Atmospheric Corrosion Investigation of Aluminum-Coated, Zinc-Coated, and Copper-Bearing STEEL WIRE and WIRE PRODUCTS

A THIRTY-TWO YEAR REPORT

Beryle G. Sweet
Thomas C. Britton, Jr.

ASTM DS [illegible]

Atmospheric Corrosion Investigation of Aluminum-Coated, Zinc-Coated, and Copper-Bearing Steel Wire and Wire Products: A Thirty-Two Year Report

Sponsored by ASTM Committee A5 on Metallic-Coated Iron and Steel Products

Beryle G. Sweet
Thomas C. Britton, Jr.

ASTM Data Series: DS 65
Revision of STP 585A
ASTM Publication Code Number (PCN):
05-015950-02

ASTM ■ 1916 Race Street ■ Philadelphia, PA 19103
Printed in the U.S.A.

Library of Congress Cataloging-in-Publication Data
Sweet, Beryle G.
Atmospheric corrosion investigation of aluminum-coated, zinc-coated, and copper-bearing steel wire and wire products: a thirty-two year report / sponsored by ASTM Committee A5 on Metallic-Coated Iron and Steel Products; Beryle G. Sweet and Thomas C. Britton, Jr. (ASTM data series; DS 65)
"Revision of STP 585A."
"ASTM publication code number (PCN): 05-015950-02."
ISBN 0-8031-2064-8
1. Steel wire—Corrosion. 2. Corrosion and anti-corrosives. I. Britton, Thomas C., 1951- . II. ASTM Committee A-5 on Metallic-Coated Iron and Steel Products. III. Title. IV. Series: ASTM data series publication; DS 65.
TA467.S893 1995
620.1'723--dc20 95-9111
CIP

Printed in Philadelphia, PA
June 1995

Foreword

Committee A5 on Metallic-Coated Iron and Steel Products[1] was organized in 1907 to investigate the corrosion of iron and steel. In 1908, the Committee sponsored its first atmospheric exposure of metallic-coated wires to evaluate their corrosion resistance. Since this date, there have been a considerable number of test programs involving wire, sheet, and hardware. Of particular interest is the program initiated in 1936 and reported on in ASTM STP 290 entitled "Twenty-Year Atmospheric Corrosion Investigation of Zinc-Coated and Uncoated Wire and Wire Products" by Fred M. Reinhart.

In June 1959, the Advisory Committee on Corrosion authorized Committee A5 to conduct atmospheric corrosion tests of aluminum coated wire and wire products at seven ASTM sites in the United States (see map on next page) and an eighth site in Warrington, England. The responsibility for the latter site was assumed by Rylands Whitecross Limited.

Exposure of the wire and wire products specimens was initiated in 1961. For comparative purposes, bare copper-bearing steel wire and zinc-coated steel wire and fabricated products were included in the testing program.

A twelve year report on the 1961 exposure program entitled ASTM STP 585 "Atmospheric Corrosion Investigation of Aluminum-Coated, Zinc-Coated, and Copper-Bearing Steel Wire and Wire Products" by V. I. Kelley was published in 1975.

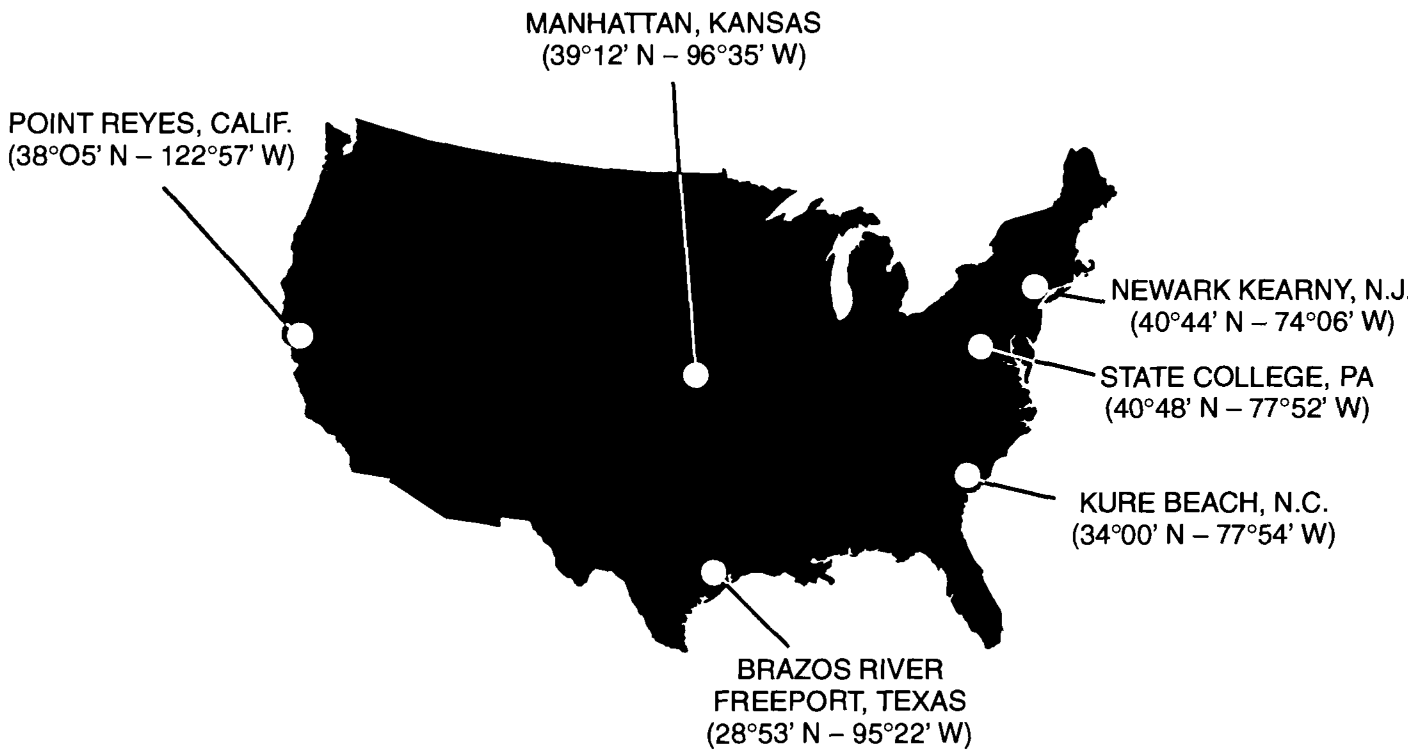
A twenty year report on the 1961 exposure program entitled ASTM STP 585A "Atmospheric Corrosion Investigation of Aluminum-Coated, Zinc-Coated, and Copper-Bearing Steel Wire and Wire Products, a Twenty-Year Report" by John F. Occasione, Thomas C. Britton, Jr., and Roy C. Collins was published in 1984.

This report presents the results of 32 years of exposure for the 1961 exposure program, and was prepared by Beryle G. Sweet[2] and Thomas C. Britton, Jr.[3]

[1]Committee A5 was originally titled "Corrosion of Iron and Steel."

[2]Retired chairman and chief executive officer of Page Aluminized Steel Corporation, 100 Monongahela Street, Monessen, PA 15062-1355. Self-employed in a consulting business under the name of Sweet Wire & Fence Associates, 394 McClellan Circle, Pittsburgh, PA 15236-4106.

[3]Consulting engineer with Duke Power Company, Mail Stop WC22C, P. O. Box 1007, Charlotte, NC 28201-1007. Chairman of ASTM Subcommittee A05.15 on Wire Tests.



MAP – LOCATION OF TEST SITES IN THE UNITED STATES

Acknowledgments

The authors wish to acknowledge and extend thanks to the following people who helped with the compilation and peer review of this document:

Donald L. Deetscreek, Johnstown Wire Technologies, Johnstown, PA.
Phillip C. Elser, Indiana Steel & Wire Co., Muncie, IN.
Jeffrey A. Feldman, Guardian Fence Co., Newark, NJ.
Robert M. Kain, LaQue Center for Corrosion Technology, Wrightsville Beach, NC.
Kenneth E. Niewoehner, Bethlehem Steel Co. (retired), Bethlehem, PA.
Stanley J. Pikul, LaQue Center for Corrosion Technology, Wrightsville Beach, NC.
Paul W. Shumway, American Tube Co., Phoenix, AZ.
Ralph H. Vogler, Michigan Dept. of Transportation (retired), Lansing, MI.
All the site inspectors who volunteered their time.
The staff people of ASTM who made it all possible.

Contents

Figures

Author's Commentary

Metallic coatings on iron and steel products have been around ever since the need was recognized to add a degree of corrosion resistance to a material noted for its strength, ductility, and durability. Indeed, zinc coatings in various processes on iron or steel have been employed since the mid-19th century.

It was well into the 20th century before aluminum coatings over steel were perfected. While aluminum powder coatings were first introduced earlier in the century, it was not until the 1930s that hot-dip aluminum coatings were introduced, and then only on sheet steel products. The process of hot-dip aluminizing to protect steel wire was first perfected in the late 1940s; the first shipment of a finished product being made in 1953, only eight years before the start of the atmospheric corrosion tests which are the subject of this publication.

As with any new product being offered in the marketplace, the need was recognized to conduct tests to determine its advantages, if any, over the traditional product being offered. While accelerated laboratory tests, such as salt spray, could tell much about a product's corrosion resistance, nothing could take the place of direct exposure in a variety of atmospheres over a long period of time. This became the impetus for the voluntary efforts which resulted in the launching of these tests.

It should be noted here that the placement of zinc-coated and copper-bearing bare steel wire and wire products at the test sites was for the purpose of providing control specimens against which to compare the performance of aluminum-coated wire and wire products, since the former products are considered "grandfather" materials in existence long before the introduction of aluminum-coated wire.

The lead author of this booklet is acknowledged to be a retired producer of hot-dip aluminum-coated steel wire. In order to lend balance to the report and ensure that any conclusions drawn are unbiased, he insisted upon the appointment of a user of the product as co-author. That was accomplished when Tom Britton of Duke Power Company agreed to fill that role.

The peer review required by ASTM proved to be a worthwhile undertaking. Composed of a total of eight individuals representing both producer and user interests, plus several staff members of ASTM, this peer group contributed invaluable input which resulted in many clarifications and amplifications to the text and the various tables in the report.

Insofar as possible, the annual inspections of the specimens at the various test sites were conducted by two or more people to ensure a consensus of opinion on the condition of the specimens. The authors wish to thank the many individuals who volunteered their time for this very important task. Without them the compilation of the extensive data in this report would have been impossible.

The primary audience for this publication is perceived to be users, potential users, and specifiers of metallic-coated steel wire and wire products. It is hoped that the conclusions drawn in this report will aid them in selecting the product which will best serve their requirements for atmospheric corrosion protection.

Beryle G. Sweet
Lead author

Scope of A5 and Authorization

The scope of Committee A5 on Metallic-Coated Iron and Steel Products is "The promotion of knowledge, the stimulation of research, and the development of standards in the area of iron and steel products protected against corrosion by use of metallic coatings, and nonmetallic coatings which may be specified for use as supplemental protection. The types of standards developed include, but are not limited to, specifications, practices, test methods, and definitions." Subcommittee A05.15 on Wire Tests is responsible for the performance of tests on the atmospheric corrosion of wire and wire products, be they bare or metallic-coated.

With the June 1959 authorization from the Advisory committee on Corrosion, Subcommittee A05.15 organized a task group composed of the following:

E. G. Baker, Steel Company of Canada
B. A. Beery, American Chain & Cable Co., Page Steel & Wire Division (now Page Aluminized Steel Corp.)
W. W. Bradley, Bell Telephone Labs, Inc.
R. S. Dalrymple, Reynolds Metals Co.
O. B. Ellis, Armco Steel Corp.
P. M. Emmons, Rural Electrification Administration
E. T. Englehart, Aluminum Company of America
H. H. Hormann, Consolidated Edison of New York
J. B. Horton, Bethlehem Steel Co.
R. B. Koontz, National Standard Co.
J. B. Kopec, Keystone Steel & Wire Co.
T. A. Lowe, Kaiser Steel & Wire Co.
J. F. Murphy, Olin Mathieson Chemical Corp.
F. J. Reinhart, U. S. Naval Engineering Laboratory
J. H. Rigo, United States Steel Corp. (now USX Corp.)
T. A. Schneider, J. A. Roebling's Sons Division
C. W. Straitor, Detroit Edison Co.
C. E. Topping, Consumers Power Co.
L. C. Whitney, Copperweld Steel Co.

Seven producers contributed the aluminum-coated steel wire test specimens for the exposure program. These producers were:

Bethlehem Steel Co.
Copperweld Steel Co.
Keystone Steel & Wire Co.
National Standard Co.
American Chain & Cable Co., Page Steel & Wire Div.
J. A. Roebling's Sons Division
United States Steel Corp.

Copper-bearing steel and zinc-coated steel wires were also provided for comparative purposes. Southern Electrical Co., Division of Olin Mathieson Chemical Corp. contributed to the program in the stranding of the steel-reinforced aluminum conductors. Performed Line Products Co. supplied the dead-end fittings used in the test installations of high-strength strand and steel-reinforced aluminum conductors.

Fabricated items were installed at eight exposure sites. At four of the sites, unfabricated wires were also exposed. Five types of fabricated wire products are under test. These are barbed wire, chain-link fence fabric, farm-field fence fabric, high-strength steel wire strand, and steel-reinforced aluminum conductor. The latter two products are referred to as "7-wire strand" in this document. The relative corrosion resistance of the various test items in the several atmospheres was established by visual inspection of the unfabricated and fabricated wire items and by periodic determination of percentile loss in breaking strength of the 0.148 and 0.099 in. (3.76 and 2.51 mm) unfabricated wires.

Text

1

Summary of Results

The wire and wire product specimens were exposed at the seven U.S. sites in the spring and summer of 1961 and at Warrington, England, on 1 March 1964. There were 1520 unfabricated tension test specimens exposed at each of four sites. To date, 370 have been removed and tested. Wire product specimens (farm-field fence, barbed wire, chain-link fence fabric, and 7-wire strand) were exposed at all eight sites.

The hot dipped aluminum-coated specimens ranged from 0.27 to 0.63 oz/ft^2 (82 to 192 g/m^2), and the aluminum powder metallurgy clad specimen ranged from 1.76 to 4.54 oz/ft^2 (537 to 1385 g/m^2). The hot dipped zinc coatings ranged from 0.36 to 2.81 oz/ft^2 (110 to 857 g/m^2), and the electroplated zinc coatings ranged from 0.87 to 2.98 oz/ft^2 (265 to 909 g/m^2). (NOTE: All coating weight values in this document are expressed in ounces (grams) of aluminum or zinc per square foot (square metre) of uncoated wire surface.)

The corrosion rates of the coatings to initial rust on aluminum-coated unfabricated wires ranged from 0.02 oz/ft^2-year (6 g/m^2-year) at Newark-Kearny, New Jersey, to 0.06 oz/ft^2-year (18 g/m^2-year) at Warrington, England. In general the corrosion rates of the coatings to initial rust on aluminum-coated fabricated product specimens were within this range at all locations. The corrosion rates of the coatings to initial rust on the zinc-coated unfabricated wires ranged from 0.06 oz/ft^2-year (18 g/m^2-year) at State College, Pennsylvania, to 0.20 oz/ft^2-year (61 g/m^2-year) at Warrington, England. The corrosion rates of the coatings to initial rust on zinc-coated fabricated products varied considerably from a low of 0.02 oz/ft^2-year (6 g/m^2-year) at Manhattan, Kansas, to a high of 0.38 oz/ft^2-year (116 g/m^2-year) at the Kure Beach, North Carolina, 80 ft (25 m) site.

The corrosion rates of the coatings to complete rust on aluminum-coated unfabricated wires ranged from 0.01 oz/ft^2-year (3 g/m^2-year) at the Kure Beach, North Carolina, 800 ft (250 m) site to 0.03 oz/ft^2-year (9 g/m^2-year) at Warrington, England. However, complete rust had not been reached at the 32-year point at Newark-Kearny, New Jersey, and State College, Pennsylvania, on the aluminum-coated unfabricated wires. The corrosion rates on aluminum-coated fabricated product specimens were all within this same range, with the exception of the Warrington, England, site where the barbed wire and chain link fence specimens exhibited a corrosion rate to complete rust of 0.04 oz/ft^2-year (12 g/m^2-year).

The corrosion rates of the coatings to complete rust on zinc-coated unfabricated wires ranged from 0.05 oz/ft^2-year) (15 g/m^2-year) at the Kure Beach, North Carolina, 800 ft (250 m) site and the State College, Pennsylvania site to 0.17 oz/ft^2-year (52 g/m^2-year) at Warrington, England. The corrosion rates of the coatings to complete rust on zinc-coated fabricated products varied considerably from a low of 0.01 oz/ft^2-year (3 g/m^2-year) at Manhattan, Kansas, to a high of 0.22 oz/ft^2-year (67 g/m^2-year) at Warrington, England.

The loss in breaking strength over the first 30 years varied considerably from a high of 70% for uncoated wires exposed at the Kure Beach, North Carolina, 800 ft (250 m) site and 68% for zinc-coated wires exposed at Warrington, England, to some slight gain in strength for some of the heavier aluminum-coated specimens. In general, the loss in strength of aluminum-coated wires was less than that of zinc-coated wires.

2

Test Plan

The test plan involved the exposure of specimens representing the following:

1. *Unfabricated Wires*—Evaluation by visual observation and by loss in breaking strength
   Number of replicates: 20
   Test length: 39 in. (991 mm)
   Materials:
   (*a*) Bare copper-bearing steel wire 0.148 in. (3.76 mm) diameter
   (*b*) Zinc-coated steel wire 0.148 in. (3.76 mm) diameter
      Hot dipped
      Electroplated
   (*c*) Aluminum-coated steel wire 0.148 in. (3.76 mm) diameter
      Hot dipped
      Powder metallurgical technique
   (*d*) Aluminum-coated steel wire 0.099 in. (2.51 mm) diameter
      Hot dipped
      Powder metallurgical technique
2. *Fabricated Wire Products*—Evaluation by visual observation
   Number of replicates: 1
   Test length: 10 ft (3.05 m)
   Materials:
   (*a*) Farm-field fence fabric—two sizes: 939-6-11 and 939-6-9 (See Specifications A 116 and A 584 for size terminology)
      Zinc-coated steel wire—Hot dipped—two coating weight classes
      Aluminum-coated steel wire—Hot dipped
   (*b*) Barbed wire—12 1/2 gage 4-point
      Zinc-coated steel wire—Hot dipped—two coating weight classes
      Aluminum-coated steel wire—Hot dipped—three coating weights (two specimens have aluminum alloy barbs)
   (*c*) Chain-link fence fabric—2 in. (51 mm) mesh, 0.148 in. (3.76 mm) diameter wire, 48 in. (1219 mm) high, twisted top, knuckled bottom
      Zinc-coated steel wire
         Hot dipped—two coating weight classes
         Electroplated—two coating weight classes
      Aluminum-coated steel wire
         Hot dipped—three coating weights
   (*d*) High-strength strand
      Zinc-coated steel wire—Electroplated 0.375 in. (9.53 mm) strand diameter, 7-wire 0.120 in. (3.05 mm)—two coating weights
      Aluminum-coated steel wire—Various processes, 0.375 in. (9.53 mm) strand diameter, 7-wire 0.120 in. (3.05 mm), and 0.3125 in. (7.94 mm) strand diameter, 7-wire 0.104 in. (2.64 mm)–range of coating weights
   (*e*) Aluminum conductors, steel reinforced (ACSR)
      No. 4—7/1 ACSR (See Specification B 232 for size terminology) in conventional stranding and compacted stranding. Zinc-coated, electroplated steel core wire and aluminum-coated steel core wire—various processes
3. *Placement of Specimens*—Figures 1 through 3 depict the manner in which the unfabricated wire and fabricated wire products are exposed at the several atmospheric test sites. In all instances precautions are taken to eliminate dissimilar metal contact.

Figure 1 illustrates the manner in which the unfabricated test wires are racked in groups of 10 on the standard ASTM pipe stands by insertion into predrilled 1 1/2 in. (38 mm) diameter aluminum rounds, mounted at 30° from horizontal. Prior to insertion into the aluminum rounds, both ends of the wire were dipped into an adhesive, EC 1099 (product of Minnesota Mining and Manufacturing Co.). The aluminum rounds are installed at center-to-center distance of approximately 35 in. (889 mm) to accommodate the coil set of the test wires. Each round was predrilled with holes of prescribed diameters to a 1/4 in. (6 mm) depth at 2 in. (51 mm) centers.

The high-strength steel strands and the steel reinforced aluminum conductors are supported on braces of 1 1/4 in. (32 mm) galvanized pipe, drilled at 3 in. (76 mm) centers for the strand and 3 3/4 in. (95 mm) centers for the conductors. The test strands and conductors are outfitted at either end of the test lengths with galvanized or aluminum-coated dead ends, depending upon the contact metal involved.

Farm-field fence and chain-link fencing are erected on suitable finished fence posts set in typical vertical fashion as shown in Figs. 2 and 3. The barbed wire specimens are shown mounted on appropriately finished arms, the aluminum fittings in contact with aluminum coated steel, and the zinc-coated fittings in contact with zinc-coated steel. Since these specimens were installed by professional erectors, they were tensioned to the degree normally encountered in service.

4. *Test Locations and Exposure Sites*—Table 1 lists the exposure sites, the assigned site numbers, the exposure dates, and the type of product, that is, fabricated or unfabricated. The type of atmosphere at each location is classified in accordance with that set forth in the 1958 Report of the Advisory Committee on Corrosion. The three major types are industrial, marine, and rural. A brief description of each site follows.

Site No. 1—Brazos River, Texas

In 1952, a test site was established on the Brazos River on property owned by the U.S. Army Corps of Engineers, 3900 ft (1189 m) northwest of the Gulf of Mexico. The nonfabricated specimens are mounted at 30° from the horizontal and all specimens face southeast at an azimuth of 144°. The climate in this area is noted for its consistently high humidity. The daytime relative humidity varies between 85 and 93% in the summer and averages 80% in the winter. The night-time relative humidity is 100% all year with frequent heavy dews.

Sites Nos. 2 and 3—Kure Beach, North Carolina

The two exposure sites at Kure Beach are under the ownership and direction of the LaQue Center for Corrosion Technology Inc. and are located on the Cape Fear peninsula 17 miles (27.4 km) southeast of Wilmington, North Carolina. One test site is approximately 800 ft (250 m) and the other 80 ft (25 m) from the Atlantic Ocean. The nonfabricated specimens are mounted 30° from the horizontal and all specimens face south at an azimuth of 177° at the 800 ft (250 m) site. At the 80 ft (25 m) site, the specimens face the ocean directly at an azimuth of 110°. The 80 ft (25 m) site is characterized by seawater spray falling directly on the test specimens and is considered a severely corrosive marine environment. The 800 ft (250 m) site is considered a moderately severe marine environment.

Site No. 4—Manhattan, Kansas

This rural site is located on the campus of Kansas State University in an agricultural area with very little industrial contamination. It is a continental climate with relatively large diurnal and annual temperature ranges. There is abundant sunshine as compared to the eastern United States. The elevation is approximately 1100 ft (335 m) above sea level. The annual average rainfall is 33.52 in. (851 mm).

Site No. 5—Newark-Kearny, New Jersey

This severe industrial test site was established in 1956 to replace the original test site on property owned by the Port Authority of New York and New Jersey in Newark. The new site was established on 2 July 1970 and is situated on the grounds of the Kearny Generation Station of Public Service Electric and Gas Company. The nonfabricated specimens are mounted at an angle of 30° from the horizontal and all specimens face the south-southwest at an azimuth of 193° (elevation 11 ft (3 m)).

Site No. 6—Point Reyes, California

Point Reyes test site was established in 1950 on property owned by American Telephone and Telegraph Company and is located 1930 ft (588 m) from the Pacific Ocean behind low hills covered with salt grass and bushes. The nonfabricated specimens are mounted at an angle of 30° from the horizontal and all specimens face due west, toward the Pacific Ocean. The atmosphere here is characterized by salt spray and condensation exposure due to westerly winds, dense fogs, and heavy rains which keep the specimens moist during most of the winter. In summer the area is very dry by day with frequent heavy fogs at night.

Site No. 7—State College, Pennsylvania

This rural site was established in 1925 and is located on the campus of Pennsylvania State University, 1 mile (1.6 km) north of State College, Pennsylvania (elevation 1175 ft (358 m)). The nonfabricated specimens are mounted 30° from the horizontal and all specimens face southeast at an azimuth of 147°.

Site No. 8—Warrington, England

This industrial site was located on the recreation grounds at Rylands-Whitecross, Ltd. at an elevation of 28 ft (9 m) above sea level. The location was at 53° 24′ N latitude and 2° 34.5′ W longitude. The prevailing wind is southwesterly blowing from the town over the site. The exposure racks ran from east to west and faced south. The town has a diversified industry which includes wire production, light and heavy engineering, hot-rolled steel products, board and paper mills, chemical processing, and extensive brewing. The average annual sulfur dioxide (SO_2) contamination for the years 1964 through 1973 was 0.065 ppm. The more recent years (1974 through 1977) indicated a 50% reduction of SO_2 from the earlier annual figures. This site was terminated and closed in April 1977 after 13.2 years of exposure (see Table 1).

3

Description of the Test Specimens

The following information was provided by each manufacturer for the unfabricated and fabricated wire products which each supplied:

(*a*) General description of the coating process.
(*b*) Chemical analysis of the base metal and metallic coating.
(*c*) Weight of metallic coating.
(*d*) Mechanical properties of the unfabricated wires.
(*e*) Minimum and maximum coating thicknesses as measured microscopically.
(*f*) Cross-sectional photomicrograph to illustrate structure of coating only.

Most of the descriptive information which was supplied by the several manufacturers was accepted without verification. Only the coating weights and mechanical properties were rechecked, and any discrepancies were resolved.

General descriptions of the coating processes for the test wires are summarized in Table 2. According to these descriptions the zinc-coated steel wires were processed by conventional hot dip or electrolytic methods. Aluminum-coated steel wires prepared by processes 1, 2, 4, and 5 were coated by passage through a molten bath of aluminum or an aluminum-silicon alloy. Except for two processes, 1 and 6, the steel wires were chemically fluxed prior to passage through the molten bath of coating metal. Process 3 utilizes a powder metallurgical technique.

Table 3 reports the chemical analyses of the base metal for all test specimens, unfabricated, and fabricated. A review of these steel analyses shows the carbon content of the base metal for aluminum coating in a molten bath to be significantly higher than for comparable zinc-coated wire. Starting with a higher carbon content for the aluminum-coated steel wire compensates for the greater reduction in tensile strength which is caused by a higher operating temperature for an aluminum bath as compared to a molten zinc bath. The operating temperature for an aluminum bath ranges from 1200 to 1300° F (649 to 704° C) whereas the operating temperature of a zinc bath varies from 800 to 900° F (427 to 482° C).

Low, medium, and high-carbon steel analyses are represented among the unfabricated wires. Aluminum conductor steel reinforced (ACSR) core wires and high-strength steel strand are high-carbon products, while barbed wire and farm-field fence fabric are essentially low-carbon products. Base metal analyses classifies the zinc-coated chain-link fence fabric as a steel product of lower carbon content than the aluminum-coated steel chain-link fence fabric. The latter utilized steels of medium carbon content.

The reported coating weights are tabulated in Table 4 and indicate the range of coating weights observed for the electrolytic and hot dip zinc coatings, and for the two types of aluminum coatings.

See Chapter 6 for a listing of current ASTM specifications pertaining to the products exposed in this program. No ASTM specifications for aluminum coated wire and wire products were in existence in 1961 when these exposure tests were started, and comparisons to specification requirements which follow are to specifications adopted subsequently.

Of the unfabricated 9 gage zinc-coated wire specimens, the hot-dipped specimen had a coating weight 42.9% over that specified in Table 1 of Specification A 641[4] (A 641 M) for Class 1 coating. Of the two electroplated specimens, one had a coating weight 10.0% over that specified in Table 1 of Specification A 641 (A 641 M) for Class 1 coating, while the other had a coating weight 5.2% over that specified in Table 1 of Specification A 641 (A 641 M) for Class C coating.

Of the three unfabricated 9 gage hot-dipped aluminum-coated specimens, one had a coating weight 32.5% under and one was 20.0% over that specified in Table 2 of Specification A 809.[4] The third specimen had a coating weight 57.5% over that specified in Table 2 of Specification A 809.

The one specimen of 9 gage aluminum-coated wire processed by the powder metallurgy technique is high carbon ACSR wire and had a coating weight of 2.44 oz/ft^2 (745 g/m^2), more than seven times the 0.34 oz/ft^2 (104 g/m^2) specified in Table 4 of Specification B 341[4] (B 341 M).

With the exception of the chain link fabric specimens, the heavier zinc coatings were deposited by the electrolytic method as opposed to the hot dip method.

Of the two hot-dipped zinc-coated chain link fabric specimens, one had a coating weight 47.5% over that specified in Specification A 392[4] for Class 1 coating, while the other had a coating weight 40.5% over that specified in Specifica-

[4]*Annual Book of ASTM Standards*, Vol. 01.06.

tion A 392 for Class 2 coating. Both of these specimens were coated with zinc by the hot dip process after being woven into chain link fabric. In many cases, this process results in a heavier deposition of zinc at the wire intersections as compared to the straight portions of the wire in the chain link fabric.

Of the two zinc-coated chain link fabric specimens that were coated by the electrolytic method, one had a coating weight 27.5% over that specified in Table 3 of Specification A 817[4] for Type II, Class 1 coating, while the other had a coating weight 11.5% over that specified in Table 3 of Specification A 817 for Type II, Class 2 coating. Both of these specimens were woven from wire that was zinc-coated before fabrication by the electrolytic process.

Of the three aluminum-coated chain link fabric specimens, all were coated by the hot-dip method before weaving. The coating weights were 10.0, 35.0, and 42.5% over that specified in Table 2 of Specification A 817 for Type I coating.

The aluminum coatings deposited by passage through a molten bath were substantially lighter than those deposited by the powder metallurgical technique. The range for the hot-dip aluminum coatings was 0.21 to 0.63 oz/ft^2 (64 to 192 g/m^2) as compared to 1.76 to 4.54 oz/ft^2 (537 to 1385 g/m^2) for the powder applied aluminum coatings.

4

Coating Data

The weights and analyses of the coating metals as well as minimum and maximum coating thicknesses are reported in Table 5. These are original data as reported at the inception of the program. The coating thicknesses were determined microscopically. Photomicrographs of the wire's cross-sectional area illustrating the structure of the metallic coating were published in the 20-year report (STP 585A) and no attempt is made to reproduce them here.

As shown in Table 5, the coating analyses of the zinc coatings for iron range from a trace of iron for the electrolytically deposited coatings to a maximum of 15% iron for the hot dip coatings. Steel wires which were coated with essentially pure aluminum by a hot dip or a powder metallurgical technique showed an iron content of less than 1% in the outer portion of the coating. Wires which were aluminum-coated in siliconized aluminum baths had iron contents in the outer portion of the coatings in excess of 1%. In these instances, the overall range in iron content was 1 to 5%. Aluminum-coated steel Specimens 7, 19, 51, 57, and 58, where the entire aluminum coating instead of just the outer portion was analyzed for iron, had iron contents ranging from approximately 8.75% iron for a 3 to 4% siliconized aluminum coating to an excess of 20% for a siliconized aluminum coating of approximately 1% silicon. However, as previously noted (see footnote *a* under Table 2) these specimens were dropped from the program after 5 years.

5

Mechanical Properties

Initial mechanical properties of the nominally sized 0.148 and 0.099 in. (3.76 and 2.51 mm) unfabricated wires are listed in Table 6. Information tabulated includes wire diameter, breaking strength, tensile strength, percent elongation in 10 in. (254 mm), and percent reduction in area. Corroded specimens were subsequently mechanically tested for breaking strength only.

The zinc-coated steel wire specimens had tensile strengths ranging from 58 to 87 ksi (400 to 600 MPa). All aluminum-coated wires which were coated by passage through a molten bath except for Specimen 6 had tensile strengths ranging from 59 to 99 ksi (407 to 683 MPa), significantly lower than those of wires coated by the powder metallurgical technique (Specimens 8, 21, and 22), which ranged from 101 to 177 ksi (695 to 1220 MPa). Specimen 6 was able to attain its high tensile strength of 165 ksi (1140 MPa) by utilizing steel with a chemical analysis of 0.72% carbon.

The data on percent elongation in 10 in. (254 mm) indicate that significantly lower percent elongations (1.5 to 2.2%) are associated with the higher tensile strengths of wires aluminum coated by the powder metallurgical technique. Steel wires which were aluminum coated by passage through a molten bath had percent elongations in 10 in. (254 mm) varying from 5.8 to 15.7%. The percent elongations of the zinc-coated steel wires ranged from 5.8 to 11.6%.

Table 7 records the chemical analyses and physical properties which were reported for the aluminum conductor wires used in the fabrication of the No. 4, 7/1 ACSR conventional and compacted conductors. Also listed for comparative purposes are the specified minimum values which aluminum wire must meet for this application.

6

Materials and ASTM Specifications

The materials exposed in this program have wide variations in coating weight due to the many different coating processes employed. Some of these items do not meet the ASTM specifications which eventually evolved in the aluminum-coated product line. The following ASTM specifications[4] pertain to the products exposed in this program. The date of original issue is given in parentheses. It should be noted that some of these specifications were not in existence at the time of initiation of the tests, and that the listing of those ASTM specifications issued after 1961 does not imply full compliance with those specifications.

1. A 116 Specification for Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric (1927)
2. A 121 Specification for Zinc-Coated (Galvanized) Steel Barbed Wire (1928)
3. A 363 Specification for Zinc-Coated (Galvanized) Steel Overhead Ground Wire Strand (1952)
4. A 392 Specification for Zinc-Coated Steel Chain-Link Fence Fabric (1955)
5. A 474 Specification for Aluminum-Coated Steel Wire Strand (1962)
6. A 475 Specification for Zinc-Coated Steel Wire Strand (1962)
7. A 491 Specification for Aluminum-Coated Steel Chain-Link Fence Fabric (1963)
8. A 584 Specification for Aluminum-Coated Steel Woven Wire Fence Fabric (1968)
9. A 585 Specification for Aluminum-Coated Steel Barbed Wire (1968)
10. A 586 Specification for Zinc-Coated Parallel and Helical Steel Wire Structural Strand (1968)
11. A 641 Specification for Zinc-Coated (Galvanized) Carbon Steel Wire (1971)
12. A 641M Specification for Zinc-Coated (Galvanized) Carbon Steel Wire [Metric] (1984)
13. A 809 Specification for Aluminum-Coated (Aluminized) Carbon Steel Wire (1983)
14. A 817 Specification for Metallic-Coated Steel Wire for Chain Link Fence Fabric (1983)
15. B 341 Specification for Aluminum-Coated (Aluminized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR) (1963)
16. B 498[5] Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR) (1969)
17. B 498M Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR) [Metric] (1983)

The first fourteen specifications listed were promulgated by Committee A5, whereas the last three were sponsored by Committee B1 on Electrical Conductors. Specifications A 392 and A 491 are now under the jurisdiction of Committee F14 on Fences.

[5]This specification was issued in 1969 to replace Specifications B 245 and B 261.

7

Inspection of Wire and Wire Products

Visual Examination

Visual examination of the extent of corrosion was done almost annually. The time of exposure was recorded to the nearest 0.1 year. This report summarizes the observations made over a period of 32 years at all test sites except Warrington, England, where the test was terminated after 13.2 years. Observations were made by one or more inspectors and the consensus was reported. These data have been published in ASTM A5 reports.[6] A summary of these observations is presented in Tables 8 through 12 covering all but the ACSR specimens. Table 13 shows the abbreviations and symbols used to describe the nature of the corrosion. The extent of corrosion was estimated in terms of the percent of the area of the specimen affected. The corrosion rates in terms of ounces per square foot (grams per square metre) to initial rust (CIR) and to complete rust (CCR) were calculated as follows:

$$(a)\ \text{CIR} = \frac{\text{weight of coating oz/ft}^2\ (\text{g/m}^2)}{\text{years to initial rust}}$$

$$(b)\ \text{CCR} = \frac{\text{weight of coating oz/ft}^2\ (\text{g/m}^2)}{\text{years to complete rust}}$$

The CIR and CCR values are not intended to constitute a valid comparison between aluminum-coated and zinc-coated steel wire products. Metallic coatings are expressed customarily in terms of unit weight rather than thickness; therefore, the CIR and CCR values have been calculated in terms of unit weight.

In 1991, the 30th anniversary year of the exposure tests, a project was undertaken to photograph all of the chain link fabric specimens at each of the seven active test sites. The photographs are reproduced here as Figs. 4 through 53. They are grouped by specimen number at each test site.

Beneath the caption on each photograph, the 30-year (1991) inspection data are reproduced. It should be noted here that the inspection data reflects the *average* observed condition of the entire specimen and not necessarily that of the section of the specimen depicted photographically.

Absent from the series of photographs are electrogalvanized Specimens 34 and 35 at the Kure Beach 80 ft (25 m) site. These specimens reached complete rust at 17.1 and 23.1 years, respectively, and have been scrapped.

At the Newark-Kearny site, the three aluminum-coated fabric specimens (Specimens 36, 37, and 38, illustrated in Figs. 34, 42, and 50, respectively), are coated with a black corrosion product. These three specimens were photographed a second time after the black corrosion product was removed on one straight wire segment, to illustrate that the aluminum coating was still intact. The cleaned Specimens 36, 37, and 38 are depicted in Figs. 35, 43, and 51, respectively.

Analysis

The average corrosion rate to initial rust for each aluminum-coated product and each zinc-coated product is shown in Tables 14 and 16. The average corrosion rate to complete rust for each aluminum-coated product and each zinc-coated product is shown in Tables 15 and 17. An all-products average and standard deviation for each location are also shown. The all-products average corrosion rates and standard deviations were calculated using the individual corrosion rates for each product at each location from Tables 8 through 12. The standard deviation is a measure of the spread of the individual results around the average. The large standard deviations for the all products averages are not surprising considering the large differences among the individual product averages. Therefore, caution should be used in the interpretation of these average rates. All the data necessary for a more in-depth analysis are contained within this report.

Steel Reinforced Aluminum Conductors

The aluminum conductor steel reinforced (ACSR) specimens at the Kure Beach, North Carolina, 80 ft (25 m) ex-

[6]Reports of Subcommittee A05.15 on Wire Tests, as published in *Proceedings*, American Society for Testing and Materials, through 1977, and from 1980 through present as published annually in the minutes.

posure site are showing signs of corrosion of the internal steel core wire. As detailed earlier in this report, there are a total of twelve conductor specimens exposed at each site, in two styles of six each, conventional stranding and compacted stranding. In both styles, seven all-aluminum wires surround a single steel core wire. The specimens are summarized in Table 18 by style, core wire coating metal and weights, and the coating method.

Because of the surrounding aluminum wires, direct observation of the zinc or aluminum coated steel core wire is not possible. Indirect observation is made by noting the presence of corrosion products in the interstices or cracks between the outer all-aluminum strands and the appearance of bulges produced by internal expansion of corrosion products from the core wire. The terms "fair," "good," and "excellent" are qualitative and refer to the specimen's current appearance as compared to its original new condition.

At the Kure Beach, North Carolina, 80 ft (25 m) site, after 32 years' of exposure, the zinc-coated core wire Specimens 46 and 52 are showing serious signs of internal corrosion. The conventional stranded ACSR, Specimen 46, has three broken outside strands. The compacted strand ACSR, Specimen 52, has similar broken strands and a single bulge. A review of the yearly reports shows the following progression; in 1974 both specimens have the interstices filled with white corrosion product and Specimen 52 has a single bulge at one end, in 1985 broken strands are reported on Specimen 52, and in 1990 broken strands are reported on Specimen 46. The aluminum-coated steel core wire specimens, Nos. 47 through 51 and 53 through 57, appear in fair condition with the interstices filled with white corrosion product but with no bulges or broken strands.

The Kure Beach, North Carolina, 800 ft (250 m) ACSR specimens appear in fair to excellent condition. The zinc-coated core wire specimens appear in fair condition with the interstices filled with white corrosion product but no bulges or broken strands. The aluminum-coated core wire specimens appear in excellent condition with no corrosion product in the interstices.

The Point Reyes, California, ACSR specimens appear in good to excellent condition. The zinc-coated core wire specimens appear in good condition with the interstices completely filled with white corrosion product. This condition was first noted in 1975. The aluminum-coated core wire specimens appear in excellent condition with some partial filling of the interstices on the compacted strand conductors, Nos. 53 to 57. There are no reported bulges or broken strands on any specimens.

At Brazos River, Texas, the interstices are partially to completely filled but the inspector cannot distinguish any difference in appearance between the two core wire coating types. 1983 was the first year that reported the interstices partially filled. There are no reported bulges or broken strands.

The Newark-Kearny, New Jersey, specimens are reported as all 100 G with some black staining and no comment of bulges or broken strands.

At State College, Pennsylvania, there are no indications of corrosion and no mention of bulges or broken strands.

The Manhattan, Kansas, site reports that all the conductor specimens appear 60 M and 40 St. It does not indicate the nature and location of the stain. There are no reported bulges or broken strands. The first appearance of stain was in 1981 on the compacted conductor specimens, Nos. 52 to 57. In 1989, the conventional specimens were reported as 90 M and 10 St, and the compacted specimens were reported 80 M and 20 St. From 1990 to the present, the inspectors have reported 60 M and 40 St.

In summary, the indirect visual indications of corrosion of the ACSR core wire at the Kure Beach 80 ft (25 m) and 800 ft (250 m) and Point Reyes sites suggest that aluminum-coated core wire resists corrosion better than zinc-coated steel core wire at marine coastal sites.

8

Breaking Strength Loss

At four of the eight exposure sites, unfabricated tension test specimens were exposed, and 370 of the original specimens exposed in 1961 (1964 at Warrington) have been removed and tested for breaking strength. Tables 19 through 35 tabulate the results through the 30-year period 1961 to 1991.

Although the data are minimal, statistically meaningful results were obtained from fourteen location-code number sets. Table 36 tabulates the linear regression equation and the coefficient of linear correlation for each set. The coefficient of linear correlation is the measure of the strength of the linear relationship between two variables. Higher ordered equations were considered but rejected, based on the good results obtained by the linear assumption as indicated by the high correlation coefficients. The two variables used in the analysis were the total years of exposure (years exposed) and the percent loss in breaking strength (loss percent). Because no loss in breaking strength was expected before initial rust occurred, an initial point of years to initial rust and zero percent loss in breaking strength was added to each data set. An alternate initial point, years to complete rust and zero percent loss, was considered but rejected because of the possibility of loss in strength between initial and complete rust, particularly for the aluminum-coated wires. For three data sets, points not consistent with the data were removed before the linear equations were generated. These points are indicated in the notes with Table 36.

The statistical analysis of the tensile data showed that the percent loss in breaking strength for bare, zinc-coated, and aluminum-coated wires increased linearly with the years of exposure.

At all four sites Code 1, 9 gage bare copper-bearing wire, Code 2, 9 gage wire with 0.5 oz/ft^2 (153 g/m^2) zinc coating and Code 3, 9 gage wire with 0.99 oz/ft^2 (303 g/m^2) zinc coating had sufficient data to establish a meaningful equation.

The rate of loss of breaking strengths per year is the slope of the calculated line. For uncoated and zinc-coated wire the rates were different for different locations. The maximum difference for bare wire was a ratio of 5.9:1 for Warrington and Newark-Kearny and is calculated as the ratio of the slopes of the linear equations in Table 36 of Warrington to Newark-Kearny, that is, 4.47/0.76 = 5.9. The maximum differences for zinc-coated wires were a ratio of 6.8:1 for Warrington and Newark-Kearny for Code 2 and 12.2:1 for Warrington and Kure Beach for Code 3.

At two sites, Kure Beach and Warrington, Code 1 wire performed better than Code 2 wire. However, the light zinc coat on Code 2 wire offered only a few years of protection. Past that point the comparison is between an uncoated copper-bearing steel and an uncoated noncopper-bearing steel. It appears that the copper-bearing wire, Code 1, outperformed the noncopper-bearing wire, Code 2.

At all four sites the Code 3, 9 gage 0.99 oz/ft^2 (302 g/m^2) zinc-coated wire had sufficient data to establish significant but questionable equations. Note that the maximum loss in strength at Kure Beach and State College are 10.4 and 14.3%, respectively. It is quite possible that until a significant loss in strength has been observed, there will not be sufficient data to determine the true rate of loss of strength.

At the Warrington site Code 11, 9 gage, 0.27 oz/ft^2 (82 g/m^2) aluminum-coated wire, and Code 17, 12 1/2 gage, 0.29 oz/ft^2 (88 g/m^2) aluminum-coated wire had sufficient data to establish meaningful equations. At this site, the Code 11 wire outperformed the Code 17 wire. This result indicates that the rate of loss of breaking strengths per year for aluminum-coated wire decreased with increased wire diameter, which is expected since corrosion is proportional to cross-sectional area. Therefore, smaller diameter wires will lose more area at the same corrosion rate and thus lose more strength.

While the conclusions drawn here are based on a small sample, they are supported by the earlier work done by Reinhart.[7]

Breaking Strengths

Tables 19 through 35 give a summary of breaking strengths on specimens removed during the 30 year period 1961 through 1991.

[7]Reinhart, F. M., *Twenty-Year Atmospheric Corrosion Investigation of Zinc-Coated and Uncoated Wire and Wire Products, ASTM STP 290,* American Society for Testing and Materials, 1961.

9

Summary

This atmospheric exposure investigation of aluminum-coated and zinc-coated wire and wire products was authorized by ASTM Committee A5 on Metallic-Coated Iron and Steel Products and was conducted by its Subcommittee A05.15 on Wire Tests. The data for the 32-year exposure in the United States and 13-year exposure in England were the basis of this report.

The following information is summarized from the visual observations and the tension tests on unfabricated and fabricated wire and wire products:

1. The average corrosion rates to initial rusting (CIR) were less for aluminum-coated products (Table 14) than for zinc-coated products (Table 16).
2. Likewise, the average corrosion rates to complete rust (CCR) were less for aluminum-coated products (Table 15) than for zinc-coated products (Table 17).
3. Based on the average CIR for all aluminum-coated products, the Warrington site has the highest corrosion rate and the Manhattan, Newark-Kearny, and Point Reyes sites have the lowest. For zinc-coated products, the Warrington site has the highest corrosion rate and the Manhattan site has the lowest.
4. Based on the average CCR for all aluminum-coated products, the Warrington site has the highest corrosion rate and the Manhattan and Newark-Kearny sites have the lowest. For zinc-coated products, the Warrington site has the highest corrosion rate and the Manhattan site has the lowest.
5. The statistical analysis of the tension data showed a linear relationship between the percent loss of breaking strength and years of exposure.
6. The rates of loss of breaking strength per year for uncoated and zinc-coated wire were different for different locations. The maximum difference for bare wire was a ratio of 5.9:1 for Warrington and Newark-Kearny. The maximum differences for zinc-coated wires were a ratio of 6.8:1 for Warrington and Newark-Kearny for Code 2 and 12.2:1 for Warrington and Kure Beach-800 ft (250 m) for Code 3.
7. The rate of loss of breaking strength per year for zinc-coated wire decreased with increase in coating weight.
8. The aluminum-coated steel core wire (ACSR) resists corrosion in coastal environments better than the zinc-coated steel core wire.
9. The copper-bearing steel (0.23% copper) wire is more resistant to corrosion than the low copper steel (0.03% copper) wire.

Tables

TABLE 1—Exposure sites.

Exposure Site Number and Location	Type of Atmosphere	Exposure Date	Product Exposed
1. Brazos River, TX	marine	17 July 1961	fabricated
2. Kure Beach, NC (80 ft (25 m))	marine coastal site	22 May 1961	fabricated
3. Kure Beach, NC (800 ft (250 m))	marine coastal site	23 May 1961	fabricated and unfabricated
4. Manhattan, KS	rural	19 July 1961	fabricated
5. Newark-Kearny, NJ[a]	industrial	12 June 1961	fabricated and unfabricated
6. Point Reyes, CA	marine coastal site	21 July 1961	fabricated
7. State College, PA	rural	19 June 1961	fabricated and unfabricated
8. Warrington, England[b]	industrial	1 March 1964	fabricated and unfabricated

[a]Specimens moved from Newark, NJ to Kearny, NJ on 2 July 1970.
[b]Site closed April 1977.

TABLE 2—Process description of test specimens.

Specimen No.	Description	Coating Process
	BARE STEEL	
1	copper-bearing steel, hard drawn	
	ZINC-COATED STEEL	
2, 24, 25, 27, 28, 32, 33	hot dipped	cleaned steel wire coated in a molten bath of zinc
3, 4, 34, 35, 39, 40, 46, 52	electrolytic	cleaned steel wire electroplated in a zinc sulfate bath using insoluble anodes
	ALUMINUM-COATED STEEL	
9, 11, 17, 26, 29, 37, 42, 49, 55	process 1	fluxless molten aluminum-coated method employing vibratory technique on precleaned wire
5, 6, 41, 48, 54	process 2	cleaned steel wire immersed in aqueous flux solution, dried, dipped in silicon-bearing aluminum bath
8, 21, 45, 47, 53	process 3	powdered aluminum is applied to a steel core to produce a composite rod which is subsequently cold drawn to size
7, 19, 51, 57, 58	process 4[a]	straight-line, hot dip method
10, 12, 18, 20, 30, 31, 38, 43, 50, 56, 59	process 5	prefluxed in aqueous solution of fluoride salt and dipped in molten aluminum bath
13, 36	process 6	continuous fluxless hot-dip process
22, 44	process 7	heavy coating applied by patented process

[a]Specimens manufactured by process 4 were dropped from the program after 5 years because the manufacturer informed that the wire was no longer commercially available from process 4.

TABLE 3—Base metal analysis of unfabricated and fabricated wires.

Specimen	Coating	Carbon, %	Manganese, %	Phosphorus, %	Sulfur, %	Silicon, %	Copper, %
		9 GAGE 0.148 in. (3.76 mm) UNFABRICATED TEST WIRE					
No. 1	...	0.09	0.34	0.010	0.026	0.01	0.23
No. 2	Zn	0.08	0.50	0.010	0.021	0.16	0.03
No. 3	Zn	0.04	0.44	0.013	0.032	0.01	0.14
No. 4	Zn	0.05	0.34	0.012	0.033	0.01	0.09
No. 5	Al	0.07	0.45	0.014	0.03	0.01	0.10
No. 6	Al	0.72	0.75	0.015	0.033	0.22	0.14
No. 7[a]	Al	0.06	0.41	0.006	0.035	0.103	0.28
No. 8	Al	0.44	0.81	0.020	0.013	0.21	0.02
No. 9	Al	0.29	0.82	0.011	0.026	0.23	0.03
No. 10	Al	0.23	0.48	0.013	0.042	0.007	...
No. 11	Al	0.22	0.91	0.012	0.019	0.01	...
No. 12	Al	0.26	0.51	0.014	0.046	0.023	...
No. 13	Al	0.25	0.44	0.010	0.027	0.19	0.07
		12 1/2 GAGE 0.099 in. (2.51 mm) UNFABRICATED TEST WIRE					
No. 17	Al	0.18	0.41	0.010	0.027	0.01	0.03
No. 18	Al	0.08	0.49	0.012	0.25	0.005	...
No. 19[a]	Al	0.07	0.41	0.006	0.032	0.103	0.32
No. 20	Al	0.12	0.58	0.012	0.031	0.005	...
No. 21	Al	0.06	0.27	0.034	0.010	0.010	0.03
No. 22	Al	0.72	0.90	0.013	0.024	0.22	...
		ACSR CORE WIRE					
No. 46, 52	Zn	0.66	1.04	0.012	0.032	0.14	0.14
No. 47, 53	Al	0.56	0.86	0.021	0.018	0.19	0.02
No. 48, 54	Al	0.84	0.74	0.015	0.028	0.15	0.11
No. 49, 55	Al	0.82	0.92	0.010	0.032	0.28	trace
No. 50, 56	Al	0.80	0.70	0.013	0.034	0.132	...
No. 51, 57[a]	Al	0.85	0.73	0.011	0.023	0.19	0.10
		LYMAN 4 POINT BARBED WIRE, 12 1/2 GAGE LINE WIRE					
No. 27	Zn	0.10	0.38	0.012	0.021	0.16	0.03
No. 28	Zn	0.08	0.40	0.010	0.025	0.16	0.03
No. 29	Al	0.17	0.40	0.010	0.026	0.01	0.03
No. 30	Al	0.08	0.49	0.012	0.025	0.005	...
No. 31	Al	0.12	0.58	0.012	0.031	0.005	...
		9 GAGE 2 in. (50.8 mm) CHAIN-LINK FABRIC					
No. 32	Zn	0.10	0.59	0.015	0.037	0.13	0.08
No. 33	Zn	0.08	0.38	0.013	0.028	0.18	0.03
No. 34	Zn	0.14	0.38	0.013	0.026	0.01	0.06
No. 35	Zn	0.17	0.41	0.013	0.027	0.02	0.03
No. 36	Al	0.23	0.53	0.008	0.025	0.18	0.08
No. 37	Al	0.29	0.81	0.011	0.030	0.22	0.03
No. 38	Al	0.23	0.48	0.013	0.042	0.007	...
		FARM-FIELD FENCE					
No. 24 line (9 gage)	Zn	0.11	0.43	0.011	0.032	0.19	0.03
No. 24 line (11 gage)	Zn	0.09	0.44	0.010	0.024	0.16	0.03
No. 24 stay (11 gage)	Zn	0.08	0.39	0.015	0.015	0.20	0.07
No. 25 line (9 gage)	Zn	0.11	0.34	0.015	0.026	0.20	0.07
No. 25 stay (9 gage)	Zn	0.11	0.37	0.014	0.027	0.21	0.10
No. 26 line (9 gage)	Al	0.21	0.86	0.013	0.022	0.01	0.10
No. 26 line (11 gage)	Al	0.21	0.83	0.012	0.022	0.01	0.08
No. 26 stay (11 gage)	Al	0.07	0.45	0.010	0.020	0.01	0.03
		3/8 in. (9.53 mm) 7-WIRE STRAND					
No. 39	Zn	0.55	0.91	0.013	0.026	0.17	0.07
No. 40	Zn	0.54	0.95	0.003	0.023	0.14	0.07
No. 41	Al	0.60	0.61	0.020	0.028	0.14	0.06
No. 43	Al	0.79	0.84	0.010	0.024	0.11	...
No. 44	Al	0.65	0.89	0.010	0.017	0.09	...
No. 45	Al	0.45	0.81	0.02	0.013	0.21	0.03
No. 58[b]	Al	0.77	0.66	0.010	0.026	0.15	0.12
		5/16 in. (7.94 mm) 7-WIRE STRAND					
No. 42	Al	0.82	0.80	0.024	0.034	0.22	0.07
No. 59	Al drawn[b]	0.75	0.88	0.013	0.026	0.15	...

[a]Specimens dropped after 5 years (See footnote *a* under Table 2).
[b]Drawn after coating.

TABLE 4—Coating weights and processes of test specimens.

Specimen	Zinc, oz/ft^2 (g/m^2)		Aluminum, oz/ft^2 (g/m^2)	
	Hot Dipped	Electroplated	Hot dipped	Powder Metallurgy
Unfabricated 9 gage	0.50 (153)	0.99, 2.84 (302, 867)	(light weight) 0.27 (82) (heavy weight) 0.48 to 0.63 (146 to 192)	2.44 (745)
Unfabricated 12 1/2 gage	...	...	0.21, 0.29, 0.37, 0.43 (64, 88, 113, 131)	1.76, 3.36 (537, 1025)
ACSR core	...	0.87 (265)	0.30, 0.34, 0.43, 0.45 (92, 104, 131, 137)	1.92 (586)
Barbed wire	0.43, 0.97	...	0.25, 0.39, 0.42 (76, 119, 128)	...
Chain link fabric	1.77, 2.81 (540, 857)	1.53, 2.23 (467, 680)	0.44, 0.54, 0.57 (134, 165, 174)	...
Field fence fabric	0.36, 0.42, 0.49, 0.99 (110, 128, 150, 302)	...	0.27, 0.38, 0.43 (82, 116, 131)	...
High-strength strand	...	0.99, 2.98 (302, 909)	0.32, 0.33, 0.43, 0.49 (98, 101, 131, 150)	2.26, 4.54 (690, 1385)

TABLE 5—Coating data on test specimens.

Specimen Number	Metal	Weight		Analysis, %		Coating Thickness, mil		Thickness, μm	
		oz/ft²	g/m²	Iron	Silicon	min	max	min	max
1[a]									
2[b]	Zn	0.50	153	10	...	0.54	0.84	14	21
3[b]	Zn	0.99	302	trace	...	1.58	1.76	40	45
4[b]	Zn	2.84	867	trace	...	4.42	4.62	112	117
5[b]	Al	0.52	159	4.10	1.70	0.65	4.07	17	103
6[b]	Al	0.54	165	2.80	1.90	0.96	2.94	24	75
7[b]	Al	0.27	82	22.31	1.10	0.80	2.30	20	58
8[b]	Al	2.44	745	0.084	0.005	8.80	11.5	224	292
9[b]	Al	0.48	146	2.52	2.82	0.97	3.06	25	78
10[b]	Al	0.51	156	1.50	2.81	0.78	2.59	20	66
11[b]	Al	0.27	82	1.30	2.96	0.60	2.36	15	60
12[b]	Al	0.48	146	0.98	4.43	0.945	3.70	24	94
13[b]	Al	0.63	192	0.61	0.057	1.70	4.80	43	122
17[c]	Al	0.29	88	1.20	2.70	0.66	2.24	17	57
18[c]	Al	0.43	131	1.24	2.91	1.73	2.60	44	66
19[c]	Al	0.21	64	20.25	0.93	0.70	2.70	18	69
20[c]	Al	0.37	113	1.29	4.71	1.02	2.60	26	66
21[c]	Al	1.76	537	0.08	0.006	5.1	8.7	130	221
22[c]	Al	3.36	1025	0.47	0.69	11.9	15.3	302	389
24[d]	Zn	0.49	150	8.7	...	0.64	1.31	16	33
24[e]	Zn	0.42	128	11.4	...	0.42	1.21	11	31
24[f]	Zn	0.36	110	10.0	...	0.42	0.80	11	20
25[e]	Zn	1.00	305	3.5	...	1.10	1.83	28	46
25[g]	Zn	0.99	302	4.3	...	0.92	2.16	23	55
26[d]	Al	0.43	131	1.72	2.98	0.81	4.20	21	107
26[e]	Al	0.38	116	1.57	6.08	0.66	3.52	17	89
26[f]	Al	0.27	82	2.05	3.91	0.68	1.45	17	37
27[h]	Zn	0.43	131	15	...	0.30	0.81	8	21
28[h]	Zn	0.97	296	9.2	...	1.01	2.95	26	75
29[h]	Al	0.25	76	1.34	2.92	0.60	2.41	15	61
30[h]	Al	0.42	128	1.24	2.91	1.73	2.60	44	66
31[h]	Al	0.39	119	1.29	4.71	1.02	2.60	26	66
32[i]	Zn	1.77[j]	540[j]	4.25	...	0.63	1.96	16	50
33[i]	Zn	2.81	857	5.07	...	3.00	4.90	76	124
34[k]	Zn	1.53	467	trace	...	2.29	2.61	58	66
35[k]	Zn	2.23	680	trace	...	3.45	3.87	88	98
36[l]	Al	0.57	174	1.21	0.035	1.0	4.4	25	112
37[l]	Al	0.44	134	1.60	2.80	0.79	3.18	20	81
38[l]	Al	0.54	165	1.50	2.81	0.945	3.700	24	94
39[m]	Zn	0.99	302	trace	...	1.37	1.48	35	38
40[m]	Zn	2.98	909	trace	...	4.50	4.71	114	120
41[m]	Al	0.43	131	5.1	3.1	0.40	2.76	10	70
42[n]	Al	0.33	101	0.86	3.24	0.47	2.72	12	69
43[m]	Al	0.49	150	0.97	4.47	1.65	2.52	42	64
44[m]	Al	4.54	1385	0.17	0.047	12.0	18.0	305	457
45[m]	Al	2.26	690	0.090	0.007	7.4	9.6	188	244
46, 52[o]	Zn	0.87	265	trace	...	1.46	1.58	37	40
47, 53[o]	Al	1.92	586	0.080	0.006	6.2	10.3	157	262
48, 54[o]	Al	0.45	137	4.20	0.70	0.91	2.84	23	72
49, 55[o]	Al	0.34	104	1.0	4.0	0.28	2.16	7	55
50, 56[o]	Al	0.43	131	0.49	4.93	1.0	3.9	25	99
51, 57[o]	Al	0.30	92	8.59	3.91	0.50	2.60	13	66
58[p]	Al	0.30	92	9.24	3.14	0.70	2.10	18	53
59[q]	Al	0.32	98	1.57	3.30	0.70	2.60	18	66

[a]Plain copper-bearing steel; 9 gage, 0.148 in. (3.76 mm) unfabricated wire.
[b]9 gage, 0.148 in. (3.76 mm) unfabricated test wire.
[c]12 1/2 gage, 0.099 in. (2.51 mm) unfabricated test wire.
[d]9 gage, 0.148 in. (3.76 mm) farm-field fence top/bottom wire.
[e]11 gage, 0.120 in. (3.05 mm) farm-field fence line wire.
[f]11 gage, 0.120 in. (3.05 mm) farm-field fence stay wire.
[g]9 gage, 0.148 in. (3.76 mm) farm-field fence stay wire.
[h]12 1/2 gage, 0.099 in. (2.51 mm) Lyman 4-point barb, barbed wire line wire.
[i]9 gage, 0.148 in. (3.76 mm) chain link fabric, hot-dip zinc-coated after weaving.
[j]An apparent inconsistency between the reported coating weight and the min/max coating thickness was investigated. Based chiefly on specimens taken in 1983 of the fence at Manhattan, Kansas, we believe the weight of 1.77 oz/ft² (540 g/m²) and the minimum thickness of 0.63 mil (16 μm) to be accurate and the maximum thickness of 1.96 mil (50 μm) to be understated by a factor of at least 2.5. This does not affect the printed results.
[k]9 gage, 0.148 in. (3.76 mm) chain link fabric, zinc electroplated before weaving.
[l]9 gage, 0.148 in. (3.76 mm) chain link fabric, hot-dip aluminum-coated before weaving.
[m]3/8 in. (9.53 mm) 7-wire strand.
[n]5/16 in. (7.94 mm) 7-wire strand.
[o]ACSR core wire.
[p]3/8 in. (9.53 mm) 7-wire strand, drawn after aluminum coating.
[q]5/16 in. (7.94 mm) 7-wire strand, drawn after aluminum coating.
NOTE—Specimen 14, 15, 16, and 23 were not included in this test.

TABLE 6—Initial mechanical properties of unfabricated wires.

Specimen Number	Coating Metal	Coating Weight oz/ft²	Coating Weight g/m²	Diameter in.	Diameter mm	Breaking Strength lbf	Breaking Strength N	Tensile Strength ksi	Tensile Strength MPa	Elongation in 10 in. (254 mm), %	Reduction of Area, %
1	..	...	...	...	...	1723	7 660	100	690	0.9	53.7
2	Zn	0.50	153	0.148	3.76	1487	6 610	87	600	5.8	55.2
3	Zn	0.99	302	0.146	3.71	1058	4 710	63	435	11.4	48.2
4	Zn	2.84	867	0.150	3.81	1030	4 580	58	400	11.6	55.6
5	Al	0.52	159	0.150	3.81	1040	4 630	59	405	13.2	51.4
6	Al	0.54	165	0.149	3.78	2885	12 830	165	1140	9.6	53.8
7	Al	0.27	82	0.148	3.76	1245	5 540	72	495	11.5	50.3
8	Al	2.44	745	0.149	3.78	3077	13 690	177	1220	2.2	56.3
9	Al	0.48	146	0.144	3.66	1617	7 190	99	685	9.8	51.7
10	Al	0.51	156	0.149	3.78	1438	6 400	83	570	9.5	54.4
11	Al	0.27	82	0.148	3.76	1488	6 620	86	595	9.7	57.4
12	Al	0.48	146	0.148	3.76	1407	6 260	83	570	11.3	48.4
13	Al	0.63	192	0.150	3.81	1423	6 330	80	550	10.8	55.4
17	Al	0.29	88	0.098	2.49	487	2 170	64	440	12.2	60.1
18	Al	0.43	131	0.103	2.62	490	2 180	59	405	15.7	75.4
19	Al	0.21	64	0.102	2.59	558	2 480	68	470	10.9	64.3
20	Al	0.37	113	0.102	2.59	565	2 510	75	515	5.8	59.5
21	Al	1.76	537	0.0985	2.50	768	3 420	101	695	1.9	42.5
22	Al	3.36	1025	0.0980	1.49	1012	4 500	135	930	1.5	51.8

NOTE
Procedure utilized three 18-in. replicates for the Method of Tension Testing of Steel Wire (Procedure A 318). Free-running crosshead speed was 1/2 in. (12.7 mm) per min.
A 318 has since been replaced by A 370, Test Methods and Definitions for Mechanical Testing of Steel Products.

TABLE 7—Description of aluminum conductor wire used in fabrication of No. 4, 7/1 aluminum conductor, steel reinforced, conventional and compacted.

Physical Parameter	Conventional Specified	Conventional Actual	Compacted Specified	Compacted Actual
Average diameter, in. (mm)	...	0.0767 (1.95)	...	0.0824 (2.09)
Elongation in 10 in. (254 mm), %	1.4	1.8	...	1.8
Average tensile strength, ksi (MPa)	28 (195)	29 (200)	28 (195)	29 (200)
Conductivity, % of International Annealed Copper Standard	61	62.1	61	62.2
Wrap test turns	5	passed	5	passed
CHEMICAL ANALYSIS, %				
Copper	...	0.02	...	0.02
Iron	...	0.12	...	0.13
Silicon	...	0.06	...	0.06
Boron	...	0.01	...	0.01
Manganese	...	0.004	...	0.004
Titanium	...	<0.002	...	<0.002
Vanadium	...	<0.002	...	<0.002
Magnesium	...	<0.001	...	<0.001
Chromium	...	<0.002	...	<0.002
Zinc	...	<0.01	...	<0.01
Gallium	...	0.01	...	0.01
Aluminum	...	99.77	...	99.76

TABLE 8—1961 exposure of zinc and aluminum coated unfabricated wire[a] average of observed years until initial rust (IR) and complete rust (CR) or condition after approximately 32-years exposure and calculated corrosion rates (ounces per square foot per year)[b] to initial rust (CIR) and to complete rust (CCR).

Wire No. and Coating				Kure Beach, NC (800 ft)					Newark-Kearny, NJ					State College, PA					Warrington, England[c]				
No.	Ctg.	Gage	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
1	Steel[d]	9	Bare	100R	0		0		100R	0		0		100R	0		0			0		0	
2	Zn	9	0.50	Scrapped	5.0	0.100	9.1	0.055	100R	3.0	0.167	3.9	0.128	100R	7.9	0.063	9.8	0.051		2.8	0.179	3.8	0.132
3	Zn	9	0.99	100R	9.1	0.109	28.1	0.035	100R	5.9	0.168	6.9	0.143	100R	17.0	0.058	22	0.045		4.7	0.211	4.7	0.211
4	Zn	9	2.84	95wc,5Y	23.1	0.123			100R	15.8	0.180	22	0.129	100G						13.2	0.215		
5	Al	9	0.52	80G,10wc, 10Y,trPPR					95blk, 5PPR	27.1	0.019			10G,70Y, 20PPR	9.8	0.053				7.8	0.067		
6	Al	9	0.54	85G,10wc, 4Y,1PPR	32.3	0.017			80blk,10brst, 10PHR	25.0	0.022			5G,60Y, 35PPR	8.9	0.061				10.9	0.050		
8	Al	9	2.44	80G,20wc					95G,5blk					100M									
9	Al	9	0.48	80G,20wc, trY,trPPR					95blk,5PPR	28.3	0.017			85G,13st, 2PPR	21.0	0.023				8.5	0.056		
10	Al	9	0.51	80G,20wc, trY,trPPR					85blk, 15PHR	26.4	0.019			60G,10Y, 30PHR	8.9	0.057				7.8	0.065		
11	Al	9	0.27	70G,10wc, 20R	10.0	0.027			40blk,10brst, 50PHR	8.9	0.030			25G,35Y, 40R	8.9	0.030				4.7	0.057	8.5	0.032
12	Al	9	0.48	40G,45wc, 15R	20.2	0.024			85blk, 15PPR	26.4	0.018			55G,30Y, 15PPR	11.0	0.044				9.4	0.051		
13	Al	9	0.63	5M,75G, 20wc,trPPR					60G,15br, 20blk,5PPR	29.2	0.022			100G, trPPR									
17	Al	12 1/2	0.29	100R	10.0	0.029	32.3	0.009	50blk,25PPR, 25PHR	19.1	0.015			30G,40Y, 30PPR	8.9	0.033				4.7	0.062	7.8	0.037
18	Al	12 1/2	0.43	60G,40wc, trPPR					90blk, 10PPR	25.0	0.017			40G,40Y, 20PPR	9.8	0.044				5.8	0.074		
20	Al	12 1/2	0.37	20wc,80R	9.1	0.041			90blk, 10PHR	19.1	0.019			50Y, 20PPR,30R	8.9	0.042				5.8	0.064		
21	Al	12 1/2	1.76	80G,20wc					100G					100M									
22	Al	12 1/2	3.36	50G,50wc					100G,trblk					100M									

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.
[b] 1 oz/ft² = 305.15 g/m²
[c] Warrington, England site closed in 1977; other sites still active.
[d] Copper-bearing steel.

TABLE 9—1961 **exposure of zinc and aluminum coated farm-field fence**[a] average of observed years until initial rust (IR) and complete rust (CR) or condition after approximately 32-years exposure and calculated corrosion rates (ounces per square foot per year)[b] to initial rust (CIR) and to complete rust (CCR).

Fence Number and Coating					Brazos River, TX					Kure Beach, NC 80 ft					Kure Beach, NC 800 ft					Manhattan, KS				
No.	Coating	Item	Gage	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
24	Zn	Top	9	0.49	100 R	3.2	0.153	7.1	0.069	100 R	3	0.163	6.3	0.078	100 R	5	0.098	7.3	0.067	10Y, 90R	25	0.020		
		Line	11	0.42	100 R	1.2	0.350	7.1	0.059	100 R	2	0.210	7.3	0.058	100 R	4	0.105	9.1	0.046	5Y, 95R	25	0.017		
		Stay	11	0.36	100 R	2.2	0.164	7.1	0.051	100 R	2	0.180	7.3	0.049	100 R	4	0.090	7.3	0.049	100R	21.1	0.017	32.1	0.011
		Bottom	9	0.49	100 R	4.2	0.117	9.3	0.053	100 R	4	0.123	7.3	0.067	100 R	10	0.049	15	0.033	100Y				
		Wraps	-	-	100 R	2		7.1		100 R	1		7.3		100 R	5		9.1		10Y, 90R	22			
		Cut Ends	-	-	100 R	1.2		4.2		100 R	4		7.3		100 R	7.3		7.3		100R	21.1		25	
25	Zn	Top	9	1.00	100 R	10.3	0.097	20.8	0.048	100 R	2	0.500	15	0.067	100R	5	0.200	19.1	0.052	95G, 5Y				
		Line	9	1.00	100 R	10.3	0.097	19	0.053	100 R	4	0.250	15	0.067	100R	7.9	0.127	29.2	0.034	90G, 10Y				
		Stay	9	0.99	100 R	9.3	0.106	13.3	0.074	100 R	4	0.248	15	0.066	100R	5	0.198	19.1	0.052	90G, 10Y				
		Bottom	9	1.00	100 R	10.3	0.097	22.2	0.045	100 R	7.3	0.137	15	0.067	10G, 10wc, 80R	24.2	0.041			95G, 5Y				
		Wraps	-	-	100 R	10.3		22.2		100 R	2		15		100R	7.3		22.2		85G, 15Y				
		Cut Ends	-	-	100 R	1.2		8.2		100 R	7.3		8		100R	9.1		22.2		75Y, 25R	29.1			
26	Al	Top	9	0.43	50 R	9.3	0.046	[d]		100 R	9.1	0.047	15	0.029	10Y, 90R	11	0.039			15M, 85st				
		Line	11	0.38	10 R	19	0.020	[d]		100 R	9.1	0.042	15	0.025	5M, 35G, 40wc, 10Y, 10R	11	0.035			60M, 40st				
		Stay	11	0.27	100 R	2.2	0.123	10.3	0.026	100 R	8.3	0.043	12	0.023	100R	10	0.027	32.3	0.008	10M, 90st				
		Bottom	9	0.43	10 R	11.3	0.038	[d]		100 R	11	0.039	15	0.029	70M, 20Y, 10R	29.2	0.015			85M, 15st				
		Wraps	-	-	100 R	3.2		10.3		100 R	6.3		9.1		100R	9.1		29.2		90Y, 10R	27.1			
		Cut Ends	-	-	100 R	1.2		3.2		100 R	7.3		8		100R	2		15		100R	1.1		14.2	

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.

[b] 1 oz/ft² = 305.15 g/m²

[c] Warrington, England site closed in 1977; other sites still active.

[d] Sample failed before CR.

TABLE 9—*Continued.*

Fence Number and Coating					Newark-Kearny, NJ					Point Reyes, CA					State College, PA					Warrington, England[c]				
No.	Coating	Item	Gage	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
24	Zn	Top	9	0.49	100 R	3	0.163	3.9	0.126	100 R	18	0.031	20.2	0.024	100 R	8.9	0.071	9.8	0.050		1.8	0.272	3.8	0.129
		Line	11	0.42	100 R	3	0.140	4.9	0.066	100 R	6.3	0.067	17.8	0.024	100 R	7.9	0.053	11	0.038		1.8	0.233	3.8	0.111
		Stay	11	0.36	100 R	1.9	0.189	4.9	0.073	100 R	10.3	0.035	14.3	0.025	100 R	8.9	0.052	8.9	0.040		1.8	0.200	3.8	0.095
		Bottom	9	0.49	100 R	5.9	0.083	8.9	0.071	100 R	20.2	0.024	[d]		100 R	9.8	0.050	13.8	0.036		1.8	0.272	3.8	0.129
		Wraps	-	-	100 R	3		4.9		100 R	12.1		14.3		100 R	5.9		11			1.8		3.8	
		Cut Ends	-	-	100 R	1.9		5.9		100 R	10.3		14.3		100 R	5.9		7.9			0.8		3.8	
25	Zn	Top	9	1.00	100 R	4.9	0.204	8.9	0.145	100 R	14.3	0.070	20.2	0.050	100 R	15.8	0.063	23	0.043		3.8	0.263	3.8	0.263
		Line	9	1.00	100 R	4.9	0.204	8.9	0.145	5wc, 95R	10.3	0.097			100 R	15.8	0.083	24	0.042		3.8	0.263	4.7	0.213
		Stay	9	0.99	100 R	4.9	0.202	8.9	0.111	100 R	8.3	0.157	21.2	0.047	100 R	14.9	0.066	23	0.043		3.8	0.261	3.8	0.261
		Bottom	9	1.00	100 R	8.9	0.145	8.9	0.112	70wc, 30R	23.2	0.043			60Y, 40R	23	0.043				3.8	0.263	8.9	0.145
		Wraps	-	-	100 R	5.9		8.9		5wc, 95R	10.3				5Y, 95R	24					3.8		3.8	
		Cut Ends	-	-	100 R	3		7.9		100 R	6.3		10.3		100 R	7.9		7.9			2.8		3.8	
26	Al	Top	9	0.43	90blk, 10PHR	27.1	0.016			90wc, 10R	20.2	0.021			85G, 15PPR	11	0.039				7.8	0.055		
		Line	11	0.38	85blk, 15PPR	25	0.015			90wc, 10R	20.2	0.019			90G, 10PPR	9.8	0.039				7.8	0.049		
		Stay	11	0.27	80blk, 20PPR	15.8	0.017			100 R	8.3	0.033	17.8	0.015	100 R	9.8	0.028	24	0.011		5.8	0.047	7.8	0.035
		Bottom	9	0.43	80blk, 20PPR	9.8	0.044			95wc, 5R	20.2	0.021			95G, 5PPR	23	0.019				7.8	0.055		
		Wraps	-	-	75blk, 25PPR	20.2				100R	8.3		10.3		10Y, 90R	7.9		24			8.9		7.8	
		Cut Ends	-	-	100R	23		30		100 R	1.2		5.3		100 R	0.9		7.9			0.7		0.7	

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.

[b] 1 oz/ft² = 305.15 g/m²

[c] Warrington, England site closed in 1977; *other sites still active.*

[d] Sample failed before CR.

TABLE 10—1961 exposure of zinc and aluminum coated lyman 4-point barbed wire[a] average of observed years until initial rust (IR) and complete rust (CR) or condition after approximately 32-years exposure and calculated corrosion rates (ounces per square foot per year)[b] to initial rust (CIR) and to complete rust (CCR).

Wire No. and Coating					Brazos River, TX					Kure Beach, NC 80 ft					Kure Beach, NC 800 ft					Manhattan, KS				
No.	Coating	Item	Gage	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
27	Zn	line	12.5	0.43		1.2	0.358	7.1	0.061		4	0.108	7.3	0.059		4	0.108	8	0.054	100 R	20.1	0.021	25	0.017
		barb				1.2	0.358	8.3	0.068		1.2	0.358	7.3	0.059		2	0.215	7.3	0.059	100 R	13.2	0.033	19.3	0.022
28	Zn	line	12.5	0.97		8.3	0.154	20.8	0.047		4	0.243	18	0.061		8.3	0.154	17.1	0.057	90G, 10Y				
		barb				1.2	0.808	20.8	0.047		1	0.970	18	0.061		8.3	0.154	17.1	0.057	80G, 15Y, 5R	25.8	0.038		
29	Al	line	12.5	0.25		7.1	0.035	14.4	0.017		7.3	0.034	10	0.025		7.3	0.034	22.2	0.011	5M, 75st, 20Y				
		barb				1.2	0.208	8.3	0.040		1.2	0.208	8	0.031		2	0.125	18	0.018	5M, 75st, 20R	13.2	0.019		
30	Al	line	12.5	0.42		8.3	0.067	[d]			9.1	0.046	[d]		75G, 20wc, 5Y, trR	7.3	0.058			15M, 85st				
		Al barb																						
31	Al	line	12.5	0.39		8.3	0.082	24.5	0.018		8.3	0.082	[d]		10Y, 75wc, 15R	7.3	0.053			15M, 85st				
		Al barb																						

Wire No. and Coating					Newark-Kearny, NJ					Point Reyes, CA					State College, PA					Warrington, England[c]				
No.	Coating	Item	Gage	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
27	Zn	line	12.5	0.43		3	0.143	3.9	0.110		13.1	0.033	14.3	0.030		5.9	0.073	9.8	0.044		2.8	0.154	3.8	0.113
		barb				1.9	0.226	3.9	0.110		9.8	0.044	9.8	0.044		5.9	0.073	7.9	0.054		0.8	0.538	3.8	0.113
28	Zn	line	12.5	0.97		4.9	0.198	8.9	0.141		4.2	0.231	10.3	0.094		19.1	0.051	24	0.040		3.8	0.255	4.7	0.206
		barb				3.9	0.249	8.9	0.141		4.2	0.231	9.8	0.099		13.8	0.070	23	0.042		0.8	1.213	3.8	0.255
29	Al	line	12.5	0.25	20PHR, 20brst,60blk	19.1	0.013				5.3	0.047	20.2	0.012	60Y, 20PPR,20R	8.9	0.028				5.8	0.043	5.8	0.043
		barb			40blk, 40R 20brst	9.8	0.026				1.2	0.208	11	0.023	100R	8.9	0.028	32.1	0.008		0.8	0.313	5.8	0.043
30	Al	line	12.5	0.42	90blk, 10PPR	27.1	0.015			95wc, 5R	11	0.038			35st, 35Y, 20PPR, 10R	8.9	0.047				7.8	0.054		
		Al barb																						
31	Al	line	12.5	0.39	85blk, 15PPR	25	0.018			50wc, 50R	9.8	0.040			65Y, 25PPR,10R	8.9	0.044				8.9	0.057	13.2	0.030
		Al barb																						

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.
[b] 1 oz/ft² = 305.15 g/m²
[c] Warrington, England site closed in 1977; other sites still active.
[d] Sample failed before CR.

TABLE 11—1961 exposure of zinc and aluminum coated chain link fence[a] average of observed years until initial rust (IR) and complete rust (CR) or condition after approximately 32-years exposure and calculated corrosion rates (ounces per square foot per year)[b] to initial rust (CIR) and to complete rust (CCR).

Wire No. and Coating					Brazos River, TX					Kure Beach, NC (80 ft)					Kure Beach, NC (800 ft)					Manhattan, KS				
No.	Ctg.	Ga.	oz/ft^2	Item	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
				Barbs	100R	9.3	0.190	19	0.093	buried	11	0.161			100R	6.3	0.261	22.2	0.080	33G, 67Y				
32	Zn	9	1.77	Links	100R	9.3	0.190	31.2	0.057	100R	4	0.443	29.2	0.061	100R	5	0.354	32.3	0.055	40G, 60Y				
				Knuckles	buried					100R	5	0.354	28.1	0.063	buried					40G, 60Y				
				Barbs	80wc, 20R	19	0.148			buried					100R	7.3	0.385	32.3	0.087	37G, 63Y				
33	Zn	9	2.81	Links	40wc, 60R	19	0.148			100R	7.3	0.385	32.3	0.087	10G,30wc, 60R	7.3	0.385			40G, 60Y				
				Knuckles	buried					100R	7.3	0.385	32.3	0.087	buried					40G, 60Y				
				Barbs	10wc, 90R	8.2	0.187								100R	7.3	0.210	29.2	0.052	50G, 50Y				
34	Zn	9	1.53	Links	10wc, 90R	20.6	0.074				4	0.383	17.1	0.089	5G,35wc, 60R	11	0.139			100G				
				Knuckles	buried	20.6	0.074				4	0.383	17.1	0.089	buried					100G				
				Barbs	90wc, 10R	20.8	0.107								100R	9.1	0.245	32.3	0.069	60G, 40Y				
35	Zn	9	2.23	Links	85wc, 15R	20.8	0.107				5	0.446	23.1	0.097	10G,60wc, 30R	19.2	0.116			100G				
				Knuckles	buried						5	0.446	23.1	0.097	buried					100G				
				Barbs	100R	10.3	0.055	22.2	0.026	buried					20wc,10Y, 70R	7.3	0.078			10M, 35Y, 55R	19.3	0.030		
36	Al	9	0.57	Links	65G,15wc, 20R	20.6	0.027			trM, 40G, 20Y, 40R	10	0.057			10M,78G, 10wc,2R	21.2	0.027			35M, 65G				
				Knuckles	buried					100R	6.3	0.090	20.2	0.026	buried					35M, 65G				
				Barbs	100R	10.3	0.043	14.4	0.031						100R	8.3	0.070	28.1	0.018	20Y, 25st, 55R	19.3	0.023		
37	Al	9	0.44	Links	15G,60wc, 25R	19	0.023				6	0.055			5M,74G, 20wc,1R	21.2	0.021			40M, 60st				
				Knuckles	buried						7.3	0.060	30.2	0.015	buried					40M, 60st				
				Barbs	100R	10.3	0.052	22.2	0.024	buried	19.2	0.028			20G,20wc, 10Y,50R	7.3	0.074			48st,52R	19.3	0.028		
38	Al	9	0.54	Links	60G,30wc, 10R	20.6	0.026			25G, 25Y, 50R	9.1	0.059			10M,50G, 40wc,trY,trR	11	0.049			40M,60st				
				Knuckles	buried					100R	7.3	0.074	25.1	0.022	buried					40M,60st				

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.
[b] $1\ oz/ft^2 = 305.15\ g/m^2$
[c] Warrington, England site closed in 1977; other sites still active.
[d] Sample failed before CR.

TABLE 11—*Continued.*

Wire No. and Coating					Newark-Kearny, NJ					Point Reyes, CA					State College, PA					Warrington, England[c]				
No.	Ctg.	Ga.	oz/ft^2	Item	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
				Barbs	100R	8.9	0.199	28.3	0.063	50wc, 50R	9.8	0.181			70Y, 30R	28	0.063				7.8	0.227		
32	Zn	9	1.77	Links	100R	8.9	0.257	23	0.077	40wc, 60R	9.8	0.181			5Y, 95R	14.9	0.119				4.7	0.377	8.5	0.208
				Knuckles	buried	11.9	0.149			100wc·	9.8	0.181			5G,5Y,90R	14.9	0.119				5.8	0.305	9.4	0.188
				Barbs	100R	9.8	0.287	28.3	0.099	75wc, 25R	22.4	0.125			100G						7.8	0.360	9.4	0.299
33	Zn	9	2.81	Links	100R	8.9	0.318	28.3	0.099	95wc, 5PPR	24.3	0.118			5G, 95Y						8.9	0.407	9.4	0.299
				Knuckles	buried					95wc, 5R	29.1	0.097			1G, 99Y						7.8	0.360	9.4	0.299
				Barbs	100R	5.9	0.259	8.9	0.172	5wc, 95R	20.2	0.078			100G						8.9	0.222	7.8	0.196
34	Zn	9	1.53	Links	100R	5.9	0.259	23	0.067	20G, 25wc, 55R	17.8	0.087			100G						6.9	0.222	9.4	0.163
				Knuckles	100R	11	0.139	23	0.067	85wc, 35R	20.2	0.078			50G, 50R	22	0.070				8.9	0.222	8.5	0.180
				Barbs	100R	8.9	0.251	19.1	0.117	95wc, 5PPR	24.3	0.092			100G						8.5	0.262		
35	Zn	9	2.23	Links	100R	8.9	0.251	23	0.097	20G, 72wc, 8R	24.3	0.092			100G						7.8	0.286		
				Knuckles	100R	19.1	0.117	23	0.097	90wc, 10R	24.3	0.092			95G, 5R	32.1	0.069				10.9	0.205	13.2	0.169
				Barbs	30G, 70blk					95wc, 5R	24.3	0.023			100G									
36	Al	9	0.57	Links	25G,75blk	27.1	0.021			50M, 50G					100G,trY, trPPR	19.1	0.030							
				Knuckles	90blk 10PPR	9.8	0.058			100wc, trR					25G,65Y, 10R	8.9	0.064							
				Barbs	85blk, 15PPR	29.2	0.015			20wc, 80R	10.3	0.043			80G,20Y						8.5	0.052		
37	Al	9	0.44	Links	·90blk, 10PPR	26.4	0.017			95wc,5PPR	24.3	0.018			65G,20Y, 15PPR	8.9	0.049				8.5	0.052		
				Knuckles	buried	9.8	0.045			90wc,10R	23.2	0.019			15G,75Y, 10PPR	8.9	0.049				10.9	0.040		
				Barbs	100blk	19.1	0.028			85wc, 15R	11	0.049			95G,5Y						7.8	0.069	13.2	0.041
38	Al	9	0.54	Links	100blk	24.1	0.022			95wc,5PPR	24.3	0.022			80G,5Y, 15PPR	8.9	0.061				7.8	0.069		
				Knuckles	buried	9.8	0.055			100wc,trR					70G,25Y, 5PPR	9.8	0.055				7.8	0.069		

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.
[b] 1 oz/ft^2 = 305.15 g/m^2
[c] Warrington, England site closed in 1977; other sites still active.
[d] Sample failed before CR.

TABLE 12—1961 exposure of zinc and aluminum coated 7-wire strand[a] average of observed years until initial rust (IR) and complete rust (CR) or condition after approximately 32-years exposure and calculated corrosion rates (ounces per square foot per year)[b] to initial rust (CIR) and to complete rust (CCR).

Strand Number and Coating				Brazos River, TX					Kure Beach, NC 80 ft					Kure Beach, NC 800 ft					Manhattan, KS				
No.	Coating	Size	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
39	Zn	3/8"	0.99	50G,45wc, trY,5R	31.2	0.032			40wc, 60R	7.3	0.136			30G,60wc, trY,10R	20.2	0.049			50G,50Y				
40	Zn	3/8"	2.98	49G,45wc, trY,5R	28.1	0.114			90wc,10R	20.2	0.148			50wc,50G					50G,50Y				
41	Al	3/8"	0.43	50G,30wc, 20R	28.1	0.016			83G,10wc, 5Y,2R	21.2	0.020			trM,80G, 20wc					20M,80st				
42	Al	5/16"	0.33	70G,10wc, 20R	28.1	0.013			10G,30Y 60R	19.2	0.017			15M,75G, 10wc					25M,75st				
43	Al	3/8"	0.49	75G,15wc, 10R	7.1	0.069			78G,15Y, 7R	10.0	0.049			10M,80G, 10wc					25M,75st				
44	Al	3/8"	4.54	90G,5wc, 5R	32.1	0.141			75G,25Y					85G,15wc					50M,50st				
45	Al	3/8"	2.26	90G,5wc, 5R	32.1	0.070			75G,25Y					85G,15wc					50M,50st				
59	Al Dr. A/Ctg.	5/16"	0.39	15G,45wc, 40R	10.3	0.038			15Y,85R	6.0	0.049			50G,45wc, 5Y,trR	11.0	0.035			15M,85st				

Strand Number and Coating				Newark-Kearny, NJ					Point Reyes, CA					State College, PA					Warrington, England[c]				
No.	Coating	Size	oz/ft²	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR	32-Year Condition	IR	CIR	CR	CCR
39	Zn	3/8"	0.99	100R	6.9	0.143	22.0	0.045	50wc,50R	6.9	0.143			20G,45Y, 35R	25.9	0.038				5.8	0.171	9.4	0.105
40	Zn	3/8"	2.98	40G,60brst, trR					85wc,15R	20.2	0.148			100G									
41	Al	3/8"	0.43	95blk, 5PPR	8.9	0.048			100R	9.8	0.044	14.3	0.030	45G,40Y 15PHR	8.9	0.048							
42	Al	5/16"	0.33	80blk, 20PHR	8.9	0.037			100R	9.8	0.034	23.2	0.014	80G, 20PPR	8.9	0.037				6.5	0.039		
43	Al	3/8"	0.49	90blk, 10PPR	8.9	0.055			100R	8.3	0.059	9.8	0.050	55G,20Y, 25PPR	9.8	0.050							
44	Al	3/8"	4.54	95G, 5 blk st					5M,95wc					100G									
45	Al	3/8"	2.26	100G, tr blk st					10M,90st					100G									
59	Al Dr. A/Ctg.	5/16"	0.39	75blk, 15PPR,10R	11.0	0.035			5wc,95R	11.0	0.035			30G,35Y, 35R	7.9	0.049				6.9	0.057		

[a] Abbreviations and symbols explained in Table 13. Figures preceding abbreviations are average percentages.

[b] 1 oz/ft² = 305.15 g/m²

[c] Warrington, England site closed in 1977; other sites still active.

[d] Sample failed before CR.

TABLE 13—Wire condition abbreviations and symbols used in Tables 8 through 12.

M	=	metallic
G	=	gray
MG	=	intermediate between "metallic" and "gray"
GY	=	predominantly gray but showing indications of yellow
Y	=	yellowed or rust stained but not showing actual rust of base metal
R	=	rough rust of base metal
rg	=	reddish gold discoloration
mo	=	mottled—various shades of gray
e	=	etch—loss of metallic brightness
blk	=	black surface discoloration
s	=	soil—dark or dirty accumulation adhering to test specimens
wc	=	white corrosion product
l	=	light
m	=	medium
h	=	heavy
vh	=	very heavy
tr	=	trace
occ	=	occasional
scat	=	scattered (more extensive than occasional)
PP	=	pinpoint $<$ 1/8 in. (3 mm) in diameter
PH	=	pinhead $>$ 1/8 in. (3 mm) in diameter
10, 30, 50, etc	=	percentage of surface
bal	=	balance
mech	=	mechanical damage
br	=	brown
dk	=	dark
st	=	surface discoloration including soil or gold patina, black, mottling, etc.

TABLE 14 - *Average corrosion rates to initial rusting (CIR) (ounces per square foot per year)*[a] *for each aluminum-coated product exposed at each location for approximately 32 years.*

	Average CIR						
	Aluminum Coated						
						All Products	
Location	Unfabricated Wire	Field Fence	Barbed Wire (line)	Chain-Link Fence	Wire Strand	Average[d]	Standard Deviation[d]
Brazos River, TX	[b]	0.057	0.055	0.038	0.058	0.051	0.034
Kure Beach, NC 80 ft	[b]	0.043	0.047	0.061	0.034	0.048	0.018
Kure Beach, NC 800 ft	0.027	0.029	0.048	0.053	0.035	0.040	0.019
Manhattan, KS	[b]	[c]	[c]	0.027	[c]	0.027	0.004
Newark-Keamy, NJ	0.020	0.023	0.015	0.033	0.044	0.027	0.014
Point Reyes, CA	[b]	0.023	0.042	0.029	0.043	0.033	0.013
State College, PA	0.043	0.031	0.040	0.051	0.046	0.043	0.012
Warrington, England	0.061	0.051	0.051	0.059	0.048	0.056	0.010

[a] 1 oz/ft^2 = 305.15 g/m^2

[b] No unfabricated samples exposed at this site.

[c] Samples have not reached initial rust.

[d] The individual sample values from Tables 8 through 12 were used to derive the All Products Average and Standard Deviation.

TABLE 15 - *Average corrosion rates to complete rust (CCR) (ounces per square foot per year)*[a] *for each aluminum-coated product exposed at each location for approximately 32 years.*

	Average CCR						
	Aluminum Coated						
						All Products	
Location	Unfabricated Wire	Field Fence	Barbed Wire (line)	Chain-Link Fence	Wire Strand	Average[d]	Standard Deviation[d]
Brazos River, TX	[b]	0.026	0.017	0.027	[c]	0.023	0.006
Kure Beach, NC 80 ft	[b]	0.026	0.025	0.021	[c]	0.024	0.005
Kure Beach, NC 800 ft	0.009	0.008	0.011	0.016	[c]	0.011	0.003
Manhattan, KS	[b]	[c]	[c]	[c]	[c]		
Newark-Keamy, NJ	[c]	[c]	[c]	[c]	[c]		
Point Reyes, CA	[b]	0.015	0.012	[c]	0.031	0.024	0.016
State College, PA	[c]	0.011	[c]	[c]	[c]	0.011	0.000
Warrington, England	0.034	0.035	0.036	0.041	[c]	0.036	0.005

[a] 1 oz/ft^2 = 305.15 g/m^2

[b] No unfabricated samples exposed at this site.

[c] Samples have not reached complete rust.

[d] The individual sample values from Tables 8 through 12 were used to derive the All Products Average and Standard Deviation.

TABLE 16 - ***Average corrosion rates to initial rusting (CIR) (ounces per square foot per year)[a] for each zinc-coated product exposed at each location for approximately 32 years.***

	Average CIR						
	Zinc Coated						
						All Products	
Location	Unfabricated Wire	Field Fence	Barbed Wire (line)	Chain-Link Fence	Wire Strand	Average[d]	Standard Deviation[d]
Brazos River, TX	b	0.148	0.256	0.136	0.073	0.146	0.081
Kure Beach, NC 80 ft	b	0.226	0.175	0.376	0.142	0.278	0.130
Kure Beach, NC 800 ft	0.111	0.113	0.131	0.264	0.049	0.167	0.105
Manhattan, KS	b	0.018	0.021	c	c	0.019	0.002
Newark-Kearny, NJ	0.171	0.166	0.171	0.226	0.143	0.192	0.057
Point Reyes, CA	b	0.065	0.132	0.116	c	0.099	0.056
State College, PA	0.061	0.058	0.062	0.088	c	0.068	0.021
Warrington, England	0.201	0.253	0.204	0.288	0.171	0.256	0.064

[a] 1 oz/ft^2 = 305.15 g/m^2

[b] No unfabricated samples exposed at this site.

[c] Samples have not reached initial rust.

[d] The individual sample values from Tables 8 through 12 were used to derive the All Products Average and Standard Deviation.

TABLE 17 - ***Average corrosion rates to complete rust (CCR) (ounces per square foot per year)[a] for each zinc-coated product exposed at each location for approximately 32 years.***

	Average CCR						
	Zinc Coated						
						All Products	
Location	Unfabricated Wire	Field Fence	Barbed Wire (line)	Chain-Link Fence	Wire Strand	Average[d]	Standard Deviation[d]
Brazos River, TX	b	0.056	0.054	0.075	c	0.059	0.014
Kure Beach, NC 80 ft	b	0.065	0.060	0.084	c	0.073	0.015
Kure Beach, NC 800 ft	0.045	0.048	0.056	0.069	c	0.055	0.015
Manhattan, KS	b	0.011	0.017	c	c	0.014	0.004
Newark-Kearny, NJ	0.134	0.109	0.125	0.095	0.045	0.105	0.032
Point Reyes, CA	b	0.034	0.062	c	c	0.042	0.025
State College, PA	0.048	0.042	0.042	c	c	0.043	0.005
Warrington, England	0.171	0.168	0.160	0.222	0.105	0.187	0.065

[a] 1 oz/ft^2 = 305.15 g/m^2

[b] No unfabricated samples exposed at this site.

[c] Samples have not reached complete rust.

[d] The individual sample values from Tables 8 through 12 were used to derive the All Products Average and Standard Deviation.

TABLE 18—Style, coating metal, coating weight, and coating method of ACSR specimens.

Specimen Number		Coating Metal	Coating Weight		Coating Method
Conventional	Compacted		oz/ft^2	g/m^2	
46	52	Zn	0.87	265	electroplated
47	53	Al	1.92	586	process 3
48	54	Al	0.45	137	process 2
49	55	Al	0.34	104	process 1
50	56	Al	0.43	131	process 5
51	57	Al	0.30	92	process 4

TABLE 19 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 1 — 9 gage uncoated copper-bearing steel wire, original breaking strength 1723 lbf.* [a]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	8.0	0	8.0	100	1353	21.5	2.7
	10.0	0	10.0	100	1258	27.0	2.7
	12.0	0	12.0	100	1150	33.3	2.8
	14.0	0	14.0	100	1088	36.9	2.6
	16.0	0	16.0	100	901	47.7	3.0
	17.1	0	17.1	100	930	46.0	2.7
	18.2	0	18.2	100	863	49.9	2.7
	19.2	0	19.2	100	853	50.5	2.6
	20.2	0	20.2	100	787	54.3	2.7
	21.2	0	21.2	100	842	51.1	2.4
	22.2	0	22.2	100	757	58.1	2.5
	23.1	0	23.1	100	713	58.6	2.5
	24.1	0	24.1	100	657	61.9	2.6
	25.0	0	25.0	100	647	62.4	2.5
	28.1	0	28.1	100	563	67.3	2.4
	30.2	0	30.2	100	514	70.2	2.3
Newark-Kearny	7.9	0	7.9	100	1448	16.0	2.0
	9.8	0	9.8	100	1382	19.8	2.0
	11.9	0	11.9	100	1331	22.8	1.9
	13.8	0	13.8	100	1355	21.4	1.5
	15.8	0	15.8	100	1333	22.6	1.4
	19.1	0	19.1	100	1310	24.0	1.3
	20.0	0	20.0	100	1307	24.1	1.2
	22.0	0	22.0	100	1311	23.9	1.1
	23.0	0	23.0	100	1292	25.0	1.1
	30.0	0	30.0	100	1258	27.0	0.9
State College	7.9	0	7.9	100	1490	13.5	1.7
	9.8	0	9.8	100	1477	14.3	1.5
	11.9	0	11.9	100	1376	20.1	1.7
	13.8	0	13.8	100	1378	20.0	1.5
	15.8	0	15.8	100	1257	27.0	1.7
	19.1	0	19.1	100	1257	27.0	1.4
	20.0	0	20.0	100	1276	25.9	1.3
	22.0	0	22.0	100	1260	26.9	1.2
	23.0	0	23.0	100	1258	27.0	1.2
	27.0	0	27.0	100	1166	32.3	1.2
	30.0	0	30.0	100	1108	35.7	1.2
Warrington	5.8	0	5.8	100	1102	36.0	6.2
	9.4	0	9.4	100	895	48.1	5.1
	10.9	0	10.9	100	838	51.4	4.7
	11.6	0	11.6	100	772	55.2	4.8
	12.4	0	12.4	100	711	58.7	4.7
	12.6	0	12.6	100	722	58.1	4.6
	13.2	0	13.2	100	608	64.7	4.9
	13.2	0	13.2	100	684	60.3	4.6

[a] 1 lbf = 4.45 N

TABLE 20 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 2 – 9 gage zinc-coated steel wire 0.50 oz/ft^{2} [a], original breaking strength 1487 lbf.* [b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	8.0	5	3.0	100	1023	31.2	10.4
	10.0	5	5.0	100	1350	9.2	1.8
	12.0	5	7.0	100	1330	10.8	1.5
	14.0	5	9.0	100	1190	20.0	2.2
	16.0	5	11.0	100	831	57.6	5.2
	17.1	5	12.1	100	835	43.8	3.8
	19.2	5	14.2	100	699	53.0	3.7
Newark-Kearny	7.9	3	4.9	100	1065	28.4	5.8
	9.8	3	8.8	100	1048	29.5	4.3
	11.9	3	8.9	100	711	52.2	5.9
	13.8	3	10.8	100	967	35.0	3.2
	15.8	3	12.8	100	931	37.4	2.9
	19.1	3	16.1	100	917	38.3	2.4
	20.0	3	17.0	100	909	38.9	2.3
	22.0	3	19.0	100	923	37.9	2.0
	23.0	3	20.0	100	927	37.7	1.9
	30.0	3	27.0	100	950	36.1	1.3
State College	9.8	7.9	1.9	100	1455	2.2	1.1
	11.9	7.9	4.0	100	1318	11.5	2.9
	13.8	7.9	5.9	100	1276	14.2	2.4
	15.8	7.9	7.9	100	1203	19.1	2.4
	19.1	7.9	11.2	100	1204	19.0	1.7
	20.0	7.9	12.1	100	1170	21.3	1.8
	22.0	7.9	14.1	100	1137	23.5	1.7
	23.0	7.9	15.1	100	1132	23.9	1.6
	27.0	7.9	19.1	100	1041	30.0	1.8
	30.0	7.9	22.1	100	1012	31.9	1.4
Warrington	5.8	2.8	3.0	100	930	37.5	12.5
	9.4	2.8	6.6	100	833	57.4	8.7
	10.9	2.8	8.1	100	523	64.8	8.0
	11.6	2.8	8.8	100	464	68.8	7.8

[a] 1 oz/ft^2 = 305.15 g/m^2
[b] 1 lbf = 4.45 N

TABLE 21 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 3 – 9 gage zinc-coated steel wire 0.99 oz/ft^2[a], original breaking strength 1058 lbf.*[b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	16.0	9.1	6.9	20	1010	4.5	0.7
800 ft lot	17.1	9.1	8.0	40	1046	1.1	0.1
	18.2	9.1	9.1	65	1063	-0.5	-0.1
	19.2	9.1	10.1	65	1029	2.7	0.3
	20.2	9.1	11.1	65	1049	0.9	0.1
	21.2	9.1	12.1	65	1035	2.2	0.2
	28.1	9.1	19.0	100	1010	4.5	0.2
	30.2	9.1	21.1	100	943	10.9	0.5
Newark-Kearny	7.9	5.9	2.0	100	962	9.1	4.5
	9.8	5.9	3.9	100	960	9.3	2.4
	11.9	5.9	6.0	100	923	12.8	2.1
	13.8	5.9	7.9	100	920	13.0	1.7
	15.8	5.9	9.9	100	903	14.7	1.5
	19.1	5.9	13.2	100	911	13.9	1.1
	20.0	5.9	14.1	100	895	15.4	1.1
	22.0	5.9	16.1	100	880	16.8	1.0
	23.0	5.9	17.1	100	872	17.6	1.0
	30.0	5.9	24.1	100	866	18.1	0.8
State College	15.8	17.0	-1.2	0	1062	-0.4	0.3
	19.1	17.0	2.1	75	1085	-2.6	-1.2
	20.0	17.0	3.0	85	1038	1.9	0.6
	22.0	17.0	5.0	100	1010	4.5	0.9
	23.0	17.0	6.0	100	993	6.1	1.0
	30.0	17.0	13.0	100	907	14.3	1.1
Warrington	9.4	4.7	4.7	100	749	29.2	6.2
	10.9	4.7	6.2	100	694	34.4	5.5
	11.6	4.7	6.9	100	653	38.3	5.5
	12.4	4.7	7.7	100	622	41.2	5.4
	12.6	4.7	7.9	100	640	39.5	5.0
	13.2	4.7	8.5	100	586	44.6	5.2
	13.2	4.7	8.5	100	617	41.7	4.9

[a] 1 oz/ft^2 = 305.15 g/m^2
[b] 1 lbf = 4.45 N

TABLE 22 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 4 – 9 gage zinc-coated steel wire 2.84 oz/ft²[a], original breaking strength 1030 lbf.[b]*

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	18.0	....	0	0	1024	0.8	....
800 ft lot	17.1	....	0	0	1036	-0.8	....
	30.2	7.1	23.1	1	1018	1.2	0.1
Newark-Kearny	15.8	15.8	0.0	5	1026	0.4	....
	19.1	15.8	3.3	95	980	4.9	1.5
	20.0	15.8	4.2	95	985	4.4	1.0
	22.0	15.8	8.2	100	1000	2.9	0.5
	23.0	15.8	7.2	100	993	3.6	0.5
	30.0	15.8	14.2	100	961	8.7	0.5
State College	15.8	....	0	0	1018	1.4	....
	19.1	....	0	0	1057	-2.8	....
	20.0	....	0	0	1038	-0.8	....
	23.0	....	0	0	1058	-2.7	....
	30.0	....	0	0	1041	-1.1	....
Warrington	13.2	13.2	0.0	1	987	4.2	....
	13.2	13.2	0.0	1	1018	1.4	....

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 23 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 5 – 9 gage aluminum-coated steel wire 0.52 oz/ft²[a], original breaking strength 1040 lbf.[b]*

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	18.0	....	0	0	1011	2.8	....
800 ft lot	17.1	....	0	0	1050	-1.0	....
	30.2	....	0	0	1046	-0.6	....
Newark-Kearny	15.8	....	0	0	1048	-0.8	....
	19.1	....	0	0	1054	-1.3	....
	20.0	....	0	0	1038	0.2	....
	22.0	....	0	0	1043	-0.3	....
	28.8	27.1	1.7	5	1060	-1.9	-1.1
	30.0	27.1	2.9	5	1041	-0.1	0.0
State College	15.8	9.8	8.0	3	1040	0.0	0.0
	19.1	9.8	9.3	2	1063	-2.2	-0.2
	20.0	9.8	10.2	2	1043	-0.3	0.0
	22.0	9.8	12.2	8	1061	-2.0	-0.2
	23.0	9.8	13.2	8	1037	0.3	0.0
	28.0	9.8	18.2	12	1063	-2.2	-0.1
	30.0	9.8	20.2	15	1077	-3.6	-0.2
Warrington	13.2	7.8	5.4	15	995	4.3	0.8
	13.2	7.8	5.4	15	1054	-1.3	-0.2

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 24 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 6 – 9 gage aluminum-coated steel wire 0.54 oz/ft²*[a]*, original breaking strength 2885 lbf.*[b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	....	0	0	2836	1.7	....
	17.1	....	0	0	2940	-1.9	....
	30.2	....	0	0	2912	-0.9	....
Newark-Kearny	15.8	....	0	0	2940	-1.9	....
	19.1	....	0	0	2909	-0.8	....
	20.0	....	0	0	2896	-0.4	....
	22.0	....	0	0	2935	-1.7	....
	24.0	....	0	0	2885	0.0	....
	25.0	25.0	0	0	2937	-1.8	....
	28.8	25.0	3.8	10	2921	-1.2	-0.3
	30.0	25.0	5.0	20	2917	-1.1	-0.2
State College	15.8	8.9	6.9	5	2860	0.9	0.1
	19.1	8.9	10.2	5	2927	-1.5	-0.1
	20.0	8.9	11.1	8	2879	0.2	0.0
	22.0	8.9	13.1	10	2932	-1.6	-0.1
	23.1	8.9	14.2	8	2942	-2.0	-0.1
	24.0	8.9	15.1	10	2920	-1.2	-0.1
	30.0	8.9	21.1	25	2943	-2.0	-0.1
Warrington	13.2	10.9	2.3	5	2795	3.1	1.4
	13.2	10.9	2.3	5	2905	-0.7	-0.3

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 25 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 8 – 9 gage aluminum-coated steel wire 2.44 oz/ft²*[a]*, original breaking strength 3077 lbf.*[b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	....	0	0	3091	-0.5	....
	17.1	....	0	0	3106	-0.9	....
	30.2	....	0	0	3179	-3.3	....
Newark-Kearny	15.8	....	0	0	3181	-3.4	....
	19.1	....	0	0	3149	-2.3	....
	20.0	....	0	0	3115	-1.2	....
	22.0	....	0	0	3165	-2.9	....
	30.0	....	0	0	3145	-2.2	....
State College	15.8	....	0	0	3056	0.7	....
	19.1	....	0	0	3156	-2.6	....
	20.0	....	0	0	3093	-0.5	....
	22.0	....	0	0	3176	-3.2	....
	27.0	....	0	0	3157	-2.6	....
	30.0	....	0	0	3169	-3.0	....
Warrington	13.2	....	0	0	2987	2.9	....
	13.2	....	0	0	3130	-1.7	....

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 28 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 9 – 9 gage aluminum-coated steel wire 0.48 oz/ft² [a], original breaking strength 1617 lbf.* [b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	18.0	....	0	0	1388	14.2	....
800 ft lot	17.1	....	0	0	1465	9.4	....
	18.2	....	0	0	1463	9.5	....
	30.2	....	0	0	1447	10.5	....
Newark-Kearny	15.8	....	0	0	1460	9.7	....
	19.1	....	0	0	1395	13.7	....
	20.0	....	0	0	1459	9.8	....
	22.0	....	0	0	1474	8.8	....
	30.0	28.3	1.7	10	1449	10.4	6.1
State College	15.8	....	0	0	1291	20.2	....
	19.1	....	0	0	1504	7.0	....
	20.0	....	0	0	1510	6.6	....
	22.0	21.0	1.0	1	1407	13.0	13.0
	30.0	21.0	9.0	2	1486	8.1	0.9
Warrington	13.2	8.5	4.7	10	1447	10.5	2.2
	13.2	8.5	4.7	10	1531	5.3	1.1

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 27 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 10 – 9 gage aluminum-coated steel wire 0.51 oz/ft² [a], original breaking strength 1438 lbf.* [b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	18.0	....	0	0	1440	-0.1	....
800 ft lot	17.1	....	0	0	1450	-0.8	....
	30.2	....	0	0	1431	0.5	....
Newark-Kearny	15.8	....	0	0	1491	-3.7	....
	19.1	....	0	0	1428	0.7	....
	20.0	....	0	0	1459	-1.5	....
	22.0	....	0	0	1427	0.8	....
	23.0	....	0	0	1412	1.8	....
	28.8	26.4	2.4	7	1524	-6.0	-2.5
	30.0	26.4	3.8	15	1425	0.9	0.3
State College	15.8	8.9	6.9	0	1378	4.3	0.6
	19.1	8.9	10.2	8	1445	-0.5	0.0
	20.0	8.9	11.1	8	1510	-5.0	-0.5
	22.0	8.9	13.1	11	1451	-0.9	-0.1
	23.0	8.9	14.1	10	1412	1.8	0.1
	30.0	8.9	21.1	25	1453	-1.0	0.0
Warrington	13.2	7.8	5.4	10	1360	5.4	1.0
	13.2	7.8	5.4	10	1473	-2.4	-0.5

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 28 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 11 – 9 gage aluminum-coated steel wire 0.27 oz/ft² ª, original breaking strength 1488 lbf.* ᵇ

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	10.0	6.0	5	1403	5.7	1.0
	17.1	10.0	7.1	1	1468	1.3	0.2
	20.2	10.0	10.2	7	1505	-1.1	-0.1
	21.2	10.0	11.2	7	1483	0.3	0.0
	30.2	10.0	20.2	10	1491	-0.2	0.0
Newark-Kearny	15.6	8.9	6.9	2	1483	0.3	0.0
	19.1	8.9	10.2	20	1474	0.9	0.1
	20.0	6.9	11.1	20	1447	2.6	0.2
	22.0	6.9	13.1	25	1481	0.5	0.0
	23.0	6.9	14.1	20	1503	-1.0	-0.1
	24.0	6.9	15.1	20	1475	0.9	0.1
	30.0	6.9	21.1	40	1490	-0.1	0.0
State College	15.6	6.9	6.9	25	1445	2.9	0.4
	19.1	6.9	10.2	20	1524	-2.4	-0.2
	20.0	6.9	11.1	22	1485	0.2	0.0
	22.0	6.9	13.1	40	1489	-0.1	0.0
	23.0	6.9	14.1	25	1527	-2.6	-0.2
	24.0	6.9	15.1	30	1485	0.2	0.0
	26.0	6.9	17.1	20	1527	-2.6	-0.2
	30.0	6.9	21.1	35	1476	0.7	0.0
Warrington	9.4	4.7	4.7	100	1356	6.9	1.9
	10.9	4.7	6.2	100	1242	16.5	2.7
	11.6	4.7	6.9	100	1220	16.0	2.6
	12.4	4.7	7.7	100	1161	22.0	2.9
	12.6	4.7	7.9	100	1148	22.6	2.9
	13.2	4.7	6.5	100	1065	28.4	3.3
	13.2	4.7	8.5	100	1105	25.7	3.0

ª 1 oz/ft² = 305.15 g/m²
ᵇ 1 lbf = 4.45 N

TABLE 29 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 12 - 9 gage aluminum-coated steel wire 0.48 oz/ft² ª, original breaking strength 1407 lbf.* ᵇ

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	....	0	0	1350	4.1	....
	17.1	....	0	0	1310	6.9	....
	19.2	....	0	0	1427	-1.4	....
	20.2	20.2	0	2	1347	4.3	....
	21.2	20.2	1.0	5	1443	-2.6	-2.6
	30.2	20.2	10.0	7	1363	3.1	0.3
Newark-Kearny	15.6	....	0	0	1395	0.9	....
	19.1	....	0	0	1350	4.1	....
	20.0	....	0	0	1360	3.3	....
	22.0	....	0	0	1394	0.9	....
	23.0	....	0	0	1370	2.6	....
	30.0	26.4	3.6	10	1433	-1.6	-0.5
State College	15.6	11.0	4.6	2	1358	3.5	0.7
	19.1	11.0	6.1	1	1385	1.6	0.2
	20.0	11.0	9.0	2	1383	1.7	0.2
	22.0	11.0	11.0	2	1489	-5.6	-0.5
	23.0	11.0	12.0	2	1448	-2.9	-0.2
	30.0	11.0	19.0	10	1457	-3.6	-0.2
Warrington	13.2	9.4	3.6	5	1350	4.1	1.1
	13.2	9.4	3.8	5	1373	2.4	0.6

ª 1 oz/ft² = 305.15 g/m²
ᵇ 1 lbf = 4.45 N

TABLE 30 - *Breaking strength of wires removed during the 30-year period 1961 to 1991*
Code No. 13 – 9 gage aluminum-coated steel wire 0.63 oz/ft²[a], original breaking strength 1423 lbf.[b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	18.0	....	0	0	1373	3.5	....
	17.1	....	0	0	1409	1.0	....
	30.2	....	0	0	1411	0.8	....
Newark-Kearny	15.8	....	0	0	1413	0.7	....
	19.1	....	0	0	1417	0.4	....
	20.0	....	0	0	1417	0.4	....
	22.0	....	0	0	1424	-0.1	....
	23.0	....	0	0	1440	-1.2	....
	30.0	29.2	0.8	5	1410	0.9	1.1
State College	15.8	....	0	0	1380	3.0	....
	19.1	....	0	0	1439	-1.1	....
	20.0	....	0	0	1405	1.3	....
	22.0	....	0	0	1434	-0.8	....
	30.0	....	0	0	1432	-0.8	....
Warrington	13.2	....	0	0	1343	5.8	....
	13.2	....	0	0	1395	2.0	....

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 31 - *Breaking strength of wires removed during the 30-year period 1961 to 1991.*
Code No. 17 – 12 1/2 gage aluminum-coated steel wire 0.29 oz/ft²[a], original breaking strength 487 lbf.[b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	18.0	10.0	8.0	1	485	0.4	0.1
	17.1	10.0	7.1	1	481	1.2	0.2
	19.2	10.0	9.2	2	511	-4.9	-0.5
	20.2	10.0	10.2	3	482	1.0	0.1
	21.2	10.0	11.2	5	498	-2.3	-0.2
	30.2	10.0	20.2	50	478	2.3	0.1
Newark-Kearny	15.8	....	0	0	479	1.8	....
	19.1	19.1	0.0	2	511	-4.9	....
	20.0	19.1	0.9	15	497	-2.1	-2.3
	22.0	19.1	2.9	15	502	-3.1	-1.1
	23.0	19.1	3.9	15	453	7.0	1.8
	30.0	19.1	10.9	35	490	-0.8	-0.1
State College	15.8	8.9	8.9	45	496	-1.8	-0.3
	19.1	8.9	10.2	10	488	-0.2	0.0
	20.0	8.9	11.1	10	484	0.8	0.1
	22.0	8.9	13.1	20	485	0.4	0.0
	23.0	8.9	14.1	12	477	2.1	0.1
	24.0	8.9	15.1	15	470	3.5	0.2
	30.0	8.9	21.1	30	507	-4.1	-0.2
Warrington	9.4	4.7	4.7	100	402	17.5	3.7
	10.0	4.7	5.3	100	229	53.0	10.0
	11.8	4.7	8.9	100	308	36.8	5.3
	12.4	4.7	7.7	100	254	47.8	8.2
	12.6	4.7	7.9	100	375	23.0	2.9
	13.2	4.7	8.5	100	274	43.7	5.1
	13.2	4.7	8.5	100	271	44.4	5.2

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 32 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 18 – 12 1/2 gage aluminum-coated steel wire 0.43 oz/ft²[a], original breaking strength 490 lbf.[b]*

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	18.0	....	0	0	477	2.7	....
800 ft lot	17.1	....	0	0	485	1.0	....
	30.2	....	0	0	499	-1.8	....
Newark-Kearny	15.8	....	0	0	507	-3.5	....
	19.1	....	0	0	510	-4.1	....
	20.0	....	0	0	498	-1.6	....
	22.0	....	0	0	499	-1.8	....
	28.6	25.0	3.6	10	497	-1.4	-0.4
	30.0	25.0	5.0	10	490	0.0	0.0
State College	15.6	9.6	6.0	5	488	0.4	0.1
	19.1	9.6	9.3	7	515	-5.1	-0.5
	20.0	9.8	10.2	7	509	-3.9	-0.4
	22.0	9.8	12.2	7	516	-5.3	-0.4
	30.0	9.8	20.2	15	514	-4.9	-0.2
Warrington	13.2	5.6	7.4	40	455	7.1	1.0
	13.2	5.6	7.4	40	484	1.2	0.2

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 33 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 20 – 12 1/2 gage aluminum-coated steel wire 0.37 oz/ft²[a], original breaking strength 565 lbf.[b]*

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach	16.0	9.1	6.9	15	587	-3.9	-0.6
800 ft lot	17.1	9.1	8.0	15	571	-1.1	-0.1
	19.2	9.1	10.1	20	586	-3.7	-0.4
	20.2	9.1	11.1	25	568	-0.5	0.0
	21.2	9.1	12.1	25	562	0.5	0.0
	24.2	9.1	15.1	30	610	-8.0	-0.5
	25.0	9.1	15.9	35	600	-6.2	-0.4
	30.2	9.1	21.1	60	558	1.2	0.1
Newark-Kearny	15.8	....	0	0	587	-0.4	....
	19.1	19.1	0.0	3	589	-4.2	....
	20.0	19.1	0.9	5	566	-0.2	-0.2
	22.0	19.1	2.9	5	585	-3.5	-1.2
	28.8	19.1	9.7	10	577	-2.1	-0.2
	30.0	19.1	10.9	20	572	-1.2	-0.1
State College	15.8	8.9	6.9	10	546	3.4	0.5
	19.1	6.9	10.2	10	606	-7.3	-0.7
	20.0	8.9	11.1	10	586	-3.7	-0.3
	22.0	6.9	13.1	12	585	-4.1	-0.3
	23.0	8.9	14.1	10	652	-15.4	-1.1
	26.0	6.9	17.1	10	599	-6.0	-0.4
	30.0	6.9	21.1	25	559	1.1	0.1
Warrington	13.2	5.6	7.4	75	509	9.9	1.3
	13.2	5.8	7.4	75	528	6.5	0.9

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 34 - *Breaking strength of wires removed during the 30-year period 1961 to 1991: Code No. 21 – 12 1/2 gage aluminum-coated steel wire 1.76 oz/ft² [a], original breaking strength 768 lbf.* [b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	....	0	0	757	1.4	....
	17.1	....	0	0	548	28.6	....
	16.2	....	0	0	784	-2.1	
	20.2	....	0	0	784	-2.1	....
Newark-Kearny	15.8	....	0	0	767	-2.5	....
	19.1	....	0	0	798	-3.6	....
	20.0	....	0	0	764	0.5	....
	22.0	....	0	0	775	-0.9	....
	30.0	....	0	0	782	-1.6	....
State College	15.6	....	0	0	750	2.3	....
	19.1	....	0	0	798	-3.9	....
	20.0	....	0	0	791	-3.0	....
	22.0	....	0	0	775	-0.9	....
	30.0	....	0	0	805	-4.8	....
Warrington	13.2	....	0	0	729	5.1	....
	13.2	....	0	0	788	-2.6	....

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 35 - *Breaking strength of wires removed during the 30-year period 1961 to 1991. Code No. 22 – 12 1/2 gage aluminum-coated steel wire 3.36 oz/ft² [a], original breaking strength 1012 lbf.* [b]

Location	Years Exposed	Years to IR	Years Since IR	R, %	Breaking Strength lbf	Loss, %	% per Year Since IR
Kure Beach 800 ft lot	16.0	....	0	0	1009	0.3	....
	17.1	....	0	0	1084	-7.1	....
	30.2	....	0	0	1048	-3.6	....
Newark-Kearny	15.6	....	0	0	1047	-3.5	....
	19.1	....	0	0	1055	-4.2	....
	20.0	....	0	0	1041	-2.9	....
	22.0	....	0	0	1039	-2.7	....
	30.0	....	0	0	1050	-3.8	....
State College	15.8	....	0	0	1005	0.7	....
	19.1	....	0	0	1053	-4.1	....
	20.0	....	0	0	1040	-2.8	....
	22.0	....	0	0	1059	-4.6	....
	30.0	....	0	0	1055	-4.2	....
Warrington	13.2	....	0	0	950	6.1	....
	13.2	....	0	0	1035	-2.3	....

[a] 1 oz/ft² = 305.15 g/m²
[b] 1 lbf = 4.45 N

TABLE 36—Results of linear regression analysis of loss in breaking strength.

Location	Wire Code No.	Gage	Type Coating	Coating Weight[a] oz/ft^2	Linear[b] Equation	Coefficient of Linear Correlation, *r*	Specimen Size
Kure Beach	1	9	bare	0.00	Y = 2.34X + 4.28	0.99	17
Newark-Kearny	1	9	bare	0.00	Y = 0.76X + 8.54	0.85	11
State College	1	9	bare	0.00	Y = 1.09X + 4.29	0.96	12
Warrington	1	9	bare	0.00	Y = 4.47X + 3.80	0.99	9
Kure Beach[c]	2	9	Zn	0.50	Y = 4.32X − 29.9	0.89	7
Newark-Kearny[d]	2	9	Zn	0.50	Y = 1.09X + 14.0	0.74	10
State College	2	9	Zn	0.50	Y = 1.40X − 7.63	0.97	11
Warrington	2	9	Zn	0.50	Y = 7.45X − 14.6	0.98	5
Kure Beach	3	9	Zn	0.99	Y = 0.41X − 5.19	0.74	9
Newark-Kearny	3	9	Zn	0.99	Y = 0.61X + 2.80	0.86	11
State College	3	9	Zn	0.99	Y = 1.13X − 20.2	0.94	7
Warrington	3	9	Zn	0.99	Y = 4.99X − 21.3	0.99	8
Warrington	11	9	Al	0.27	Y = 3.19X − 17.3	0.97	8
Warrington[e]	17	12 1/2	Al	0.29	Y = 5.61X − 28.6	0.97	6

[a]1 oz/ft^2 = 305.15 g/m^2.
[b]X denotes the years of exposures and Y denotes the percent loss in breaking strength.
[c]Does not include point (8.0 years, 31.2%).
[d]Does not include point (11.9 years, 52.2%).
[e]Does not include points (10.0 years, 53.0%) and (12.6 years, 23.0%).

Figures

FIG. 1. Overall View of the Kure Beach, NC 800-ft Test Site illustrates the mounting of the unfabricated test wire specimens.

FIG. 2. Overall View of the Kure Beach, NC 800-ft Test Site illustrates the mounting of the field fence, barbed wire, and chain link fabric test specimens.

FIG. 3. Overall View of the Kure Beach, NC 800-ft Test Site illustrates the mounting of the chain link fabric test specimens.

FIG. 4. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 95R, 5wc.

FIG. 5. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Kure Beach, NC (80-ft site). 30-year condition of links (see Table 13): 100R.

FIG. 6. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 95R, 5wc.

FIG. 7. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 40G, 60Y.

FIG. 8. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Newark-Kearny, NJ. 30-year condition of links (see Table 13): 100R.

FIG. 9. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* Point Reyes, CA. 30-year condition of links (see Table 13): 60R, 40wc.

FIG. 10. Specimen 32 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 1.77 oz/ft^2 (540 g/m^2). *Exposure site:* State College, PA. 30-year condition of links (see Table 13): 95R, 5Y.

FIG. 11. Specimen 33 – Hot-dip Galvanized Chain Link Fabric. Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Brazos River, TX. 30-year condition of links (see Table 13): 60R, 40wc.

FIG. 12. Specimen 33 – Hot-dip Galvanized Chain Link Fabric. Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Kure Beach, NC (80-ft site). 30-year condition of links (see Table 13): 95R, 5wc.

FIG. 13. Specimen 33 – Hot-dip Galvanized Chain Link Fabric. Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 40R, 60wc.

FIG. 14. Specimen 33 – Hot-dip Galvanized Chain Link Fabric. Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Manhattan, KS. 30-year condition of links (see Table 13): 40G, 60Y.

FIG. 15. Specimen 33 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Newark-Kearny, NJ. 30-year condition of links (see Table 13): 100R.

FIG. 16. Specimen 33 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* Point Reyes, CA. 30-year condition of links (see Table 13): 5PPR, 95wc.

FIG. 17. Specimen 33 – Hot-dip Galvanized Chain Link Fabric.
Original coating weight: 2.81 oz/ft^2 (857 g/m^2). *Exposure site:* State College, PA. 30-year condition of links (see Table 13): 5G, 95Y.

FIG. 18. Specimen 34 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 80R, 20wc.

FIG. 19. Specimen 34 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 60R, 35wc, 5G.

FIG. 20. Specimen 34 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 100G.

FIG. 21. Specimen 34 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* Newark-Kearny, NJ. 30-year condition of links (see Table 13): 100R.

FIG. 22. Specimen 34 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* Point Reyes, CA.
30-year condition of links (see Table 13): 50R, 20wc, 30G.

FIG. 23. Specimen 34 – Zinc Electroplated Chain Link Fabric. Original coating weight: 1.53 oz/ft^2 (467 g/m^2). *Exposure site:* State College, PA.
30-year condition of links (see Table 13): 100G.

FIG. 24. Specimen 35 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 15R, 85wc.

FIG. 25. Specimen 35 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 30R, 60wc, 10G.

FIG. 26. Specimen 35 – Zinc Electroplated Chain Link Fabric.
Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 100G.

FIG. 27. Specimen 35 – Zinc Electroplated Chain Link Fabric. Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* Newark-Kearny, NJ. 30-year condition of links (see Table 13): 100R.

FIG. 28. Specimen 35 – Zinc Electroplated Chain Link Fabric. Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* Point Reyes, CA. 30-year condition of links (see Table 13): 5R, 75wc, 20G.

FIG. 29. Specimen 35 – Zinc Electroplated Chain Link Fabric. Original coating weight: 2.23 oz/ft^2 (680 g/m^2). *Exposure site:* State College, PA. 30-year condition of links (see Table 13): 100G.

FIG. 30. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 10R, 15wc, 75G.

FIG. 31. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Kure Beach, NC (80-ft site). 30-year condition of links (see Table 13): 30R, 20Y, 50G, trM.

FIG. 32. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 2R, 10wc, 78G, 10M.

FIG. 33. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 50M, 50G.

FIG. 34. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Newark-Kearny, NJ.
30-year condition of links (see Table 13): 10PPR, 90BLK.

FIG. 35. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric. Note: This is same specimen as illustrated in Fig. 34, with black corrosion product removed on one straight wire segment to illustrate that aluminum coating is still intact.

FIG. 36. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* Point Reyes, CA.
30-year condition of links (see Table 13): 50M, 50G.

FIG. 37. Specimen 36 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.57 oz/ft^2 (174 g/m^2). *Exposure site:* State College, PA.
30-year condition of links (see Table 13): 100G.

FIG. 38. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 15R, 75wc, 10G.

FIG. 39. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Kure Beach, NC (80-ft site). 30-year condition of links (see Table 13): 55R, 25Y, 20G.

FIG. 40. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Kure Beach, NC (800-ft site). 30-year condition of links (see Table 13): 1R, 20wc, 74G, 5M.

FIG. 41. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 40M, 60st.

FIG. 42. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric. Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Newark-Kearny, NJ. 30-year condition of links (see Table 13): 10PPR, 90blk.

FIG. 43. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric. Note: This is same specimen as illustrated in Fig. 42, with black corrosion product removed on one straight wire segment to illustrate that aluminum coating is still intact.

FIG. 44. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric. Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* Point Reyes, CA. 30-year condition of links (see Table 13): 1PPR, 99wc.

FIG. 45. Specimen 37 – Hot-Dip Aluminized Chain Link Fabric. Original coating weight: 0.44 oz/ft^2 (134 g/m^2). *Exposure site:* State College, PA. 30-year condition of links (see Table 13): 15PPR, 15Y, 70G.

FIG. 46. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Brazos River, TX.
30-year condition of links (see Table 13): 5R, 20wc, 75G.

FIG. 47. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Kure Beach, NC (80-ft site). 30-year condition of links (see Table 13): 50R, 25Y, 25G.

FIG. 48. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Kure Beach, NC (800 ft site). 30-year condition of links (see Table 13): trR, trY, 40wc, 50G, 10M.

FIG. 49. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Manhattan, KS.
30-year condition of links (see Table 13): 50M, 50st.

FIG. 50. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Newark-Kearny, NJ.
30-year condition of links (see Table 13): 10PPR, 90 blk.

FIG. 51. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric. Note: This is same specimen as illustrated in Fig. 50, with black corrosion product removed on one straight wire segment to illustrate that aluminum coating is still intact.

FIG. 52. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* Point Reyes, CA.
30-year condition of links (see Table 13): 5PPR, 95wc.

FIG. 53. Specimen 38 – Hot-Dip Aluminized Chain Link Fabric.
Original coating weight: 0.54 oz/ft^2 (165 g/m^2). *Exposure site:* State College, PA.
30-year condition of links (see Table 13): 15PPR, 5Y, 80G.

ISBN 0-8031-2064-8