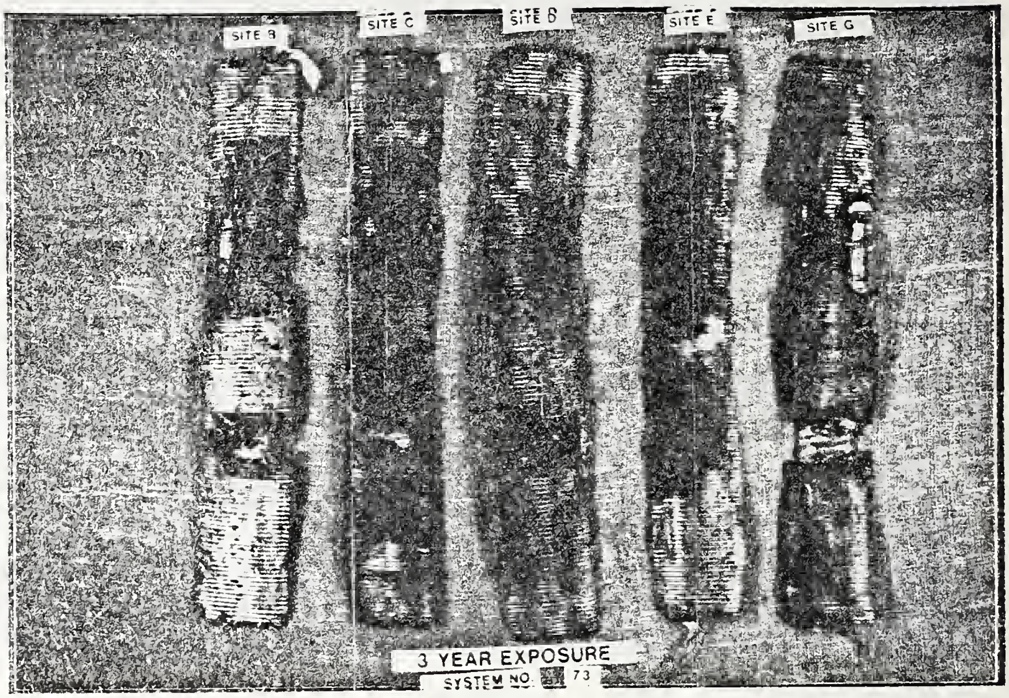

Figure 8. Outer Shield; System 73, Sites B,C,D,E, and G, left to right, exposed for three years. Specimens from Sites B,C, and G are perforated at the window and or ring areas.

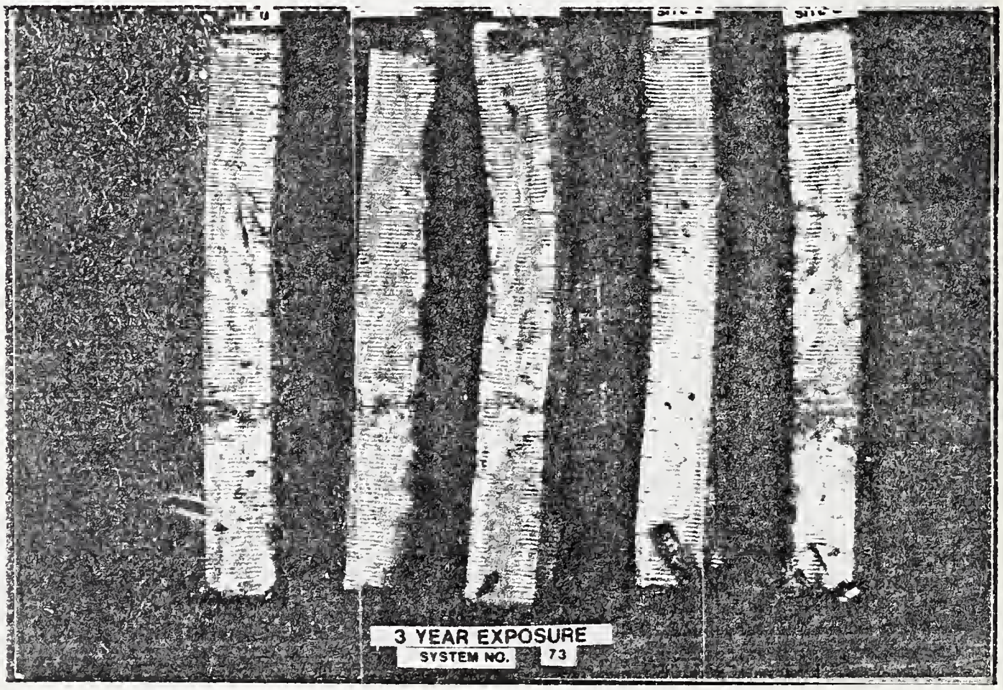

Figure 9. Inner Shield; System 73, Sites B,C,D,E, and G, left to right, exposed for three years. Severe degradation of the window and ring areas of the specimen from Site G.

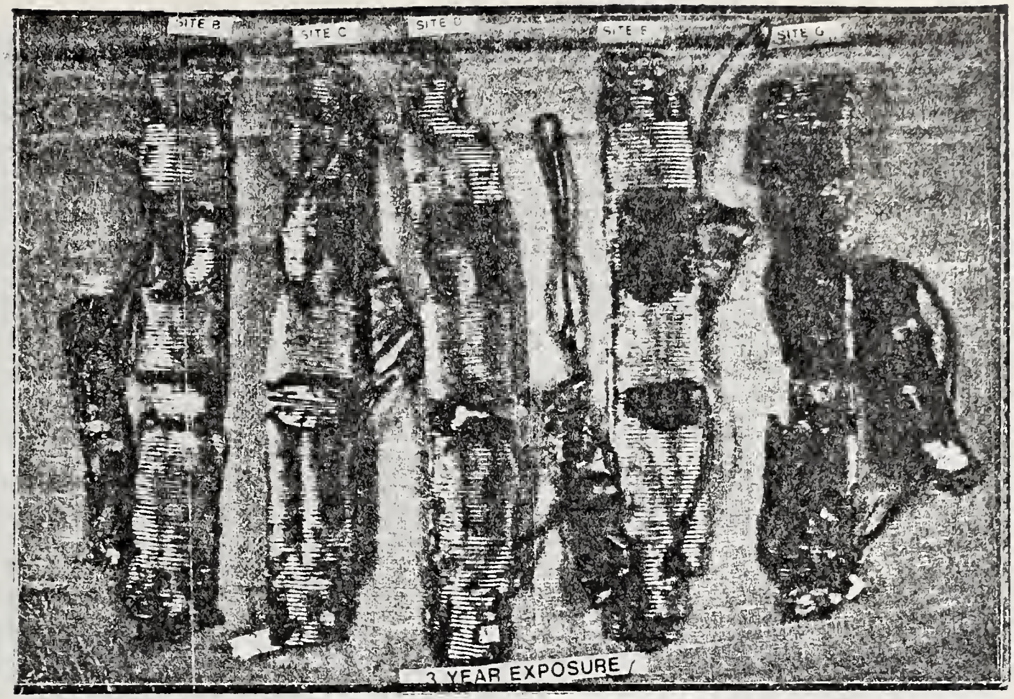

Figure 10. Outer Shield; System 74, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion on all specimens.

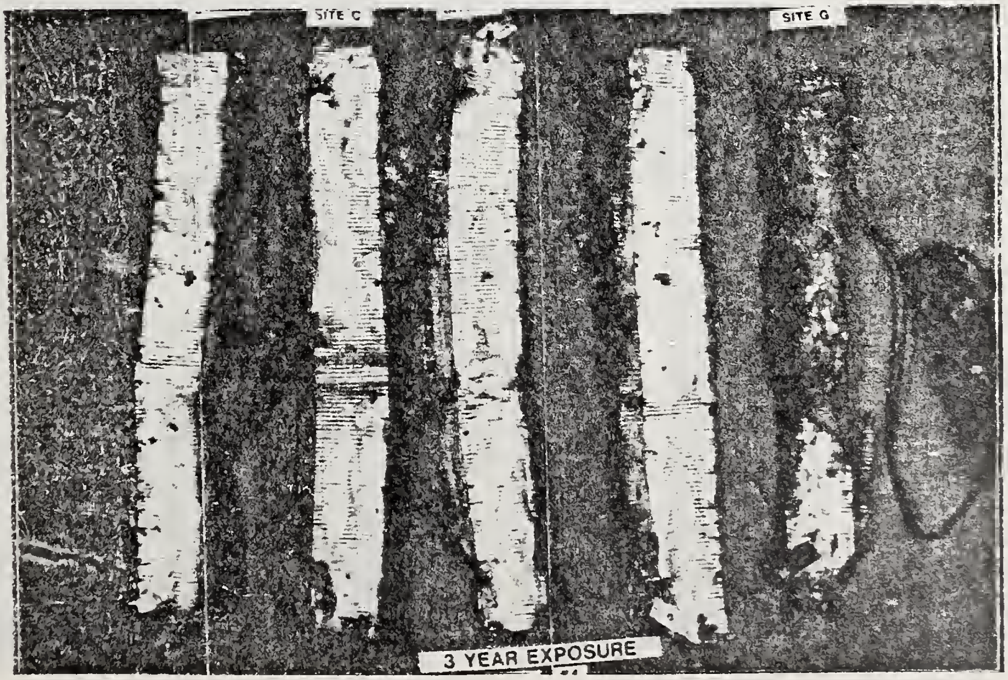

Figure 11. Inner Shield; System 74, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion on the specimen from Site G.

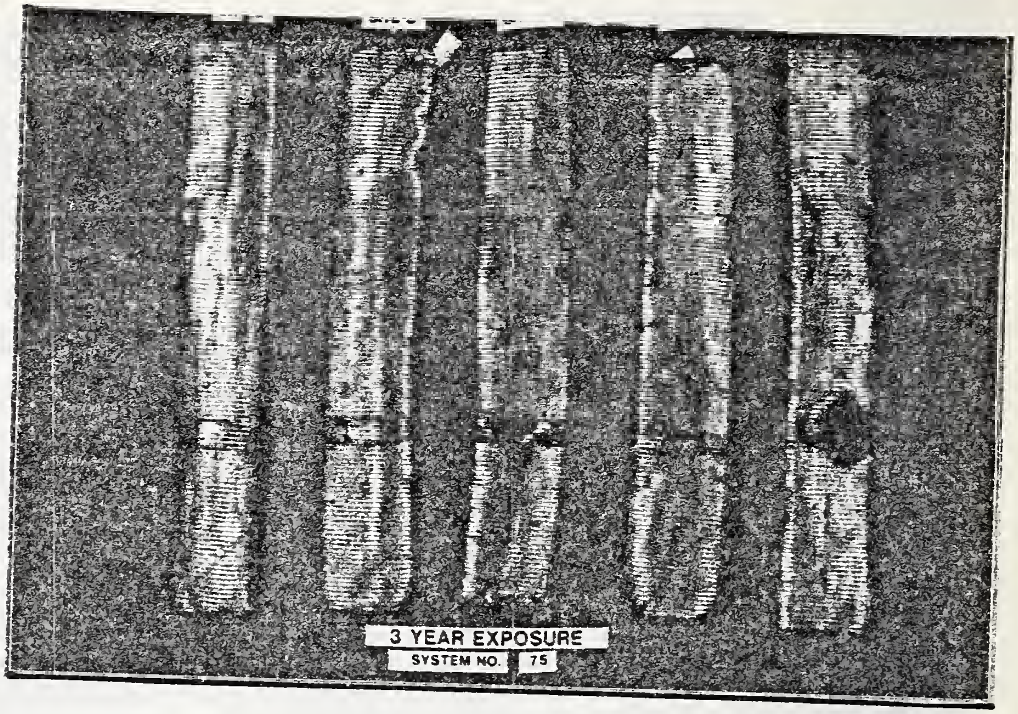

Figure 12. Outer Shield; System 75, Sites B,C,D,E, and G, left to right, exposed for three years. Dark areas indicate corrosion on the specimens.

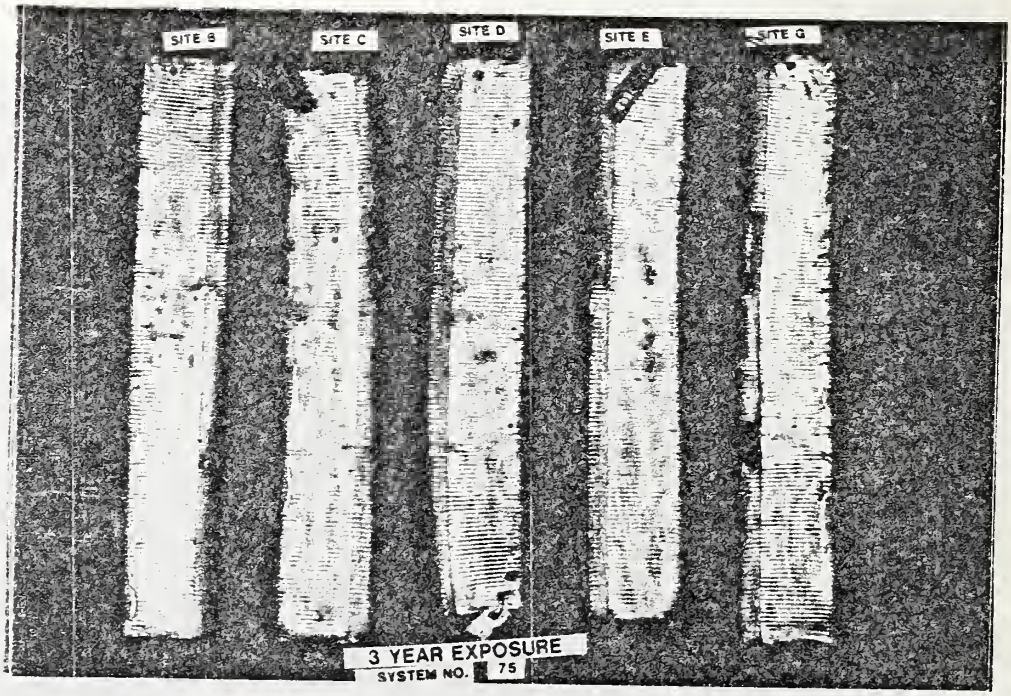

Figure 13. Inner Shield; System 75, Sites B,C,D,E, and G, left to right, exposed for three years. Corrosion was not apparent.

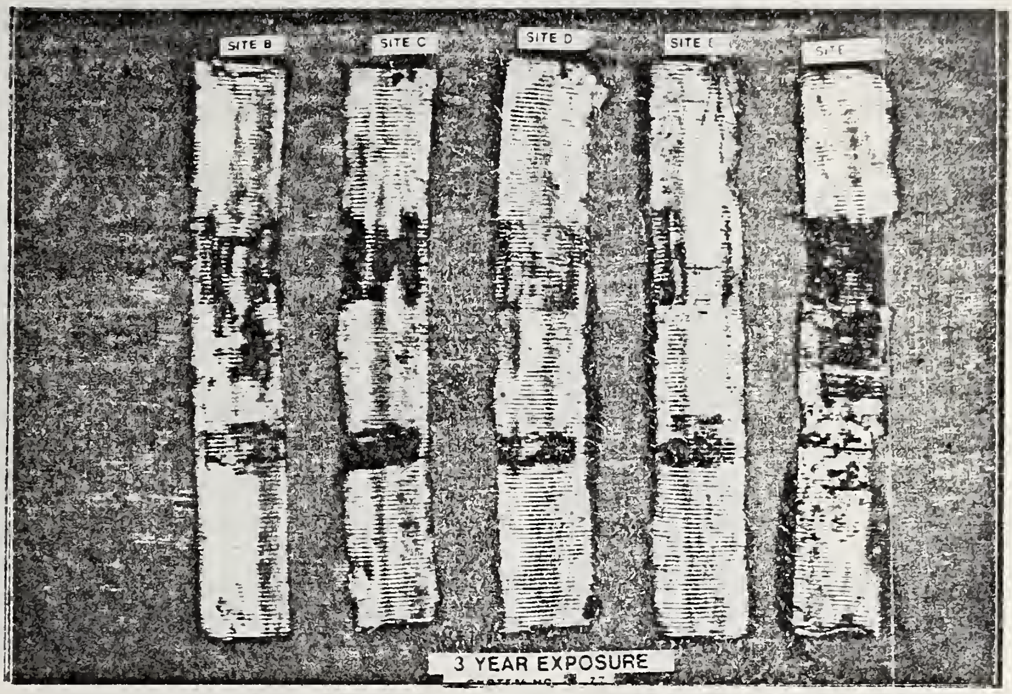

Figure 14. Outer Shield; System 77, Sites B,C.D,E, and G, left to right, exposed for three years. Severe corrosion at the window and ring areas of the specimen from Site G.

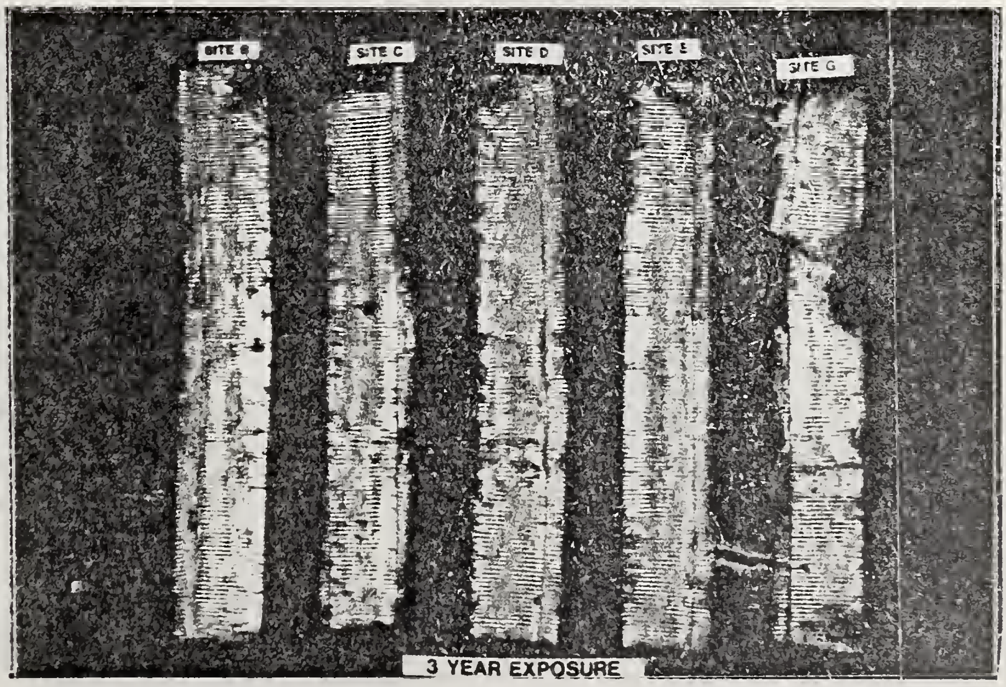

Figure 15. Inner Shield; System 77, Sites B,C,D,E, and G, left to right, exposed for three years. Degradation at the window area of the specimen from Site G.

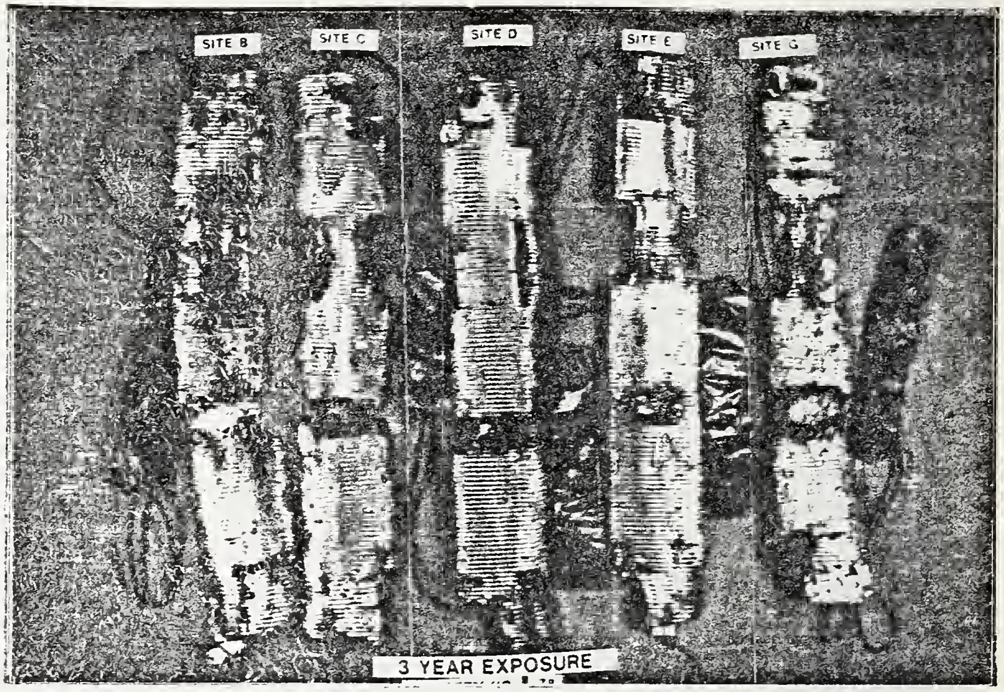

Figure 16. Outer Shield; System 78, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion at the window and ring areas on all specimens.

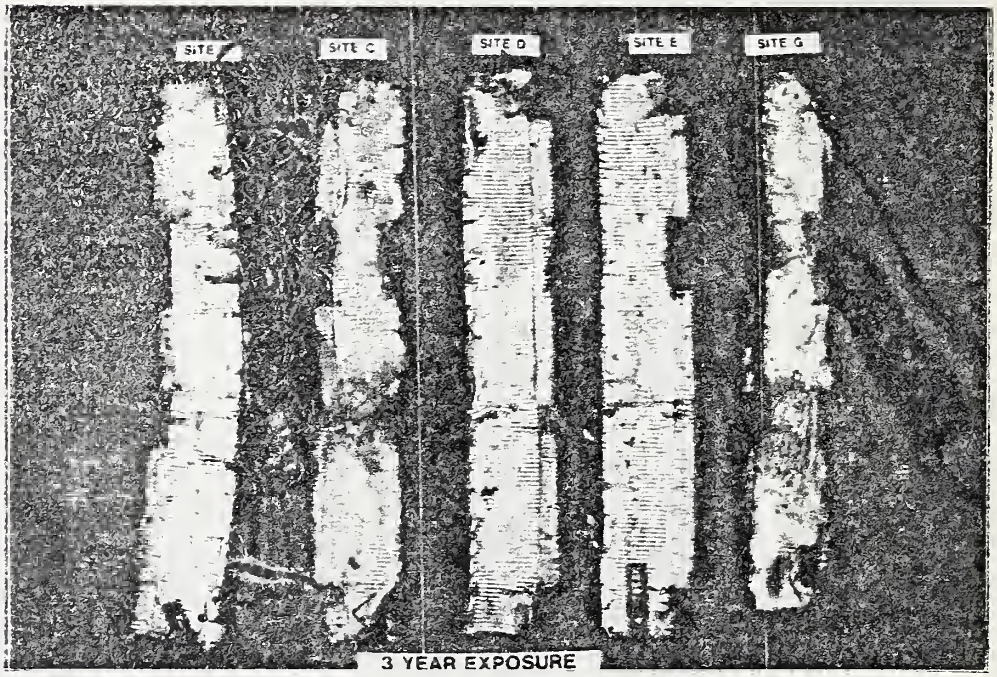

Figure 17. Inner Shield; System 78, Sites B,C.D.E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion at Sites C and G.

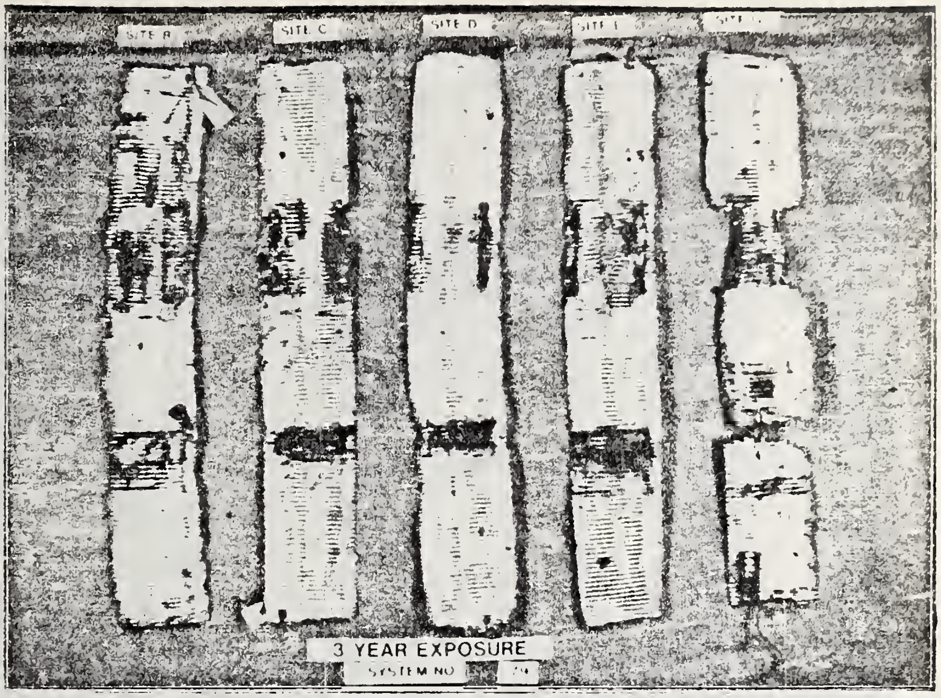

Figure 18. Outer Shield; System 79, Sites B,C,D,E, and G, left to right, exposed for three years. Dark areas indicate corrosion on specimens with severe corrosion on the specimen from Site G at window and ring areas.

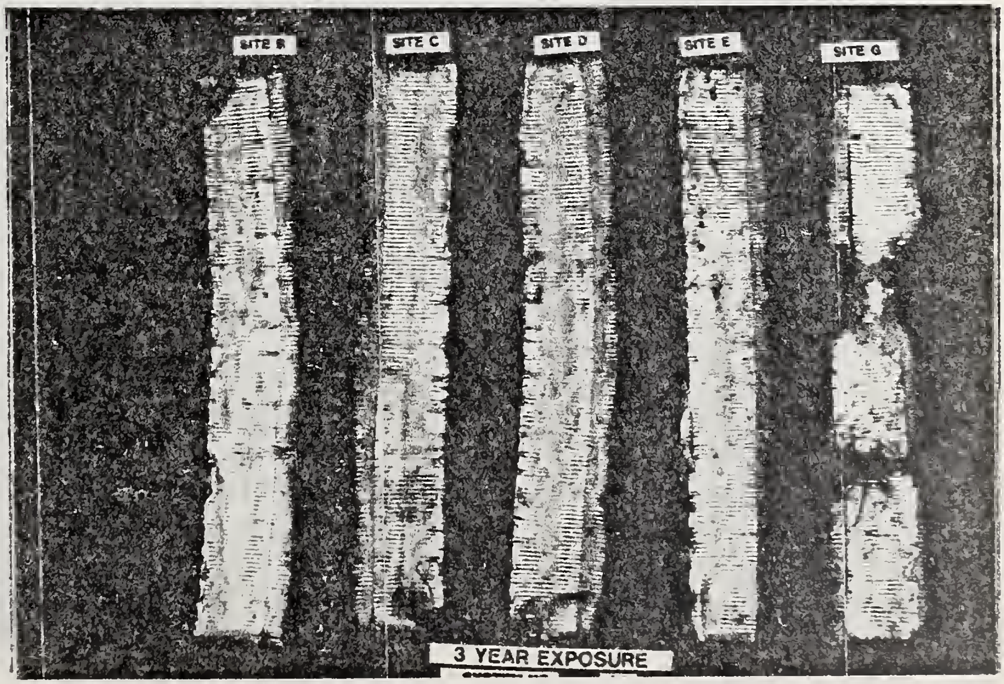

Figure 19. Inner Shield; System 79, Sites B,C,D,E, and G, left to right, exposed for three years. Severe degradation at the window and ring areas on the specimen from Site G.

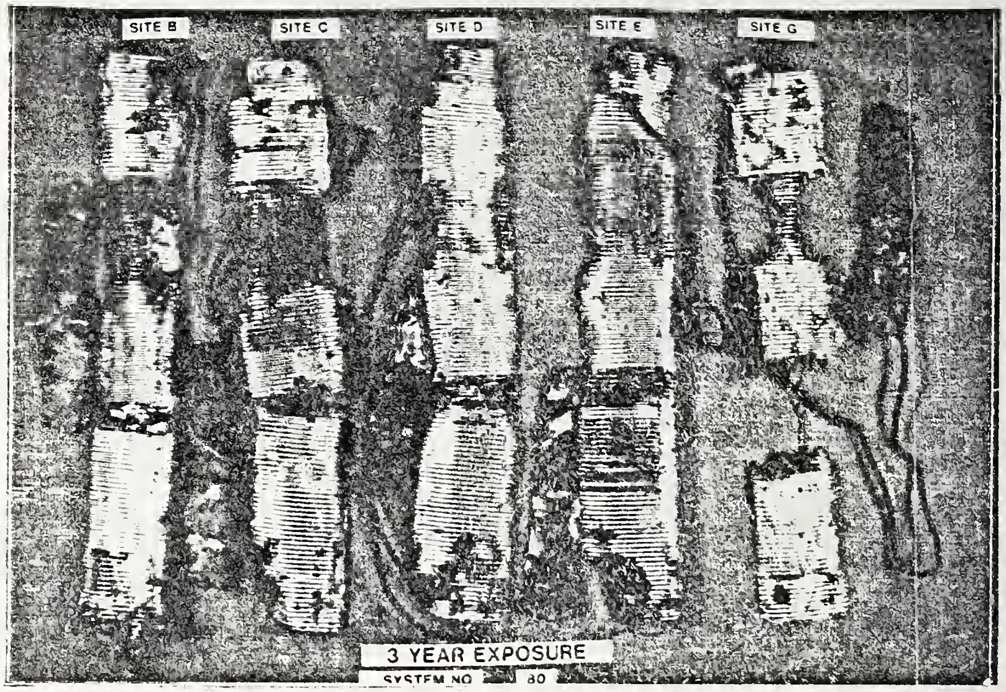

Figure 20. Outer Shield; System 80, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion at the window and ring areas on all specimens.

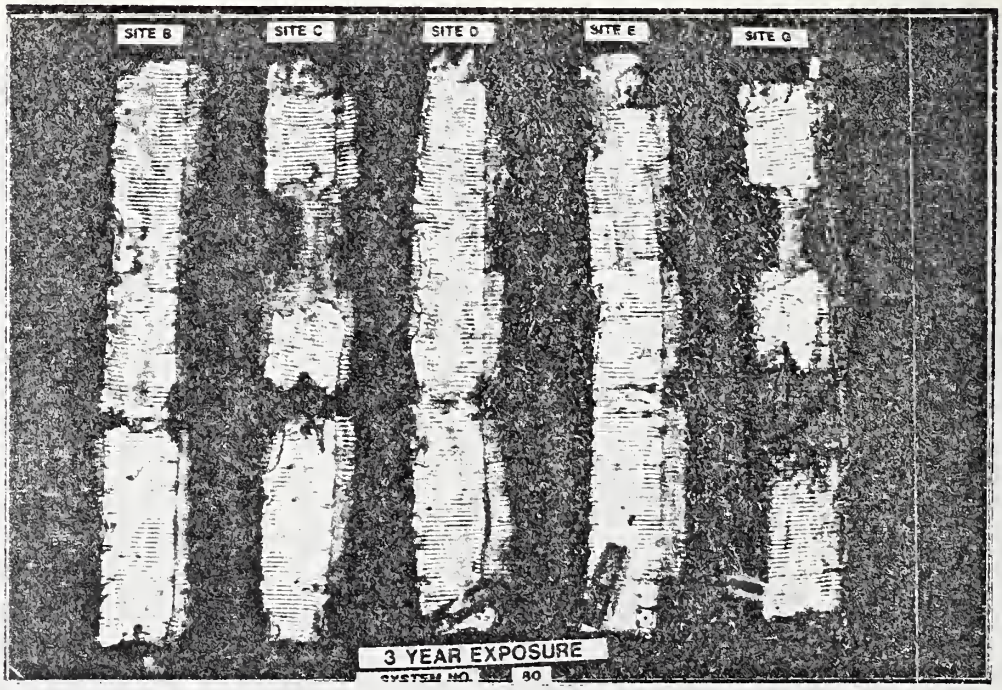

Figure 21. Inner Shield; System 80, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated degradation at the window and ring areas on specimens from Sites B,C, and G.

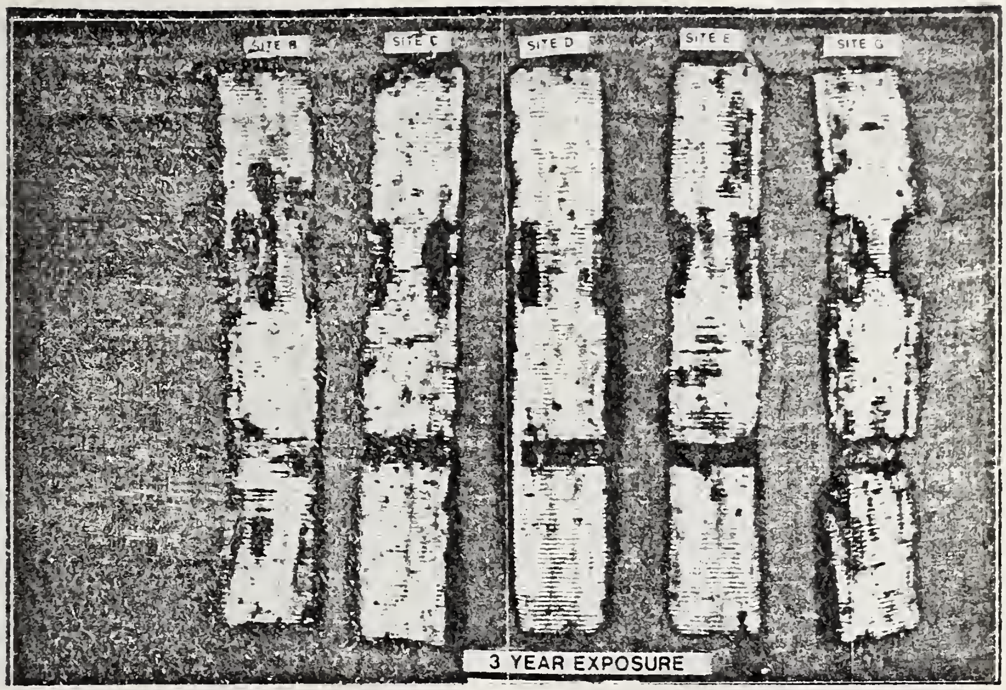

Figure 22. Outer Shield; System 81, Sites B,C,D,E, and G, left to right, exposed for three years. Dark areas indicate corrosion on specimens with severe corrosion at the window and ring areas on the specimen from Site G.

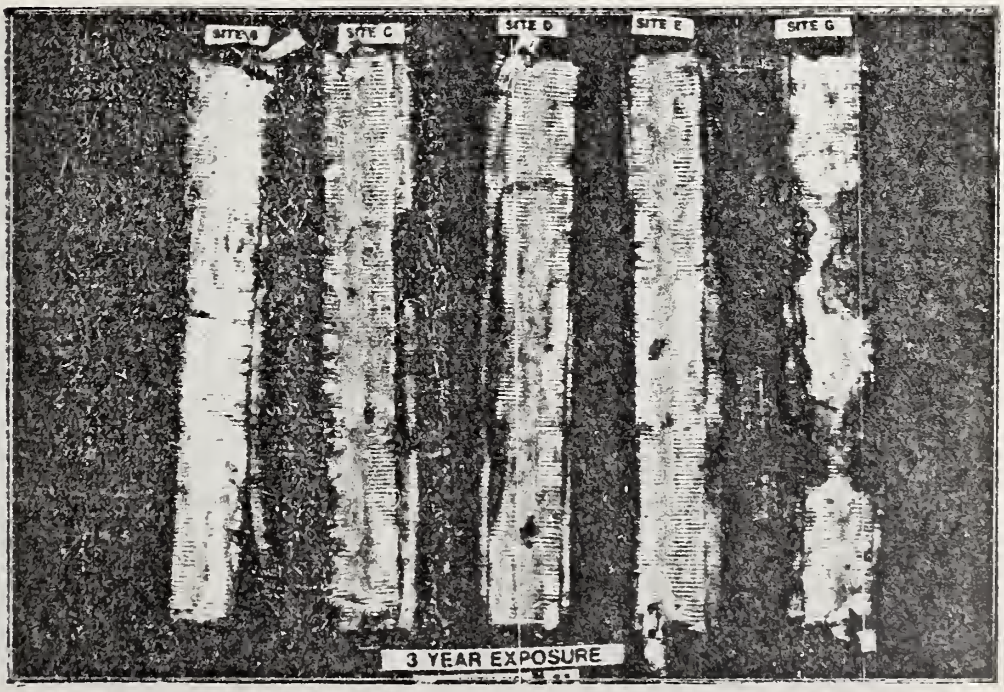

Figure 23. Inner Shield; System 81, Sites B,C,D,E, and G, left to right, exposed for three years. Severe degradation on the specimen from Site G.

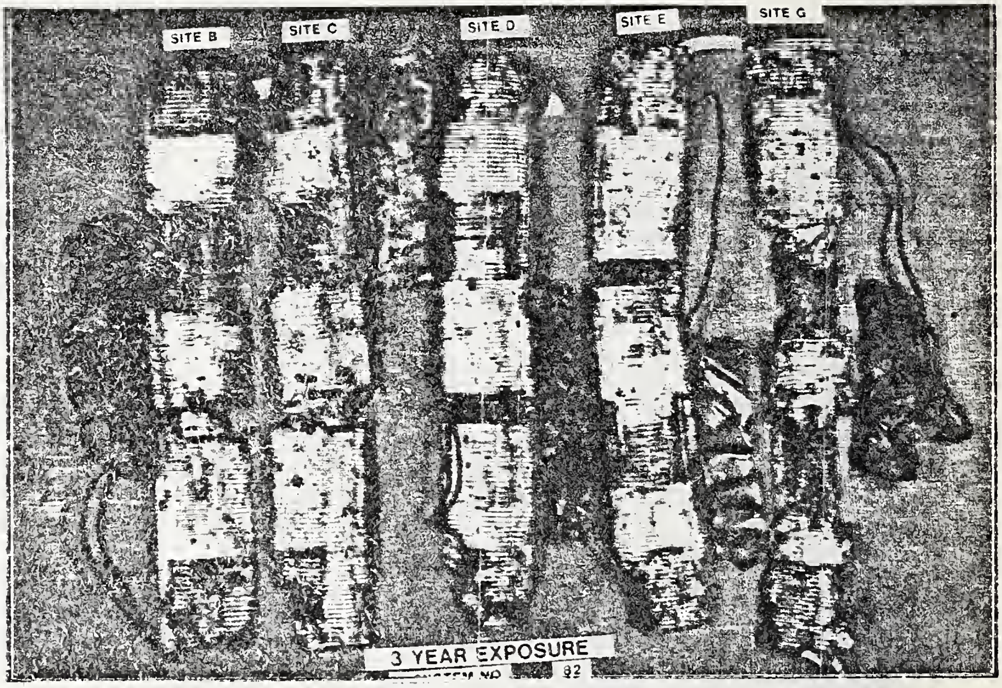

Figure 24. Outer Shield; System 82, Sites B,C,D,E,and G, left to right, exposed for three years.Coupling this system to copper accelerated corrosion on the specimens from Sites C and G severely.

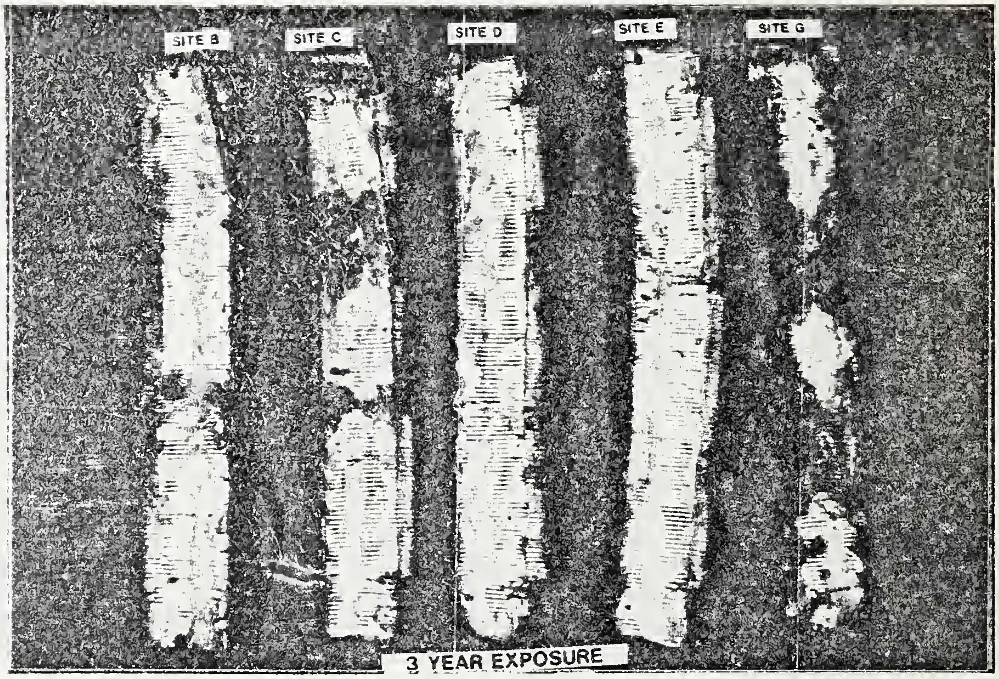

Figure 25. Inner Shield; System 82, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion on the specimens from Sites B,C, and G.

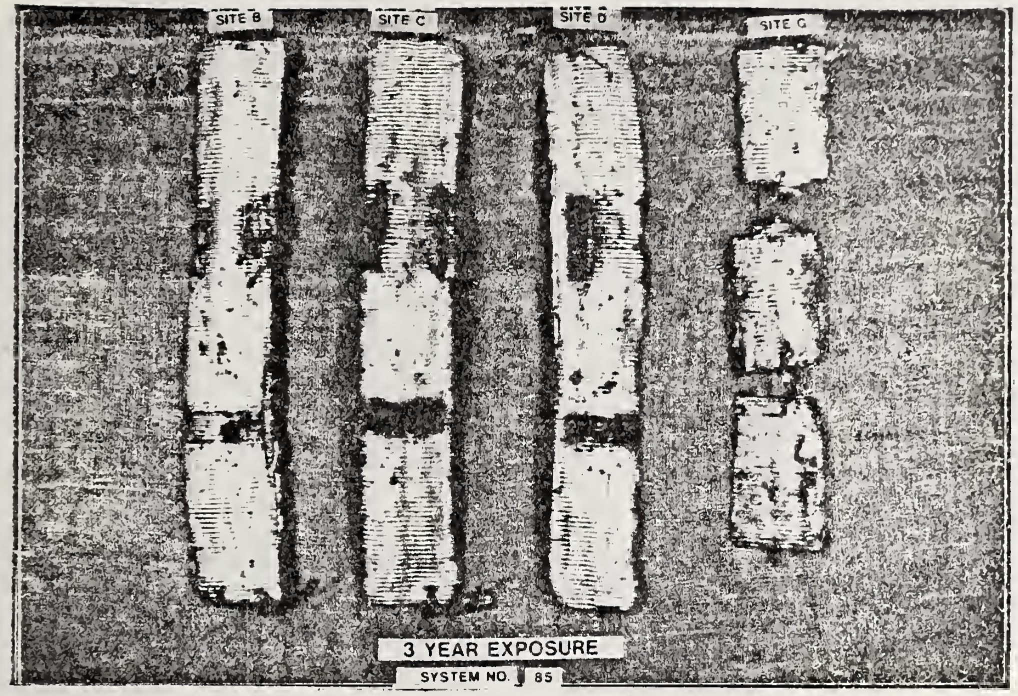

Figure 26. Outer Shield; System 85, Sites B,C,D, and G, left to right, exposed for three years. Dark areas indicate corrosion on the specimens with severe corrosion on the specimen from Site G at the window and ring areas.

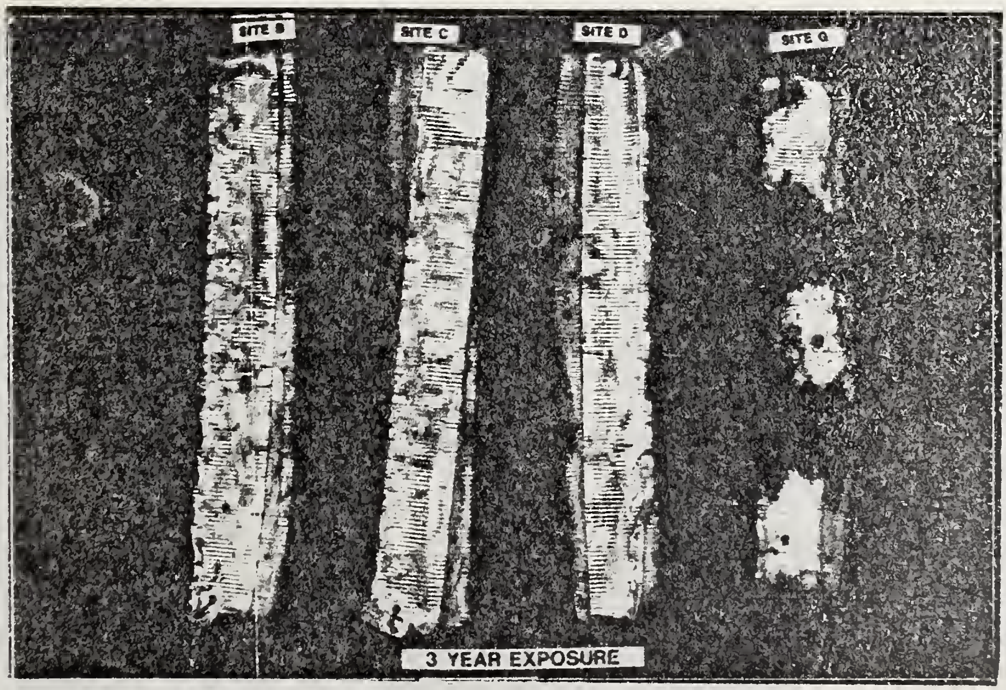

Figure 27. Inner Shield; System 85, Sites B,C,D, and G, left to right, exposed for three years. The specimen from Site G was severely corroded.

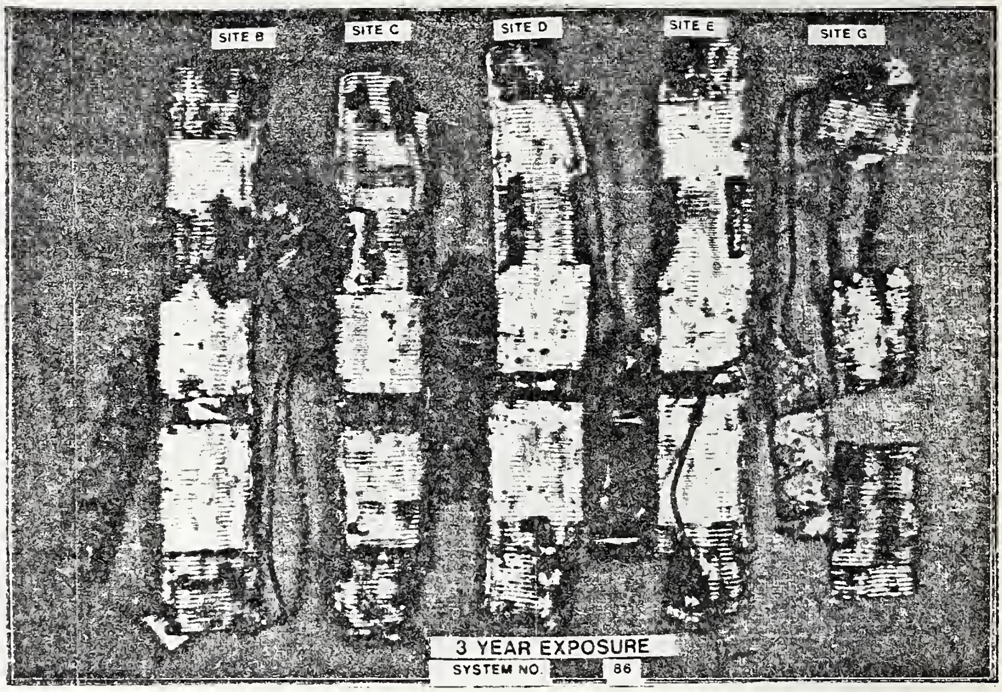

Figure 28. Outer Shield; System 86, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion at most examined areas on all specimens.

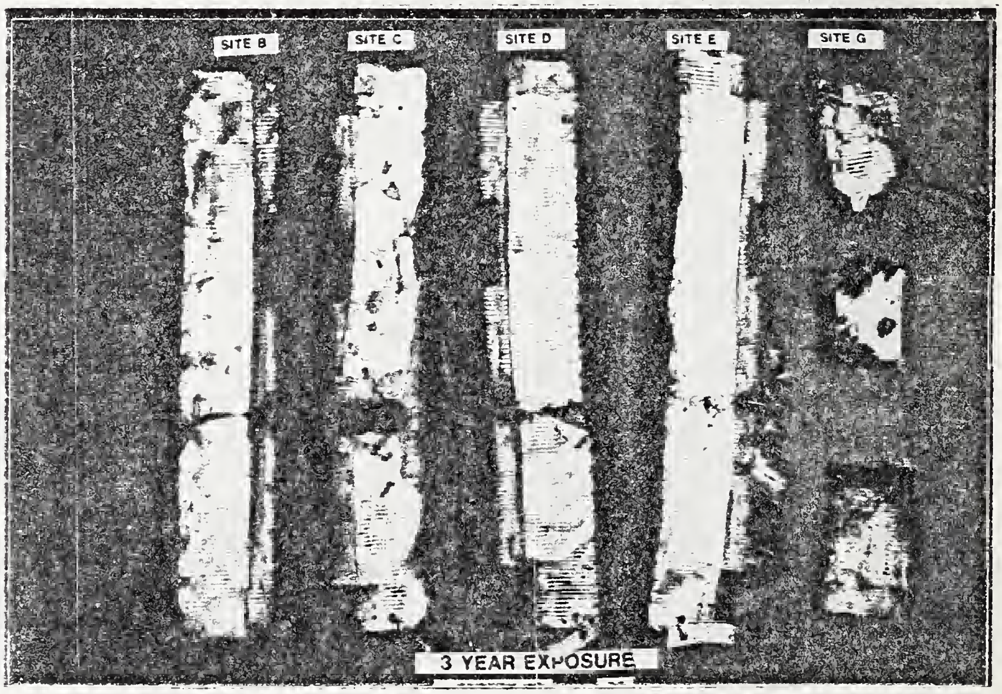

Figure 29. Inner Shield; System 86, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated degradation on most specimens with severe degradation on the specimen from Site G.

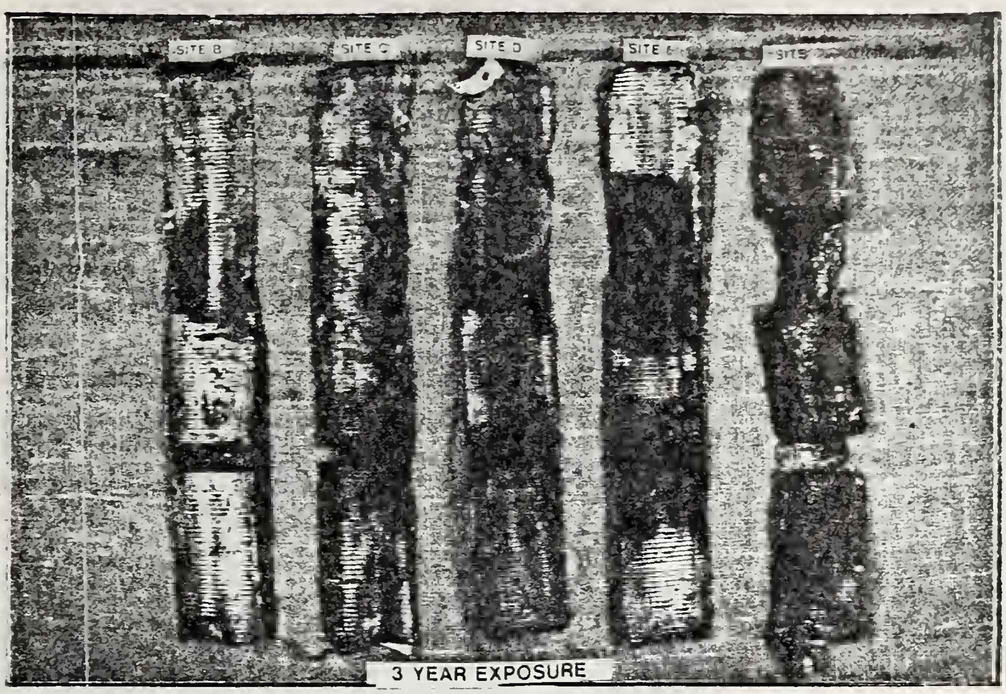

Figure 30. Outer Shield; System 87, Sites B,C,D,E, and G, left to right, exposed for three years. Dark areas indicate corrosion on specimens with severe corrosion on the specimens from Sites C and G.

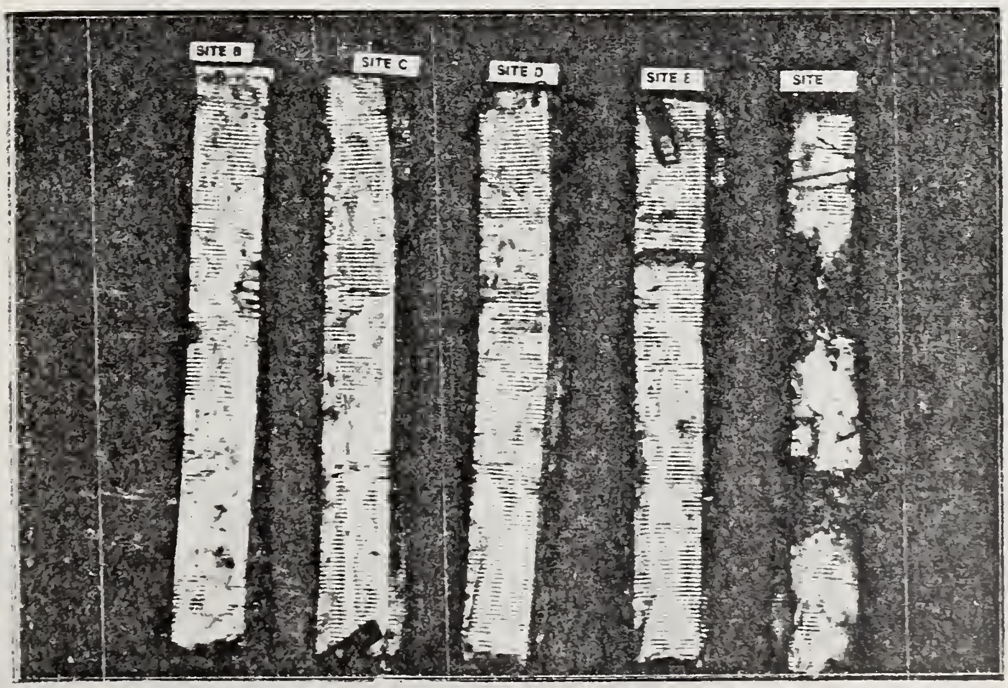

Figure 31. Inner Shield; System 87, Sites B,C,D,E, and G, left to right, exposed for three years. Severe degradation on the specimen from Site G.

Figure 32. Outer Shield; System 88, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system to copper accelerated corrosion on all specimens.

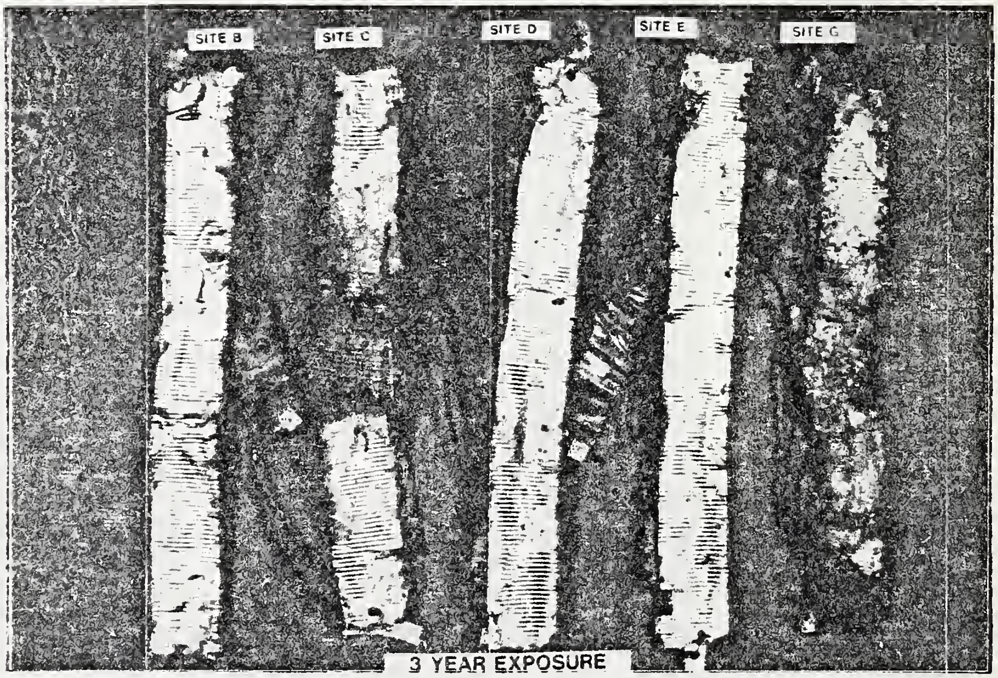

Figure 33. Inner Shield; System 88, Sites B,C,D,E, and G, left to right, exposed for three years. Coupling this system accelerated degradation on the specimens from Sites C and G.

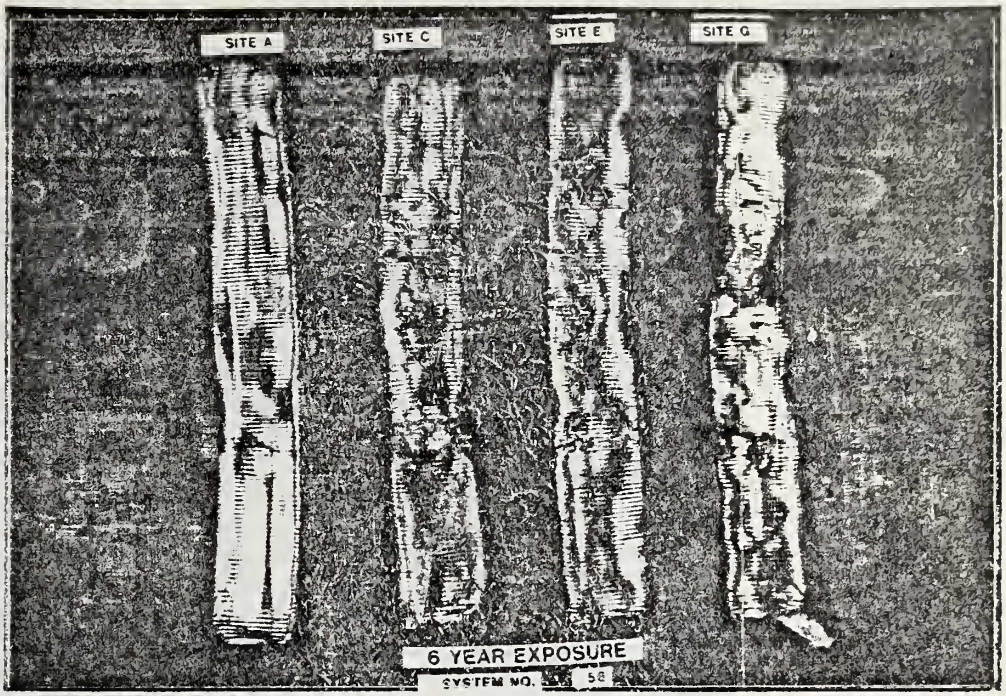

Figure 34. Outer Shield; System 56, Sites A,C,E, and G, left to right, exposed for six years. Dark areas indicate corrosion on specimens with severe corrosion on the specimen from Site G at the window and ring areas.

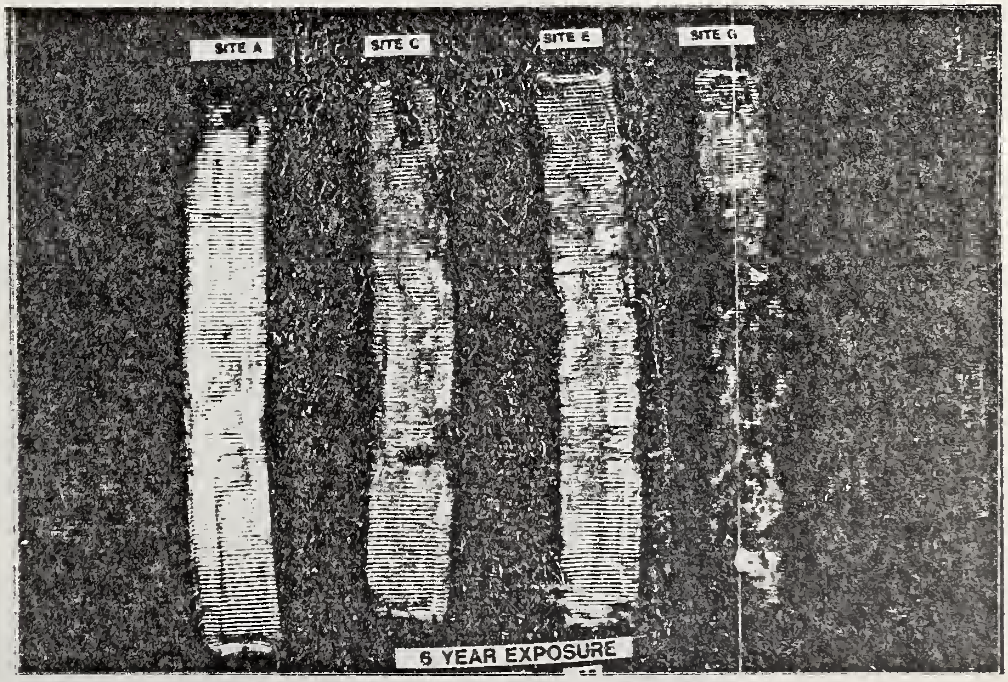

Figure 35. Inner Shield; System 56, Sites A,C,E, and G, left to right, exposed for six years. Severe degradation on the specimens from Sites C and G.

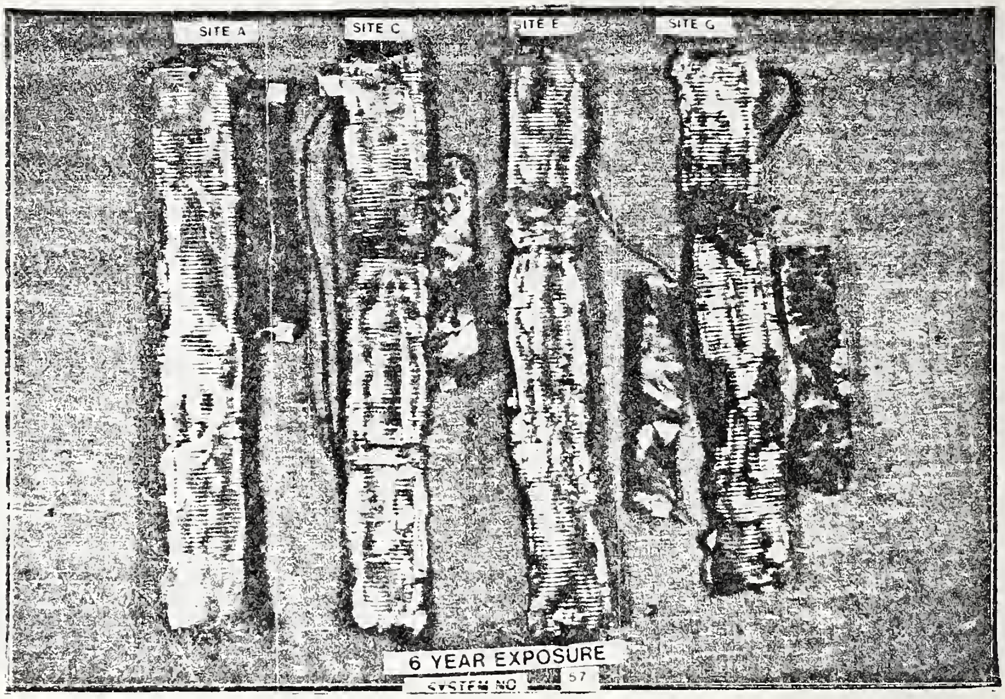

Figure 36. Outer Shield; System 57, Sites A,C,E, and G, left to right, exposed for six years. Coupling this system to copper accelerated corrosion on all specimens indicated by dark areas.

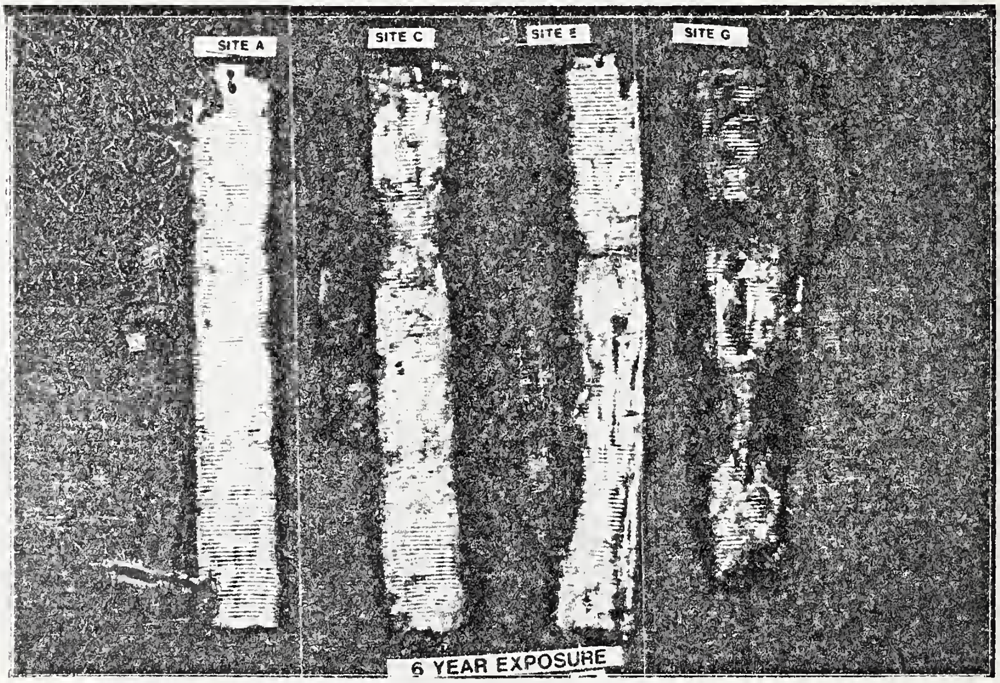

Figure 37. Inner Shield; System 57, Sites A,C,E, and G, left to right, exposed for six years. Coupling this system to copper accelerated degradation on the specimens from Sites C and G severely.

NBS-114A (REV. 2-80)

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5. AUTHOR(S)

J. L. Fink, E. Escalante, and W. F. Gerhold

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

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Washington, D.C. 20250

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

Corrosion data are given on the performance of base and plastic-coated metals intended for use as cable shields for buried telephone cable. The materials investigated on specially prepared specimens were buried for periods up to six years in six different soil environments. Metals tested included homogeneous plastic-bonded and metallurgically-bonded laminates. Some specimens were exposed bare (uncoated), while others had plastic coatings or other types of coatings on either one or both sides. Metals studied included aluminum, copper, low carbon steel, and stainless steel alloys.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

Alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground

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