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Progress Report on the Corrosion and Stress Corrosion Behavior of Selected Stainless Steels in Soil Environments

Part I. General Corrosion Behavior

W. F. Gerhold, W. P. Iverson, E. Escalante, B. T. Sanderson

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National Bureau of Standards
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May 1974

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Prepared for
Committee of Stainless Steel Producers
American Iron and Steel Institute
150 East 42nd Street
New York, New York 10017

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Progress Report on
The Corrosion and Stress Corrosion Behavior of Selected Stainless Steel Alloys in Soil Environments

Part I
General Corrosion Behavior

by

W. F. Gerhold, W. P. Iverson,
E. Escalante, and B. T. Sanderson

A. Introduction

Stainless steels have, within the past several years, successfully been used in increasing amounts for pipe clamps for joining and repairing cast iron sewer lines. Other applications in use or under test include ground rods, transformer cases, submerged switches, underground residential distribution equipment (connector sheaths, housings, clamps, and bails), gas lines (1,2), water lines, buried caskets, culverts, residential sewage disposal, etc.

Corrosion data available pertaining to the suitability of stainless steels for underground uses are reported in NBS Circular 579 (3) and the reports by Branch (1) and Steinmetz and Hoxie (2). The NBS tests, conducted for 14 years in various soils of the United States showed that Type 304 and Type 316 were highly resistant to both pitting and general attack. In certain highly aggressive soils Type 304 showed some scattered pitting. Type 316 with its almost negligible pitting attack was found to be the best alloy tested. Type 302 was tested in only a few soils. Types 410 (12% chromium) and 430 (17% chromium) were found to be fully resistant to attack in only 1/3 of those NBS tests sites where exposed. The stainless steel specimens used in these tests were flat, annealed, unstressed coupons.

In a two-year exposure to various soils in and around Baltimore, Maryland, Type 304 service gas lines (50 for a total length of 1 mile) were reported to have suffered no corrosion effects (2).

Stress corrosion cracking also has not been reported to be a problem with Types 304 or 316 in actual underground applications (1).

In order to more fully evaluate the corrosion and stress corrosion behavior of some of the alloys proposed for soil environments, NBS in cooperation with the American Iron and Steel Institute initiated in 1970 a soil burial program in representative corrosive soils utilizing nine stainless steel alloys in both the annealed and cold worked conditions with various treatments.

These treatments incorporated welds, crevices, galvanic couples, stresses, and/or sensitization by heat treatment to induce carbide precipitation. In 1971 and in 1972 the program was expanded to include other stainless steels. This report is based upon the one-and two-year burial results of the 1970 and 1971 program and the one-year burial results of the 1972 program. Results on the stressed stainless steel specimens are given in Part II.

B. Experimental Procedure

1. Soils at NBS Test Sites. Following are detailed descriptions of the soils at these test sites, which have been selected by NBS as the most representative of 128 test sites previously used:

Sagemoor sandy loam (Site A) is a well-drained alkaline soil, typical of that found in vast areas of eastern Washington and Oregon. The site is located on the Yakima Indian Reservation near Toppenish, Washington. The soil is consistent in composition to a depth of at least 7 feet and supports abundant growth of sagebrush.

Hagerstown loam (Site B) is a well-drained soil representative of the majority of well-developed soils found in the eastern part of the United States. The site is located at the Loch Raven Reservoir of the Baltimore Water Department. The soil consists of a brown loam about 1 foot deep, underlain by a reddish-brown clay that extends 5 feet or more to underlying rock. Practically all the materials that have been investigated in the extensive NBS soil corrosion tests since 1922 have been exposed at this site, which, therefore, serves as a reference site in the correlation of data obtained for specimens in the present program with data obtained from the earlier tests.

Clay soil (Site C) is located in a large clay pit on level land at Cape May, New Jersey, which floods during heavy rains. The soil consists of a plastic gray clay to a depth of 6 inches underlain by gray clay mixed with patches of brown clay to a depth of 12 inches. This is underlain by a poorly drained very heavy plastic clay.

Lakewood sand (Site D) is a white, loose sand with some black streaks occurring in places which supports the growth of beach grasses abundantly. The site is located in a well-drained rolling area at Wildwood, New Jersey, which is not subject to overflow from the ocean except under unusualy flood conditions.

Coastal sand (Site E) is a typical white, coastal beach sand, with a high content of black sand that occurs in streaks. This sand is similar to Lakewood sand except that at this site, which is located on Two-Mile Beach at Wildwood, New Jersey, the sand is constantly damp and occasionally flooded with seawater.

Tidal marsh (Site G) is a soil charged with hydrogen sulfide typical of the poorly drained marsh soils that are found along the Atlantic and Gulf coasts. The site is located along a creek (Pine Hill Run) that empties into the Chesapeake Bay at Lexington Park, Maryland.

Some of the properties of the soils at these sites are given in Table I. The corrosivity of these soils on plain carbon steels is shown in Figure 1.

2. Materials, Treatment, and Preparation

In order to simulate some of the conditions that may occur on components fabricated from stainless steel alloys, materials for these soil corrosion studies included unstressed flat sheet specimens with and without welds, welded tubing specimens and coated specimens.

Descriptions of the alloy systems buried at each test site and the alloy treatments and preparation are presented in Table II. Only Systems 1-19 and 50-66 are covered in this report; Systems Nos. 20-42 and 67-92 are covered in Part II. The chemical analyses and mechanical properties of each alloy used in Systems Nos. 1-19 and 50-66 are presented in Tables III and IV respectively.

Upon receipt of the specimens from the stainless steel companies the specimens were first stamped with identification numbers using chromium plated steel dies.

All flat sheet materials (approximately 0.06" thick) were supplied with sheared edges which had been deburred. In some instances further deburring was necessary. Following the passivation procedure (described in Table II), all specimens were scrubbed with a fiber brush, thoroughly rinsed with water, and air dried.

Half of the coated (coal tar epoxy, 16 mils per side) specimens (System No. 61) were scored diagonally from the corners, twice on one surface, by cutting through the coating to the base material with a sharp pointed instrument. The other half of the specimens were exposed in the "as-coated" condition.

Type 304 tubing was prepared according to ASTM Specification A-249. Type 409 tubing was tested in the "as-welded" condition. All proprietary alloys were tested as supplied by the producers, except for cleaning and passivating.

The ends of the tube (welded) specimens were plugged with rubber stoppers and plastic or rubber caps were placed on each end. All of the specimens with the exception of the coated specimens were weighed prior to exposure for weight loss determinations.

3. Exposure

At each test site the specimens were buried in trenches approximately 2-1/2 feet deep and 2 feet wide. The specimens were placed about one foot apart. The 8"x12" sheets were placed in a vertical position (along the long dimension). Sufficient specimens were buried at each of the six test sites to permit recovery of a complete set at specified intervals (1, 2, 4, and 8 years) and the final set to be removed at a date to be determined. For the 8"x12" flat sheet specimens and for the welded tube specimens each set consisted of four specimens.

The burial order for each test site is shown in Figure 2a, b, and c. There are 1,054 specimens buried at each test site for a total of 6,324 specimens at the six test sites. This report covers 36 of the 73 systems described in Table II.

4. Examination of Specimens After Exposure

Upon removal, all of the specimens were rinsed thoroughly in tap water to remove the adhering soil. All the specimens, except the coated ones (System No. 61) and the composites (Systems Nos. 14, 15, and 16), were cleaned ultrasonically for 20-30 minutes using a 10% nitric acid solution at 120° to 130°F. Specimens from System Nos. 14 and 16 were ultrasonically cleaned using an aqueous 10% ammonium citrate solution heated to 175° to 185°F. The time for cleaning these specimens varied and was dependent upon the tenacity of the corrosion scale. The specimens from System No. 15 were ultrasonically cleaned for approximately 30 minutes using an aqueous 10% ammonium chloride solution at 175° to 185°F. After cleaning, the specimens were rinsed in distilled water and then air dried. The sheet specimens (8"x12") were then weighed twice and the weightloss was determined. The average loss in weight of similar unexposed (control) specimens given the identical cleaning processes was subtracted from the weight loss of the exposed specimens.

Pit depth measurements and visual observations were made on all the specimens.

C. Results

All specimens were examined visually in order to determine the nature and extent of the degradation after exposure up to two years in the various soil environments. Table V summarizes the results obtained from visual examination of the non-welded, coated and uncoated 8"x12" sheet specimens. The results obtained from visual examination of the weldments (8"x12" sheet and tubing specimens) are summarized in Table VI. Results obtained from pit-depth and loss in weight determinations are given in Table VII.

The data given for each ally system is a compilation of the results obtained from four specimens. Therefore, the weight loss for a given alloy system exposed in the soil environment may appear to be extremely small in comparison to the observed corrosion. This occurs because the corrosion of stainless steels in this type of environment can often be localized and confined to a very small area. Similarly, one specimen may have only one corrosion pit which caused perforation of the specimen, while there was little or no corrosion observed on the other three specimens exposed in the same environment.

Corrosion of stainless steel alloys is generally attributed to a breakdown of the passive film on the surface of the alloy at localized or selective areas. If corrosion occurs, it may often be influenced by one or more of the following:

1. Inhomogeneities at the surface of the metal.

2. Concentration cell effects due to adhering soil particles or crevices where stagnant conditions may exist.

3. Presence of chlorides in the soil.

4. Sulfate reducing bacteria.

5. Abrasion of the metal surface by soil particles or foreign debris.

A break in the passive film at the localized area results in a small anodic site. The larger surrounding area is the cathode. The electrolytic cell formed could result in localized pitting corrosion, which can rapidly penetrate the thickness of the alloy. Similarily, concentration cells formed at stagnant areas beneath soil deposits or at crevices can also result in localized corrosion with subsequent perforation of the alloy. Tunneling is an unusual form of pitting corrosion normally associated with edges, which can be increased by gravity flow of corrosion products. All flat specimens were buried vertically, thus increasing the propensity for tunneling.

AISI 200 Series

There was little or no apparent corrosion on the austenitic Type 201 and 202 (annealed) stainless steel specimens buried in the soils for two years at Sites A, B, and D. Some rust staining was observed on two of the four Type 202 specimens exposed at Site B. Pitting corrosion was noted at the edge on one of the Type 201 specimens exposed at Site D. Pitting and tunneling corrosion occurred generally in areas at or adjacent to the edges of both Types 201 and 202 specimens exposed at Site C. The Type 202 specimens were perforated by corrosion at these areas. There were pin-point perforations of specimens of both stainless steels exposed at Site E as a result of pitting and tunneling corrosion at face and edge areas of the specimens. One of the

Type 201 specimens exposed at Site G was severely attacked by corrosion at the edge. On this and other specimens of both alloys, pitting corrosion was also observed.

AISI 300 Series

In general the corrosion behavior of the austenitic 300 series alloys exposed for two years at Sites A, B, and D was similar to that noted for the 200 series alloys. With a few exceptions, corrosion, where observed on specimens exposed at these sites, was generally superficial. Small "blister-like" eruptions on the surface were noted on one of each of the Type 301 (sensitized) and Type 304 (sensitized) specimens. These appeared to be very small corrosion pits. Tunneling corrosion was also observed at the edge on the Type 304 (sensitized) specimen.

Of the specimens exposed at Site C, corrosion of Type 316 (annealed) was superficial. Pitting corrosion with subsequent perforation of the specimens was noted in areas at or adjacent to the edges of the Type 301 (annealed), Type 304 (annealed), and Type 304 (sensitized) specimens. Tunneling corrosion was found at the edge on one of the Type 316 (sensitized) specimens. Pitting corrosion was noted in areas at and adjacent to the weld seam, and in areas adjacent to and under the caps of Type 304 tubing specimens. Similarly, pitting corrosion was observed at areas adjacent to the weld bead on the cross-bead welded Type 301 alloy specimens.

At Site E, annealed Types 301, 304, and 316, sensitized Type 304, and the cross-bead welded Type 301 specimens exhibited pitting and tunneling corrosion and subsequent perforation of the specimen. Pitting corrosion and severe etching or attack due to corrosion was observed on sensitized Types 301 and 316 and on the heliarc welded Type 304 specimens.

Corrosion of Types 301 and 304 exposed at Site G generally involved severe etching accompanied by pitting corrosion. In addition, the sensitized Types 301 and 304 and annealed Type 304 specimens were perforated by corrosion at scattered localized areas. Tunneling corrosion was also found on one of the annealed Type 301 specimens. Superficial pitting corrosion was observed on the annealed and sensitized Type 316 specimens exposed at this site.

AISI 400 Series

Stainless steels in this series include the martensitic Type 410 and the ferritic Types 409, 430, and 434.

With a few exceptions, there was little or no apparent corrosion on any of the 400 series specimens buried in the soils for two years at Sites A and B. Pitting and/or tunneling corrosion was found on the Type 410 specimens exposed at Site A.

Non-welded specimens exposed at Sites C, E, and G were perforated by corrosion. Localized corrosion wasnoted on Type 430 and Type 434 specimens exposed at Site D. Type 410 specimens at this site were perforated by corrosion at localized areas.

There were a few scattered corrosion pits on the heliarc welded Type 409 specimens exposed at Site D, although no corrosion pits were observed at or adjacent to the weld areas on these specimens. The high frequency welded Typed 409 specimens exposed at this site were perforated by corrosion at weld areas. Of the welded Type 409 specimens exposed at Sites C, E, and G, all were perforated by corrosion at localized areas. However, of the weldments exposed at these sites, only the high frequency welded Type 409 specimens exposed at Site E were perforated by corrosion at weld areas.

The coated (coal-tar epoxy) Type 409 specimens were unaffected by corrosion in any of the soil environments. However, on the coated specimens that were scored prior to exposure in the soils, there was some superficial rust staining at the scored areas of those exposed at Sites B, C, and D. Corrosion pits were noted at the scored areas on specimens buried for two years in the soils at Sites E and G, and the paint coating was blistered and brittle at the scored areas.

Specialty and Developmental Alloys

Stainless steels in this classification include proprietary and composite materials. The proprietary stainless steels may be grouped as follows according to major alloying constituents:

1. Cr Stainless Steels

   26 Cr-1 Mo
   18 Cr-2 Mo
   18 Cr-2 Mo (Nb)
   18 Cr (Ti)

2. Cr-Ni Stainless Steels

   26 Cr-6.5 Ni
   20 Cr-24 Ni-6.5 Mo
   18 Cr-8 Ni (N)

The results obtained from visual examination of these specimens exposed for one and two years are summarized in Table V.

Cr Stainless Steels

Alloy 26 Cr-1 Mo (System No. 1) specimens were relatively unaffected by corrosion after burial in the soil environments for up to two years.

There was little or no apparent corrosion of the Alloy 18 Cr-2 Mo (System No. 6) specimens buried at Sites A, B, C, and D for two years. Similar specimens exhibited scattered pitting corrosion with perforation of the specimen after exposure for two years at Sites E and G.

Of the Alloy 18 Cr-2 Mo (Nb) (Systems Nos. 7, 11, and 12) specimens buried for one year, those in the annealed condition (System No. 7) were also relatively unaffected by corrosion. There was little or no apparent corrosion on specimens with the cross-bead weld (System No. 11) or heliarc weld (System No. 12) specimens in five of the six soils. Pitting corrosion at and adjacent to the weld was observed on specimens of System No. 11 exposed at Site E. One specimen was perforated by corrosion at the weld area. Crevice corrosion with perforation of the specimen was noted at localized areas under the cap on the heliarc welded specimens.

The annealed (System No. 2), cross-bead welded (System No. 3) and heliarc welded (System No. 18) Alloy 18 Cr (Ti) specimens were similarly, relatively unaffected by corrosion after burial in the soils for two years at Sites A, B, C, and D. Tunneling corrosion at edge areas was observed on the annealed and cross-bead welded specimens exposed at Site E. Localized corrosion was noted at crevice areas under the cap on two of the heliarc welded specimens exposed at this site. There was no apparent corrosion on the other two specimens. The annealed Alloy 18 Cr (Ti) specimens buried for two years at Site G were perforated by pitting corrosion. Pitting and tunneling corrosion was observed at non-weld metal areas on the cross-bead welded specimens of this alloy buried for two years at Site G. The heliarc welded specimens buried at this site were perforated by pitting corrosion observed at non-weld metal areas.

Pitting and tunneling corrosion, particularly in areas at and adjacent to the edge of the specimens, was observed on the Alloy 26 Cr-6.5 Ni (System No. 10) specimens buried at Sites C, E, and G for two years. Similar specimens of this alloy exposed at Sites A, B, and D were relatively unaffected by corrosion.

Cr-Ni Stainless Steels

The annealed (System No. 8) and cross-bead welded (System No. 9) Alloy 18 Cr-8 Ni (Ti) specimens buried for two years at Sites A, B, C, and D exhibited little or no corrosion. Pitting corrosion was noted at the edge on two of the four annealed specimens exposed at Site E. Tunneling corrosion with subsequent perforation was observed on one of the annealed specimens exposed at Site G. Other specimens of System No. 8 exposed at these sites were relatively unaffected by corrosion. Pitting and tunneling corrosion was found at and/or adjacent to the weld on the cross-bead welded specimens (System No. 9) exposed at Site E. For similar specimens exposed at Site G, pitting corrosion was noted at weld areas.

There was little or no apparent corrosion noted on the annealed (System No. 4), sensitized (System No. 5), or heliarc-welded (System No. 19) Alloy 20 Cr-24 Ni-6.5 Mo specimens buried in the six soil environments. Where corrosion was observed, it was superficial.

Composite Materials

The composite systems are essentially sandwich materials wherein the outer layers of carbon steel are metallurgically bonded to a thin core of stainless steel (total thickness approximately 0.120"). Composites A and B (Systems Nos. 14 and 15) were fabricated with a Type 430 stainless steel, while Composite C (System 16) utilizes a Type 304 stainless steel as the core material. In addition, Composite B specimens were hot-dip zinc coated (galvanized, 4.5 to 5 oz/ft^2 Zn). This was a thicker coating than would normally be used on carbon steel products.

In general there was very little difference in the corrosion behavior of Systems Nos. 14 and 16 buried in the same soil environment for two years. The carbon steel outer layers were severely attacked by corrosion at Site A. Pitting corrosion of the carbon steel was noted on specimens buried at Site B. Corrosion of the carbon steel on specimens buried at Sites C, D, and E appeared to be relatively uniform. However, the carbon steel appeared to be blistered (raised) at one area on one of each of the System Nos. 14 and 16 specimens buried at Site C. Examination of sections machined from these areas did not reveal any corrosion. The blisters appeared to be due to a metallurgical defect in the carbon steel outer layer. Severe corrosion attack was observed on the specimens of both systems exposed at Site G, particularly at the edges where the attack was sufficient to expose the core material. The carbon steel layers were completely corroded away at large areas adjacent to the edge on one of each of the Systems Nos. 14 and 16 specimens exposing the stainless steel core. There did not appear to be any significant corrosion other than discoloration of the stainless steel alloy core on any of the specimens.

The hot-dip zinc coating on the specimens of System No. 15 provided protection to the underlying carbon steel and the stainless steel core in all of the soil environments. While the percent dissipation of the zinc varied in the various environments, there was some zinc remaining on all of the specimens after exposure for two years in the six soil environments.

D. Summary

1. AISI 200 and 300 Series

Of the austenitic stainless steel (200 and 300 series) alloys included in this soil corrosion program, all exhibited good corrosion resistance after exposure for two years in the alkaline soil (Site A), Hagerstown loam (Site B), and Lakewood sand (Site D). In general, these alloys were susceptible to corrosion in the acid clay (Site C), costal sand (Site E), and tidal marsh (Site G). Type 316 appeared to be the least susceptible to corrosion in the six soils investigated. Corrosion of the 200 and 300 series stainless steels was generally characterized as pitting and/or tunneling corrosion with subsequent perforation of the specimen at scattered localized areas. For similar specimens of these alloys exposed at Site G, corrosion occurred at large areas and was characterized as severe etching or general corrosion of the metal surfaces. Sensitization, by heat treatment, of Types 301, 304, and 316 generally resulted in increased susceptibility to corrosion in all of the soil environments. Similarly, areas at or adjacent to weld beads on sheet specimens or weld seams on the heliarc welded Type 304 tubing specimens were more susceptible to corrosion attack on specimens exposed at Sites C, E, and G. Type 304 exposed at these sites was also susceptible to crevice corrosion.

2. <u>AISI 400 Series</u>

The martensitic Type 410 and the ferritic Types 409, 430, and 434 stainless steels included in this investigation were in general susceptible to pitting and/or tunneling corrosion at Sites C, D, and E, and to severe etching or general corrosion attack at Site G. Except for Types 430 and 434 exposed at Site D, all 400 series stainless steels exposed at these sites were perforated. Similar specimens buried in the soils at Sites A and B for up to two years were relatively unaffected by corrosion. Areas at or adjacent to the weld seams on the heliarc welded Type 409 tubing specimens did not appear to be susceptible to corrosion at Sites A, B, and D. Similar specimens buried at Site G for two years were perforated by corrosion. The high-frequency welded Type 409 tubing specimens exposed at Sites C, D, E, and G were perforated by corrosion in areas at or adjacent to the weld seam. Similar specimens exposed at Sites A and B were relatively unaffected by corrosion at these areas. Type 409 was susceptible to crevice corrosion at Sites C, E, and G. The coal-tar epoxy coating applied to the Type 409 specimens appeared to be effective in providing protection from corrosion at all of the test sites. However, on specimens where the paint coating had been scored to bare metal, the specimens at these bare (uncoated) areas were susceptible to pitting corrosion at Sites E and G.

3. <u>Proprietary Stainless Steels</u>

All of the proprietary materials were relatively unaffected by corrosion after exposure up to two years in the soils at Sites A and B. With a few exceptions, particularly at weld or crevice areas of specimens buried at Sites C, E, and G, the Alloy 18 Cr-2 Mo (Nb) (buried for one year), the Alloys 26 Cr-1 Mo and 20 Cr-24 Ni-6.5 Mo (buried for two years) appeared to be the most corrosion resistant in all of the soil environments. Alloys 18 Cr (Ti), 18 Cr-2 Mo, and the 26 Cr-6.5 Ni were found to be the more susceptible to corrosion at Sites E and G after two years. Degradation of the alloys at these sites was generally due to pitting and tunneling corrosion at localized areas with subsequent perforation of the specimen.

4. Stainless Steel Core Composites

There was no apparent corrosion of Type 304 or Type 430 stainless steel core alloy on any of the composite materials buried for two years in the soil environments. There was little difference in the corrosion behavior of the carbon steel alloy layers of Composite A and C when buried in the same soil environments. The zinc coating on the Composite B specimens provided protection to the carbon steel base metal in all of the soil environments.

References

1. Branch, H. C., Corrosion Resistant Materials for URD Equipment, Materials Protection and Performance, 12. (3), 9-14 (1973).

2. Steinmetz, G. F. and Hoxie, E. C., A Field Test of Type 304 Stainless Steel for Gas Service, Materials Protection and Performance, 12, (9) 41-44 (1973).

3. Romanoff, M., Underground Corrosion (NBS Circular 579), U.S. Dept. of Commerce Clearinghouse, PB 168 350 (1957) April.

Table I. Properties of Soils at Test Sites.

Site Iden	Soil	Location	Internal Drainage of Test Site	Resistivity[a] (ohm - cm)	Composition of Water Extract (Parts per Million)										
					pH	TDS[b]	Ca	Mg	Na + K as Na	CO_3	HCO_3	So_4	Cl	NO_3
A	Sagemoor sandy loam	Toppenish, Wash.	Good	400	8.8	7,080	108	23	1,960	0.0	5,002	216	330	6
B	Hagerstown loam	Loch Raven, Md.	Good	34,760	5.3	(c)	-	-	-	-	-	-	-	-
C	Clay	Cape May, N.J.	Poor	770	4.3	14,640	540	754	2,242	0.0	0.0	6,768	3,529	118
D	Lakewood sand	Wildwood, N.J.	Good	45,700	5.7	(c)	-	-	-	-	-	-	-	-
E	Coastal sand	Wildwood, N.J.	Poor	27,200	7.1	11,020	302	329	3,230	0.0	55	1,133	5,765	31
G	Tidal marsh	Patuxent, Md.	Poor	5,300	6.0	11,580	140	165	2,392	0.0	0.0	1,709	3,259	37
						(Milligram equivalents per 100 grams of soil)								
A	-	-	-	-	-	-	0.54	0.19	8.50	0.0	8.20	0.45	0.93	0.01
B	-	-	-	-	-	(c)	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	2.70	6.18	9.51	0.0	0.0	14.0	9.94	0.19
D	-	-	-	-	-	(c)	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	1.51	2.70	13.9	0.0	0.09	2.36	16.2	0.05
G	-	-	-	-	-	-	0.70	1.35	10.2	0.0	0.0	3.56	9.18	0.06

(a) Resistivity determinations made at the test site by Wenner's 4-pin method except for Site A where Shepard's cane was used.

(b) TDS, total dissolved solids - residue dried at 105°C.

(c) Analysis not made for soils at Sites B and D because of the very low concentration of soluble salts in these soils.

Table II. Stainless Steel Systems in Underground Corrosion Tests[a]

System	Burial Year	Stainless Steel	Spec. Config. & Size*	Treatment+	Passivation° Procedure	Stressed•	Spec. Coupled To
1	1971	26 Cr-1 Mo	Sheet (8"x12")	--	I	--	--
2	"	18 Cr (Ti)	" "	--	I	--	--
3	"	"	" "	XBW	I	--	--
4	"	20 Cr-24 Ni-6.5 Mo	" "	--	I	--	--
5	"	"	" "	S	I	--	--
6	"	18 Cr-2 Mo	" "	--	I	--	--
7	1972	18 Cr-2 Mo (Nb)	" "	--	I	--	--
8	1971	18 Cr-8 Ni(N)	" "	--	I	--	--
9	"	"	" "	XBW	I	--	--
10	"	26 Cr-6.5 Ni	" "	--	I	--	--
11	1972	18 Cr-2 Mo (Nb)	" "	XBW	I	--	--
12	"	"	Tube (2" ODx12")	HW	I	--	--
14	1971	Composite A	Sheet (8"x12")	--	--	--	--
15	"	Composite B	" "	--	--	--	--
16	"	Composite C	" "	--	--	--	--
17	"	26 Cr-1 Mo	Tube (2" ODx12")	HW	I	--	--
18	"	18 Cr (Ti)	(1 1/8" ODx12")	HW	I	--	--
19	"	20 Cr-24 Ni-6.5 Mo	(7/8" ODx12")	HW	I	--	--
20	"	26 Cr-1 Mo	Sheet (1"x12")	--	I	(UU)	--
21	"	"	" "	--	I	U	--
22	"	20 Cr-24 Ni-6.5 Mo	" "	--	I	(UU)	--
23	"	"	" "	--	I	U	--
24	"	"	" "	S	I	UU	--
25	"	18Cr-2Mo	" "	--	I	(UU)	--
26	"	"	" "	--	I	U	--
27	"	18 Cr-8 Ni(N)	" "	--	I	(UU)	--
28	"	"	" "	--	I	U	--
30	"	26 Cr-6.5 Ni	" "	--	I	U	--
33	"	26 Cr-1 Mo	" "	--	I	U	Zn
34	"	"	" "	--	I	U	Mg
35	"	"	" "	--	I	U	Fe
36	"	26 Cr-6.5 Ni	" "	--	I	U	Zn
37	"	"	" "	--	I	U	Mg
38	"	"	" "	--	I	U	Fe
42	"	"	" "	--	I	--	Cu
50	1970	201	Sheet (8"x12")	--	I	--	--
51	"	202	" "	--	I	--	--
52	"	301	" "	--	I	--	--
53	"	"	" "	S	I(g)	--	--
54	"	"	" "	XBW	I	--	--
55	"	304	" "	--	I	--	--
56	"	"	" "	S	I(g)	--	--
57	"	"	Tube (2" ODx12")	HW(b)	I	--	--
58	"	316	Sheet (8"x12")	--	I	--	--
59	"	"	" "	S	I	--	--
60	"	409	" "	--	III	--	--
61	"	"	" "	C	--	--	--
62	"	"	Tube (1-1/8" ODx12")	HW	III	--	--
63	"	"	Tube (7/8" ODx12")	HFW	III	--	--
64	"	410	Sheet (8"x12")	--	III	--	--
65	"	430	" "	--	II	--	--
66	"	434	" "	--	I	--	--
67	"	301	Sheet (1"x12")	HH	I	U	--
68	"	"	" "	HH	I	(UU)	--
69	"	"	" "	HH+S	I(g)	UU	--
70	"	"	" "	FH	I	U	--
71	"	"	" "	FH	I	(UU)	--
72	"	304	" "	--	I	U	--
73	"	"	" "	--	I	(UU)	--
74	"	"	" "	HH	I	U	--
75	"	"	" "	HH	I	(UU)	--
76	"	"	" "	S	I(g)	UU	--
77	"	316	" "	--	I	U	--
78	"	"	" "	--	I	(UU)	--
79	"	"	" "	S	I(g)	UU	--
80	"	434	" "	--	I	U	--
81	"	"	" "	--	I	(UU)	--
82	"	301	" "	HH	I	U	Zn
83	"	"	" "	HH	I	U	Mg
84	"	"	" "	HH	I	U	Fe
85	"	"	" "	FH	I	U	Zn
86	"	"	" "	FH	I	U	Mg
87	"	"	" "	FH	I	U	Fe
88	"	304	" "	--	I	U	Zn
89	"	"	" "	--	I	U	Mg
90	"	"	" "	--	I	U	Fe
91	"	"	" "	--	I	--	Cu
92	"	409	" "	--	III	--	Cu

* All sheet and tube specimens 0.064" thick.
\+ All specimens in the annealed condition unless noted otherwise.
(a) Systems 1-19, 50-66, covered in this report.
(b) Welded with a full finish per ASTM Specification A249.

Table II. (Cont'd)

Key: S - Sensitized (by heating at 1200°F for 2 hours, followed by air cooling and descaling in sodium hydroxide);
XBW - Cross bead weld (specified to be done in accordance with Welding Research Council recommendations. On half of these specimens, the welds were cleaned prior to exposure. The other half of the specimens were to be exposed "as welded."
HW - Heliarc weld,
HFW - HFW High frequency weld;
C - Coated;
HH - Half hard;
FH - Full hard.

°Key: -- = Unstressed;
U = Single U-bend specimen;
UU = Double U-bend specimen, no spot weld;
(UU) = Double U-bend specimen joined by spot weld.

°Passivation procedure:

I. 20 to 40% by volume of 67% nitric acid at 120-160°F for 20-30 minutes.
II. 20% by volume of 67% nitric acid plus 2-6% sodium dichromate at 110-140°F for 20-30 minutes.
III. 20 to 40% by volume of 67% nitric acid at 110-140°F for 20-30 minutes.
(g) Minimum specified concentration of acid, temperature and time for sensitized materials.

Table III. Chemical analyses of stainless steels buried at various NBS underground test sites.

Stainless Steel	SYSTEMS	C	Mn	Si	S	P	Cr	Ni	Mo	N	Cu	Ti	OTHERS
Type 201	50	0.066	6.90	0.47	0.009	0.034	16.76	5.10		0.078			
Type 202	51	0.10	8.05	0.41	0.004	0.003	17.50	5.13	0.15	0.15	0.12		
Type 301	52,53,54	0.092	1.1	0.49	0.006	0.015	16.1	7.1					
Type 301	67,68,69,82,83,84	0.10	1.02	0.34	0.016	0.030	17.43	7.14	0.22				Co-0.09
Type 301	70,71,85,86,87	0.13	0.86	0.54	0.013	0.020	16.98	7.23					
Type 304	55,56,72,73,76,88,89,90,91	0.048	1.46	0.50	0.012	0.030	18.2	9.80	0.17	0.042	0.19		
Type 304	57	0.06	0.82	0.68	0.015	0.024	18.45	9.11	0.40		0.25		
Type 304	74,75	0.051	1.0	0.64	0.009	0.022	17.6	9.8	0.15	0.16	0.11		Al<0.01,V-0.026
Type 316	58,59,77,78,79	0.049	1.62	0.53	0.009	0.020	17.48	13.53	2.28		0.11		
Type 409	60,61,92	0.058	0.47	0.57	0.005	0.014	10.75	0.61	0.12		0.37	0.60	Al-0.13
Type 409	62	0.05	0.51	0.44	0.013	0.024	11.22	0.67				0.65	
Type 409	63	0.05	0.41	0.44	0.018	0.022	11.20	0.34				0.55	
Type 410	64	0.14	0.55	0.14	0.014	0.016	12.53						
Type 430	65	0.060	0.46	0.50	0.010	0.017	16.67						
Type 434	66,80,81	0.076	0.42	0.43	0.011	0.017	18.2	0.32	0.76	0.046	0.05		Al-0.046,V-0.025
26Cr-1Mo	1,17,20,21,33,34,35	0.002	0.01	0.21	0.011	0.010	26.18	0.10	0.94	0.010			
18Cr(Ti)	2,3,18	0.046	0.32	0.40	0.013	0.023	18.22	0.49				0.55	
20Cr-24Ni-6.5Mo	4,5,19,22,23,24	0.038	1.73	0.81	0.004	0.013	20.41	23.61	6.50				
18Cr-2Mo	6,25,26	0.013	0.91	0.10	0.010	0.023	18.90	0.15	2.15	0.023	0.08		Nb-0.07,Pb-0.002, Sn-0.005,Al-0.017
18Cr-8Ni(N)	8,9,27,28	0.035	1.64	0.36	0.012	0.029	19.29	8.15	0.26	0.25	0.18		
26Cr-6.5Ni	10,30,36,37,38,42	0.015	0.49	0.40	0.020	0.022	26.5	6.2	0.04	0.021	0.08		Al<0.01,V-0.054
18Cr-2Mo (Nb)	7,11,12	0.03	0.91	0.78	0.016	0.02	18.54	0.28	1.97	0.031	0.13		Nb-0.47,Al-0.01 Pb-0.003
Composite Alloys[a]:													
A Type 430	14	0.06	0.16	0.31	0.008	0.015	16.86	0.28					
B Type 430	15	0.06	0.16	0.31	0.008	0.015	16.86	0.28					
C Type 304	16	0.02	1.26	0.48	0.018	0.02	17.3	10.2					
Carbon steel	14,15,16	0.042	0.32	0.009	0.012	0.007					0.017		Al-0.048

(a) A. Carbon Steel/430/Carbon Steel
B. Galv. Steel/430/Galv. Steel
C. Carbon Steel/304/Carbon Steel

Table IV. Mechanical Properties[(a)] of Stainless Steels Studied in This Investigation

Alloy Designation	Treatment[(b)]	System	Tensile Strength, Ksi	Yield Strength, Ksi	Percent, Elongation in 2-in	Hardness
Type 201	--	50	103.5	53.0	52.5	R_B 92.5
Type 202	--	51	100.6	52.0	52.0	R_B 90.5
Type 301	--	52	120.1	42.1	64.0	R_B 85
Type 301	Sensitized	53	107.9	38.1	46.0	R_B 87
Type 301	Half-hard	67,68,82,83,84	162.0	116.0	25.0	R_C 34
Type 301	Half-hard + sensitized	69	147.0	97.5	26.0	R_C 28
Type 301	Full-hard	70,71,85,86,87	203.0	174.7	9.0	R_C 44
Type 301	Welded cross bead	54	See Type 301 (annealed)			
Type 304	--	55,72,73,88,89,90,91	86.9	46.4	52.0	R_B 85
Type 304	Sensitized	56,76	85.3	41.3	53.0	R_B 81.5
Type 304	Half-hard	74,75	144.7	129.3	14.0	R_C 33
Type 304	Heliarc weld	57	81.8	44.9	75.7	R_B 72
18Cr-8Ni(N)	--	8,9,27,28	103.0	60.0	45.0	R_B 91
Type 316	--	58,77,78	91.6	43.4	42.0	R_B 81
Type 316	Sensitized	59,79				
Type 409	--	60,92	70.6	46.6	31.0	R_B 77
Type 409	Heliarc weld	62	70.7	59.1	40.0	R_B 79
Type 409	Hi-Freq. weld	63	69.8	64.7	37.0	R_B 68
Type 410	--	64	74.5	52.8	29.5	R_B 84
Type 430	--	65	71.0	45.6	30.5	R_B 81
Type 434	--	66,80,81	79.8	56.3	26.0	R_B 86
26 Cr-1 Mo	--	1	71.5	54.0	26.0	R_B 88.5
26 Cr-1 Mo	--	17	79.5	48.1	31.0	R_B 78
26 Cr-1 Mo	--	20,21,33,34,35	67.0	48.6	26.5	R_B 79
18 Cr(Ti)	--	2,3,18	74.2	46.4	28.5	R_B 80
20 Cr-24 Ni-6.5 Mo	--	4,15,19,22,23,24	92.0	45.0	47.0	R_B 78.5
26 Cr-6.5 Ni	--	10,30,36,37,38,42	131.8	120.6	13.5	R_C 31
18 Cr-2 Mo	--	6,25,26	83.8	60.8	26.6	———
18 Cr-2 Mo (Nb)	--	7,11,12	81.0	61.8	36.0	R_B 86

(a) Properties are as furnished by supplier
(b) All materials were in the annealed condition unless otherwise noted.
(c) Welded with a full finish per ASTM Specification A249.

Table V. Summary of results[a] obtained from visual examination of stainless steel sheet specimens buried in the soils at the NBS soil corrosion test sites. Specimens of System No. 7 were buried for approximately two years.

System	Stainless Steel	Specimen Type and Treatment (b)	Test Site (c)	Results of Visual Examination of Specimens (d) Years Exposed 1	2
Exposed in 1970					
50	Type 201	Sheet, annealed	A	N	N
			B	N	RS
			C	T,P,H	P(F,E),T,IP
			D	IP	P,IP
			E	H,P,T	H,T,P,IP,Et(sli)
			G	A,P,IP,Et(sli)	H(E),P,A(sev),IP
51	Type 202	Sheet, annealed	A	N	IP
			B	N	RS
			C	T,P,H	H,P(F,E),T,IP
			D	IP	DS
			E	H,T(E),P,IP	H,P,T,IP,IF
			G	P,IP	P,IP
52	Type 301	Sheet, annealed	A	N	IP
			B	IP	RS
			C	T,P,IP	P(F,E),IP
			D	IP	IP
			E	H	H,P,T,IP
			G	P,T(E),IP	T,P,A and Et(sev),IP
53	Type 301	Sheet, sensitized	A	IP,Et	E(E),P,IP
			B	IP(E)	P(sli),IP
			C	P,Et	Et(sev),P(F,E),IP
			D	IP(E)	P,Bl,IP
			E	A(E),P(E,AE),IP,Et	Et(sev),Bl,A(E),P,IP
			G	Et(mod and sev),P,IP	H,A and Et(sev),P,IP
55	Type 304	Sheet	A	N	IP
			B	N	RS
			C	H,T,IP	T,P,IP
			D	IF	N
			E	H,P,IP	H,T,P,IP
			G	H(E),P,IP,Et(sev)	A(sev),P,IP
56	Type 304	Sheet, sensitized	A	Et[E(sli)],IP	P(sli),IP
			B	Et(sli),IP	N
			C	H,T(E),P	H,P(E,AE),T,A(E),IP
			D	IF	T,P(AE,E),IP,Bl
			E	H,P,IP	H,T,P,IP
			G	H(E),P,IP	H,A,P,IP,Et(sev)
58	Type 316	Sheet, annealed	A	N	IP
			B	N	N
			C	Et,IP	IP
			D	N	N
			E	A and T(E),P(F,E)	H,T,P,IP
			G	IP	P(F,AE),IP
59	Type 316	Sheet, sensitized	A	IP(E)	P(sli),IP
			B	N	DS
			C	P(E,F),H(E)	A and P(E),T,Et(sli)
			D	IP	N
			E	P(E)	P,A(E),Et(sli)
			G	P(E)	P,IP,Et(sli)
60	Type 409	Sheet, annealed	A	IP	N
			B	N	P(sli)
			C	P,H(E),Et(sev)	H,P,Et(sev),T,IP
			D	IF,RS	P,T
			E	H,T(E,F),P	H,T(AE,F),P,IP,Et(sli)
			G	H,Et(sev),P,IP	H,P,A(sev),Et,IP
61	Type 409	Sheet, painted	A	N	N
			B	N	N
			C	N	N
			D	N	N
			E	N	N
			G	N	N
61	Type 409	Sheet, painted and scored	A	RS(s)	N
			B	RS(s)	RS(s)
			C	RS(s,c)	RS[s(sli)],U
			D	c,RS(s)	RS[s(sli)]
			E	c,RS(s)	P and RS(s),U,Bl
			G	RS(s)	P and RS(s),U,Bl

Table V. (cont'd)

System	Stainless Steel	Specimen Type and Treatment (b)	Test Site (c)	Results of Visual Examination of Specimens (d) — Years Exposed 1	2
Exposed in 1970 (cont'd)					
64	Type 410	Sheet, annealed	A	P and IP(E,F)	T,P,A(E)
			B	IP	N
			C	H,P,IP	H,P,Et(sev),A,IP
			D	H,P,T,IP	H,T,P,A(E),Et(sev),IP
			E	H(E),T	H,T,P,IP
			G	Et(sev),H,P,IP	H,A and Et(sev),P,IP
65	Type 430	Sheet, annealed	A	Et(sli),IP	IP
			B	N	N
			C	H(E)	H,P,T,Et
			D	IF	T(F)
			E	H,T,IP	H,T,P,IP
			G	H,Et(sev),P,IP	H,P,A and Et(sev),IP
66	Type 434	Sheet, annealed	A	N	IP
			B	IP	N
			C	H(E)	H,P,T,IP
			D	N	P(F),IP(E)
			E	H,P,IP	H,T,P,IP
			G	H(E),P,IP	H,P,A and Et(sev),IP
Exposed in 1971					
1	26Cr-1Mo	Sheet, annealed	A	P(sli)IP	N
			B	N	RS
			C	P(AE),T,IP(E)	IP,RS
			D	IP	Et(sli)
			E	P(E,AE),IP	N
			G	P(E,F),Et,IP	N
2	18Cr(Ti)	Sheet, annealed	A	P(sli),IP	N
			B	N	Et(sli),RS
			C	H,P,Et,IP	Et,P(E,F),IP,RS
			D	P(AE),T,IP	N
			E	H,P,T	H,P(E,AE,F),T
			G	H,P,A and Et(sev),IP	H,P(E,AE,F),Et,IP
4	20Cr-24Ni-6.5Mo	Sheet, annealed	A	IP	N
			B	N	Et(sli),RS
			C	IP(E)	N
			D	N	Et(sli),RS
			E	N	N
			G	N	N
5	20Cr-24Ni-6.5Mo	Sheet, sensitized	A	IP	N
			B	N	N
			C	IP	Et(sli),IP,RS
			D	IP	Et(sli)
			E	A(E)	Et(sli)
			G	P(E),Et(sli),IP	Et(sli)
6	18Cr-2Mo	Sheet, annealed	A	P(sli),IP	N
			B	IP	N
			C	T,P(E,F),IP	RS
			D	P(F)	Et(sli)
			E	H,P,IP	H,P(AE,E,F),RS
			G	H,T,A,P,IP	H,P(AE,E,F)Et
8	18Cr-8Ni(N)	Sheet, annealed	A	IP	N
			B	N	RS
			C	IP	P,IP,RS
			D	N	Et(sli)
			E	P(E)	P(E)
			G	P(E,F),IP	H,P,T(E,AE),Et,IP
10	26Cr-6.5Ni	Sheet, annealed	A	P(sli),IP	P(sli AE)
			B	N	RS
			C	H,T,P,IP	H,T(E),P,IP
			D	N	IP
			E	H,P,IP	H,P,T(AE,E,F)IP
			G	H,P,A and Et(sev),IP	H,P,T(E,AE),IP

Table V . (cont'd)

System	Stainless Steel	Specimen Type and Treatment (b)	Test Site (c)	Results of Visual Examination of Specimens (d) Years Exposed 1	2
Exposed in 1971 (cont'd)					
14	Composite A	Sheet, hot rolled and pickled	A	Et(sev),P	P,Et[(sev)F,AE]
			B	Et(sev),P,IP	P,Et[(sev)F,AE],A(E)
			C	Et(sev),P	P,Et(F,AE),A(E)
			D	Et(sev),P	P,Et(F,AE)
			E	Et[F,E(sev)]	P,Et(F,AE)
			G	Et(sev),Bl,P(AE)	P,Et(F,AE),A(E)
15	Composite B	Sheet, hot-dip zinc coated (4.5 oz/sq ft-Zn)	A	N	N,c
			B	N	N
			C	N	N
			D	N	N
			E	A[F(sli)]	N
			G	P(F),Fl(AE,E)	P[sli(F)]
16	Composite C	Sheet, hot-rolled and pickled	A	Et(sev),P(F,AE)	P,Et(F,AE)
			B	Et(sev),P	P,Et(F,AE),A(E)
			C	Et(sev),P	P,Et(F,AE)
			D	Et(sev),P	P,Et(F,AE)
			E	Et(sev),P	P,Et(F,AE)
			G	Et(sev),P	P,Et(F,AE),A(E)
Exposed in 1972					
7	18Cr-2Mo(Nb)	Sheet, annealed	A	N	
			B	N	
			C	N	
			D	N	
			E	P,IP	
			G	N	

(a) Results given for each system exposed at each of the six soil test sites are a summary tabulation for four individual specimens.

(b) Specimen dimensions and treatment for each system are given in Table II.

(c) Properties of the soils for each of the test sites are given in Table I.

(d) Abbreviations used:

A - metal attack
AE - adjacent to edge
Bl - blisters
BS - black stain
c - coating chipped
DS - dark stain
E - edge
Et - etched
F - face
Fl - coating flaked
H - perforation
IF - irridescent film
IP - incipient pitting
mod - moderate
N - no apparent attack
P - pitting
RS - rust stain
s - scored area
sev - severe
sli - slight
T - tunneling
U - undercutting

Table VI. Summary of results[a] obtained from visual examination of welded stainless steel sheet and tube specimens buried in the soils at six NBS soil corrosion test sites. Specimens of System No.'s 11 and 12 were buried for approximately one year while all of the other specimens were buried approximately two years.

System	Stainless Steel	Material and Treatment (b)	Test Site (c)	Exposed 1 Year					Exposed 2 Years				
				Body or Face	Cap	End or Edge	Weld	Adjacent to Weld	Body or Face	Cap	End or Edge	Weld	Adjacent to Weld
Exposed in 1970													
54	Type 301	Sheet with cross-bead weld	A	N	N/A	N	N	N	IP	N/A	P(AE)	N	P
			B	N	N/A	N	N	N	IP	N/A	N	RS	RS
			C	N	N/A	P	N	P	P	N/A	P	P	P
			D	IP	N/A	N	N	N	N	N/A	N	N	P
			E	H	N/A	N	N	N	H,T,P,IP	N/A	P	N	P
			G	P	N/A	P	P	P	P,Et(sev),IP	N/A	P	P,A(sev)	P,A(sev)
57	Type 304	Tube with heliarc welded seam (2-in OD)	A	Et(sli)	N	N	N	N	Et	N	N	N	N
			B	Et(sli)	N	N	N	N	Et(sli)	Et(UC)	N	N	N
			C	Et(sli)	N	N	N	N	P	P(UC,AC),A(UC)	N	P	P
			D	Et(sli)	N	N	N	N	Et(sli)	N	N	N	N
			E	Et(mod to sev)	N	N	N	N	Et(sev),P,IP	P(AC,UC)	N	N	N
			G	Et(mod),P,IP	N	N	N	N	P,Et(sli),IP	P(AC,UC)	N	P	N
62	Type 409	Tube with heliarc welded seam (1-1/8 in OD)	A	P,IP	P&IP(UC)	N	P,IP	N	Et(sli),IP	N	N	N	IP
			B	N	N	N	N	N	P,IP	N	N	N	N
			C	H	N	N	N	N	H,P,Et,IP	H&P(AC,UC)	N	P	N
			D	N	N	N	N	N	P,ET(sli),IP	N	N	N	N
			E	H,P	N	N	N	N	H,P,Et(sli),IP	H&P(AC,UC)	N	P	N
			G	H,Et&A(sev),P,IP	N	N	N	N	H,P,A(sev),Et,IP	H&P(AC,UC)	N	H,P	H,P
63	Type 409	Tube with high-frequency welded seam (7/8-in OD)	A	Et,P	IP(AC)	N	IP	N	IP	N	P	N	IP
			B	N	N	N	N	N	P,IP	N	N	IP	IP
			C	P	N	N	N	N	H,P,Et,IP	H(AC)	N	H,P	P
			D	N	N	N	H	H,P	H,P,Et(sli),IP	N	N	H,P	H,P
			E	H,P,IP	N	N	N	N	H,T,P,IP	H&P(AC,UC)	N	H,P	H,P
			G	H,A(sev),P,IP,Et	P(AC)	N	N	N	H,P,A(sev),Et,IP	H&P(AC)	N	H,P	H,P
Exposed in 1971													
3	18Cr-0.5Ni(Ti)	Sheet with cross-bead weld	A	IP,Et	N/A	N	N	N	P	N/A	N	N	N
			B	N	N/A	N	N	N	N	N/A	N	N	N
			C	P,T,IP	N/A	P,T	P	P	P,Et(sli),IP	N/A	P	P	N
			D	P	N/A	N	P	P	N	N/A	N	N	N
			E	H,P,IP	N/A	H,P	P	P	H,P,Et,IP	N/A	P(AE,E)	P	N
			G	H,P,IP	N/A	H,P	P	P	P,Et,T	N/A	P(AE,E)	N	N
9	18Cr-8Ni(N)	Sheet with cross-bead weld	A	IP	N/A	N	Et	IP	N	N/A	N	N	N
			B	RS	N/A	N	Et	N	RS	N/A	N	RS	N
			C	A,P	N/A	N	Et,P	IP	Et,IP	N/A	Et(AE)	P	P,Et(sev)
			D	N	N/A	N	Et	IP	Et(sli)	N/A	N	N	N
			E	P,T,Et	N/A	N	P	H,P	Et(sli)	N/A	N	P	P
			G	P,Et,IP	N/A	P	P,Et	IP	P	N/A	P(AE,E)	Et,P	Et,P
17	26Cr-1Mo	Tube with heliarc welded seam (2-in OD)	A	N	N	N	N	N	N	N	N	N	N
			B	N	N	N	N	N	N	N	N	N	N
			C	N	N	N	N	N	N	P(AC,UC),RS(UC)	N	N	N
			D	N	N	N	N	N	N	N	N	N	N
			E	N	P(UC)	N	N	N	N	P&Et(UC)	N	N	N
			G	P	RS(AC)	N	N	N	P	P(UC)	N	N	N
18	18Cr(Ti)	Tube with heliarc welded seam(1-1/8 in OD)	A	N	N	N	N	N	N	N	N	N	N
			B	N	N	N	N	N	N	N	N	N	N
			C	P,IP,Et	H&P(AC)	N	P	P	P	H&P(AC)	N	P	P
			D	N	N	N	N	N	N	N	N	N	N
			E	P,IP	H(AC)	N	N	N	N	P(UC)	N	N	N
			G	H,P,Et,IP	N	N	H,P	H,P	H,P,Et	H,P&Et(AC)	N	N	N
19	20Cr-24Ni-6.5Mo	Tube with heliarc welded seam (7/8-inOD)	A	N	N	N	N	N	N	N	N	N	N
			B	N	N	N	N	N	RS	N	N	N	N
			C	RS	N	N	N	N	RS	N	N	N	N
			D	RS	N	N	N	N	N	N	N	N	N
			E	N	N	N	N	N	N	N	N	N	N
			G	N	N	N	N	N	N	RS(AC)	N	N	N
Exposed in 1972													
11	18Cr-2Mo(Nb)	Sheet with cross-bead weld	A	N	N/A	N	N	N					
			B	N	N/A	N	N	N					
			C	Et(sli)	N/A	N	P,Et(sli),IP	Et(sli),IP					
			D	N	N/A	N	N	N					
			E	P	N/A	N	P	P					
			G	N	N/A	N	N	N					
12	18Cr-2Mo(Nb)	Tube with heliarc welded seam (2-in OD)	A	N	N	N	N	N					
			B	N	N	N	N	N					
			C	N	N	N	N	N					
			D	N	N	N	N	N					
			E	H	P(UC)	N	N	N					
			G	N	N	N	N	N					

(a) Results given for each system exposed at the six soil test sites are a summary tabulation for four individual specimens.
(b) Specimen dimensions and treatment for each system are given in Table II.
(c) Properties of the soils and treatment for each system are given in Table I.
(d) Abbreviations used:

A - metal attack	N - no apparent attack
AC - adjacent to cap	N/A - not applicable
AE - adjacent to edge	P - pitting
E - edge	RS - rust stain
Et - etched	sev - severe
H - perforation	sli - slight
IP - incipient pitting	T - tunneling
mod - moderate	UC - under cap

Table VII. Average weight loss (oz/ft²) and pit depths (mils) determination for stainless steel alloy sheet and tubing specimens buried in various soil environments. Systems 7, 11, and 12 were exposed for approximately 1 year while all other systems were exposed up to two years.

System *	Alloy Designation	Treatment (a)	Years Exposed	Site A Toppenish, Washington			Site B Loch Raven, Maryland			Site C Cape May, New Jersey			Site D Wildwood, New Jersey			Site E Wildwood, New Jersey			Site G Patuxant, Maryland		
				Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)	Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)	Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)	Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)	Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)	Weight Loss oz/ft² (b)	Pit Depth, Mils (b) Max.	Pit Depth, Mils (b) Average of 5 Deepest (c)
Exposed in 1970																					
50	Type 201	-	1	-	-	-	-	-	-	0.02	H(E)	-	-	IP	-	0.03	H	-	0.10	45	-
			2	-	-	-	-	-	-	0.02	H(E,AE)	-	<0.01	40(C)	-	0.09	H(AE)	H(f)	0.03	H	-
51	Type 202	-	1	-	-	-	-	-	-	0.01	H(E,T)	-	-	-	-	0.02	H(AE)	-	<0.01	40	-
			2	-	IP	-	-	-	-	0.02	H(AE)	H	-	-	-	0.05	H(AE)	H(f)	<0.01	33	7
52	Type 301	-	1	-	-	-	-	-	-	0.04	20	-	-	IP	-	0.03	H(AE)	-	<0.01	40	-
			2	-	<5	-	-	-	-	0.01	H(AE)	H	-	IP	-	0.07	H(F,E)	H(f)	0.03	30	11
53	Type 301	S	1	<0.01	IP	-	<0.01	IP	-	0.09	48(E)	15	<0.01	Et(e)	-	0.04	<5	-	0.13	25	-
			2	<0.01	<5	-	-	-	-	0.33	19	14	0.02	-	-	0.09	8	-	0.34	H	-
54	Type 301	XBW	1	-	-	-	-	-	-	0.01	63(E)	-	-	Et	-	0.03	H	-	<0.01	13(AE)	-
			2	-	<5	-	-	-	-	0.01	16(AW)	6	-	IP	-	0.07	H(F,E)	H(f)	0.04	62(AE)	9
55	Type 304	-	1	-	-	-	-	-	-	<0.01	H	-	-	IP	-	0.04	H	-	0.02	H(E)	-
			2	-	-	-	-	-	-	0.02	H(AE)	-	<0.01	-	-	0.08	H(AE)	-	0.05	36	11
56	Type 304	S	1	<0.01	Et	-	0.02	Et	-	0.04	H(E)	-	<0.01	Et	-	0.00	H(T)	-	<0.01	20	-
			2	0.01	<5	-	0.02	-	-	0.05	H(AE)	-	0.02	H(AE)	-	0.15	H(F,AE,E)	H	0.16	H	-
57	Type 304	HW	1	-	-	-	-	-	-	-	-	-	-	-	-	0.05	38	-	-	Et	-
			2	-	Et	-	-	Et(UC)	-	0.01	16	5	-	Et	-	0.11	26(UC)	-	-	10(AC)	3
50	Type 316	-	1	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	H(E)	-	-	<5	-
			2	-	-	-	-	-	-	-	-	-	<0.01	-	-	0.01	H(AE)	-	-	<5	-
59	Type 316	S	1	-	IP	-	-	-	-	0.02	H(E)	-	<0.01	Et	-	0.03	63(E)	-	-	<5	-
			2	<0.01	<5	-	<0.01	-	-	0.02	T(E)	-	<0.01	-	-	0.08	<5	-	<0.01	<5	-
60	Type 409	-	1	-	29(E)	-	-	-	-	0.16	H(E)	-	-	-	-	0.09	H	H	0.82	H	H(f)
			2	<0.01	<5	-	<0.01	-	-	0.14	H(E)	-	0.01	54(T)	-	0.10	H(F,AE)	H(f)	1.73	H	H(f)
62	Type 409	HW	1	0.02	Et	-	-	-	-	0.11	H	-	-	-	-	0.10	H	H	1.10	H	H(f)
			2	0.01	IP,Et	-	-	IP	-	0.37	H(B,AC)	H(g)	-	21	-	0.16	H(B,UC)	H	2.23	H(B,AC)	H(f)
63	Type 409	HFW	1	-	IP	-	-	-	-	0.18	1C	-	-	H(AW)	-	0.10	H	H	0.76	H	H(f)
			2	0.02	<5	-	-	IP	-	0.36	H(B,AC)	H	0.01	H(W)	-	0.17	H(AC,W)	H	3.34	H(AC)	-
64	Type 410	-	1	0.09	48(E)	-	0.04	IP	-	0.18	30	20(d)	<0.01	H	-	0.10	H	H	0.83	H	H(f)
			2	<0.01	20	7	0.03	-	-	0.42	H(F,AE)	-	0.03	H(F,E)	-	0.10	H(F,AE)	H(f)	1.84	H	H(f)
65	Type 430	-	1	-	Et	-	-	-	-	0.12	H(E)	-	-	-	-	0.04	H	H	1.15	H	H(f)
			2	-	IP	-	<0.01	-	-	0.13	H(AE)	H	<0.01	18	-	0.08	H(F,AE)	H(f)	2.71	H	H(f)
66	Type 434	-	1	-	-	-	-	IP	-	0.01	H(E)	-	-	-	-	0.04	H	H	-	H(E)	-
			2	<0.01	IP	-	-	-	-	0.02	H(AE)	H(f)	<0.01	56	-	0.08	H(F,AE)	H(f)	0.19	H	-
Exposed in 1971																					
1	26Cr-1Mo	-	1	-	IP	-	-	-	-	<0.01	IP	-	-	IP	-	<0.01	IP	-	<0.01	IP	-
			2	-	-	-	-	-	-	-	IP	-	-	-	-	-	-	-	<0.01	-	-
2	18Cr(Ti)	-	1	<0.01	IP	-	<0.01	-	-	0.03	H(AE)	-	<0.01	23	-	0.01	H(F,AE)	H(f)	0.31	H	-
			2	<0.01	-	-	-	-	-	0.02	42	-	-	-	-	0.01	H	H	0.87	H	H
3	18Cr(Ti)	XBW	1	-	<5	-	-	-	-	0.01	H(AE)	-	<0.01	26	14	0.01	H(AE)	-	0.10	H(F,AE)	-
			2	<0.01	<5	-	-	-	-	<0.01	24	-	-	-	-	0.02	H	H	0.02	28	-
4	20Cr-24Ni-6.5Mo	-	1	-	IP	-	-	-	-	<0.01	IP	-	<0.01	-	-	-	-	-	-	-	-
			2	<0.01	-	-	<0.01	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-
5	20Cr-24Ni-6.5Mo	5	1	-	IP	-	-	-	-	<0.01	IP	-	-	IP	-	<0.01	-	-	<0.01	IP	-
			2	-	-	-	-	-	-	-	IP	-	-	-	-	<0.01	-	-	-	-	-
6	18Cr-2Mo	-	1	-	IP	-	-	IP	-	<0.01	<5	-	-	-	-	0.02	H(AE)	-	0.01(e)	H(F,AE)(e)	-
			2	<0.01	-	-	-	-	-	<0.01	-	-	<0.01	-	-	0.01	H	H	0.02	H	H
8	18Cr-8Ni(N)	-	1	-	IP	-	-	-	-	-	IP	-	-	-	-	<0.01	-	-	<0.01	5	-
			2	-	-	-	-	-	-	-	<5	-	-	-	-	<0.01	24(E)	-	<0.01	H	H
9	18Cr-8Ni(N)	XBW	1	-	IP	-	-	25(W)	-	0.01	141(W)	-	-	IP	-	0.02	H(F,AW)	-	0.02	110(W)	-
			2	-	-	-	-	-	-	0.01	10	-	-	-	-	0.04	H(W)	-	0.09	11	-
10	26Cr-6.5Ni	-	1	-	<5	-	-	-	-	0.01	H(AE)	-	-	Et	-	0.01	H(F,E)	-	0.12	H	-
			2	-	<5	-	-	-	-	<0.01	H	H	-	IP	-	0.03	H	H	<0.01	H	H
14	Composite A(g)	-	1	2.1	N/A	-	1.7	N/A	-	1.0	N/A	-	0.7	N/A	-	0.6	N/A	-	2.9	N/A	-
			2	2.8	N/A	-	2.2	N/A	-	1.6	N/A	-	0.8	N/A	-	0.7	N/A	-	9.8	N/A	-
15	Composite B(g)	HOZ	1	0.2	N/A	-	0.3	N/A	-	1.5	N/A	-	0.1	N/A	-	0.3	N/A	-	1.5	N/A	-
			2	0.6	N/A	-	0.2	N/A	-	1.5	N/A	-	-	N/A	-	<0.1	N/A	-	1.7	N/A	-
16	Composite C(g)	-	1	2.2	N/A	-	2.0	N/A	-	1.1	N/A	-	0.7	N/A	-	0.5	N/A	-	2.7	N/A	-
			2	2.9	N/A	-	2.8	N/A	-	1.5	N/A	-	1.0	N/A	-	0.5	N/A	-	6.6	N/A	-
17	26Cr-1Mo	HW	1		<5W	-		-	-		-	-		-	-		13	-		Et	-
			2	-	-	-	-	-	-	-	4(UC)	-	-	-	-	<0.01	<5(UC)	-	<0.01	4(UC)	-
18	18Cr(Ti)	HW	1		-	-		-	-		H(AC,AW)	-		-	-		H(AC)	-		H	-
			2	-	-	-	-	-	-	<0.01	H	H	-	-	-	-	6(UC)	-	3.22	H	H
19	20Cr-24Ni-6.5Mo	HW	1		-	-		-	-		-	-		-	-		-	-		-	-
			2	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Exposed in 1972																					
7	18Cr-2Mo(Nb)	-	1	-	-	-	-	-	-	-	<5	-	-	-	-	-	<5	-	-	-	-
11	18Cr-2Mo(Nb)	XBW	1	-	-	-	-	-	-	<0.01	<5(AW)	-	<0.01	-	-	0.01	H(AW,W)	-	-	-	-
12	18Cr-2Mo(Nb)	HW	1	-	-	-	-	-	-	-	-	-	-	-	-	0.01	H(UC)	H(UC)	-	-	-

* Systems 12, 17, 18, 19, 57, 62, and 63 were tube specimens fabricated from sheet material, welded at the seams, and then plugged and capped at each end to minimize internal corrosion. Specimens of all other materials were fabricated as flat sheet specimens.

(a) All materials were in the annealed condition unless noted otherwise. Abbreviations used. S - sensitized; XBW - cross bead weld; HW - heliarc welded; HFW - high frequency weld; HOZ - hot-dip zinc coated (galvanized - 4.5 oz/ft² Zn).

(b) Average for four specimens unless noted otherwise.
Abbreviations used:
- AC - adjacent to cap
- AE - adjacent to edge
- AW - adjacent to weld
- B - body of tube
- E - edge
- Et - etched
- F - face of sheet
- H - perforation
- IP - incipient pitting
- T - tunneling
- UC - under cap
- W - weld
- N/A - not applicable

(c) Average of 5 deepest pits on each of four specimens unless noted otherwise.
(d) Average of 10 deepest pits on each of four specimens.
(e) Average for three specimens, one specimen mechanically damaged on removal from soil.
(f) Ten or more perforations on each of four individual specimens.
(g) All composites metallurgically bonded.
Composite A - carbon steel/Type 430 steel/carbon steel.
Composite B - carbon steel/Type 430 steel/carbon steel - galvanized after bonding.
Composite C - carbon steel/type 304 steel/carbon steel.

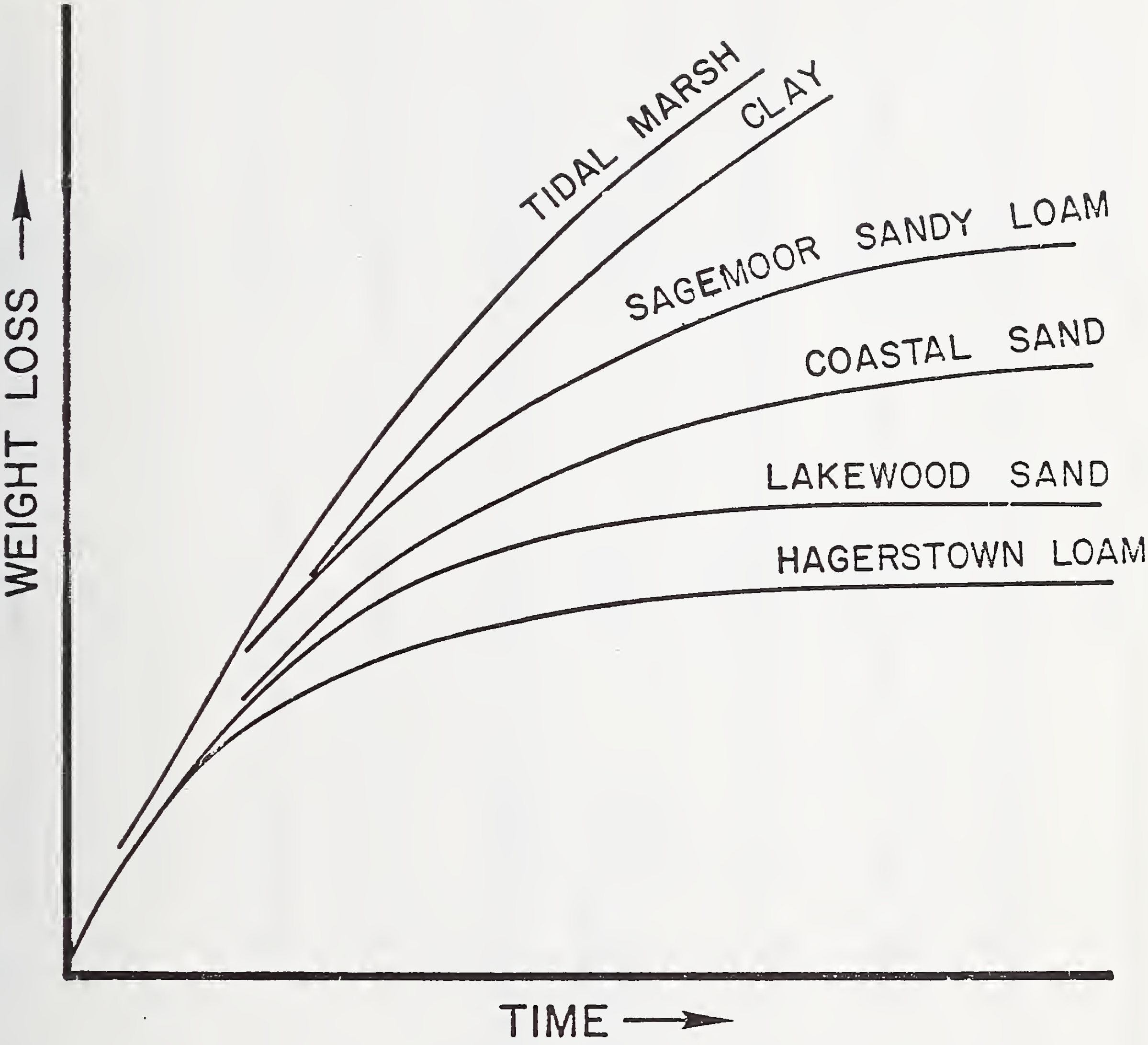

Figure 1. Relative Corrosion Effects of the Soils at the Six NBS Test Sites on Ferrous Metals.

Figure 2a. ORDER OF BURIAL OF SPECIMENS AT TEST SITES (1970)

First Removal (1 Yr)		Second Removal (2 Yr)		Third Removal (4 Yr)		Fourth Removal (8 Yr)		Fifth Removal (X Yr)	
■	■	■	■	■	■	■	■	■	■
50x01	50x03	50x05	50x07	50x09	50x11	50x13	50x15	50x17	50x19
51	51	51	51	51	51	51	51	51	51
52	52	52	52	52	52	52	52	52	52
53	53	53	53	53	53	53	53	53	53
54	54	54	54	54	54	54	54	54	54
55	55	55	55	55	55	55	55	55	55
56	56	56	56	56	56	56	56	56	56
57	57	57	57	57	57	57	57	57	57
58	58	58	58	58	58	58	58	58	58
59	59	59	59	59	59	59	59	59	59
60	60	60	60	60	60	60	60	60	60
61	61	61	61	61	61	61	61	61	61
62	62	62	62	62	62	62	62	62	62
63	63	63	63	63	63	63	63	63	63
64	64	64	64	64	64	64	64	64	64
65	65	65	65	65	65	65	65	65	65
66x01	66x03	66x05	66x07	66x09	66x11	66x13	66x15	66x17	66x19
50x02	50x04	50x06	50x08	50x10	50x12	50x14	50x16	50x18	50x20
51	51	51	51	51	51	51	51	51	51
52	52	52	52	52	52	52	52	52	52
53	53	53	53	53	53	53	53	53	53
54	54	54	54	54	54	54	54	54	54
55	55	55	55	55	55	55	55	55	55
56	56	56	56	56	56	56	56	56	56
57	57	57	57	57	57	57	57	57	57
58	58	58	58	58	58	58	58	58	58
59	59	59	59	59	59	59	59	59	59
60	60	60	60	60	60	60	60	60	60
61	61	61	61	61	61	61	61	61	61
62	62	62	62	62	62	62	62	62	62
63	63	63	63	63	63	63	63	63	63
64	64	64	64	64	64	64	64	64	64
65	65	65	65	65	65	65	65	65	65
66x02	66x04	66x06	66x08	66x10	66x12	66x14	66x16	66x18	66x20
■	■	■	■	■	■	■	■	■	■
67x02	67x04	67x06	67x08	68x10	68x12	67x14	67x16	68x18	68x20
68	68	68	68	69	69	68	68	69	69
69	69	69	69	71	71	69	69	71	71
70	70	70	70	73	73	70	70	73	73
71	71	71	71	74	74	71	71	74	74
72	72	72	72	75	75	72	72	75	75
73	73	73	73	76	76	73	73	76	76
74	74	74	74	78	78	74	74	78	78
75	75	75	75	79	79	75	75	79	79
76	76	76	76	81x10	81x12	76	76	81x18	81x20
77	77	77	77	67x10	67x12	77	77	67x18	67x20
78	78	78	78	70x10	70x12	78	78	70x18	70x20
79	79	79	79	■	■	79	79	■	■
80	80	80	80	72x10	72x12	80	80	72x18	72x20
81	81	81	81	77x10	77x12	81	81	77x18	77x20
82	82	82	82	80x10	80x12	91	91	80x18	80x20
83	83	83	83	82x10	82x12	92x14	92x16	91x18	91x20
84	84	84	84	■	■	■	■	■	■
85	85	85	85	83x10	83x12			92x18	92x20
86	86	86	86	84x10	84x12				
87	87	87	87	85x10	85x12				
88	88	88	88	86x10	86x12				
89	89	89	89	■	■				
90	90	90	90	87x10	87x12				
91	91	91	91	88x10	88x12				
92x02	92x04	92x06	92x08	89x10	89x12				
■	■	■	■	90x10	90x12				
				■	■				
				91x10	91x12				
				92x10	92x12				

■ 4"x4" Post

→■ Wire terminal to post for electrical measurements

⇉■ Wire terminals (galvanic couple) to post for electrical measurements.

Figure 2b. ORDER OF BURIAL OF SPECIMENS AT TEST SITES (1971)

First Removal (1 yr)		Second Removal (2 yr)		Third Removal (4 yr)		Fourth Removal (8 yr)		Fifth Removal (X yr)	
■	■	■	■	■	■	■	■	■	■
1x01	1x03	1x05	1x07	1x09	1x11	1x13	1x15	1x17	1x19
2x	2x	2x	2x	2x	2x	2x	2x	2x	2x
3x	3x	3x	3x	3x	3x	3x	3x	3x	3x
4x	4x	4x	4x	4x	4x	4x	4x	4x	4x
5x	5x	5x	5x	5x	5x	5x	5x	5x	5x
6x	6x	6x	6x	6x	6x	6x	6x	6x	6x
8x	8x	8x	8x	8x	8x	8x	8x	8x	8x
9x	9x	9x	9x	9x	9x	9x	9x	9x	9x
10x	10x	10x	10x	10x	10x	10x	10x	10x	10x
14x	14x	14x	14x	14x	14x	14x	14x	14x	14x
15x	15x	15x	15x	15x	15x	15x	15x	15x	15x
16x	16x	16x	16x	16x	16x	16x	16x	16x	16x
17x	17x	17x	17x	17x	17x	17x	17x	17x	17x
18x	18x	18x	18x	18x	18x	18x	18x	18x	18x
19x01	19x03	19x05	19x07	19x09	19x11	19x13	19x15	19x17	19x19
1x02	1x04	1x06	1x08	1x10	1x12	1x14	1x16	1x18	1x20
2x	2x	2x	2x	2x	2x	2x	2x	2x	2x
3x	3x	3x	3x	3x	3x	3x	3x	3x	3x
4x	4x	4x	4x	4x	4x	4x	4x	4x	4x
5x	5x	5x	5x	5x	5x	5x	5x	5x	5x
6x	6x	6x	6x	6x	6x	6x	6x	6x	6x
8x	8x	8x	8x	8x	8x	8x	8x	8x	8x
9x	9x	9x	9x	9x	9x	9x	9x	9x	9x
10x	10x	10x	10x	10x	10x	10x	10x	10x	10x
14x	14x	14x	14x	14x	14x	14x	14x	14x	14x
15x	15x	15x	15x	15x	15x	15x	15x	15x	15x
16x	16x	16x	16x	16x	16x	16x	16x	16x	16x
17x	17x	17x	17x	17x	17x	17x	17x	17x	17x
18x	18x	18x	18x	18x	18x	18x	18x	18x	18x
19x02	19x04	19x06	19x08	19x10	19x12	19x14	19x16	19x18	19x20
■	■	■	■	■	■	■	■	■	■
20x02	20x04	20x06	20x08	20x10	20x12	20x14	20x16	20x18	20x20
21x	21x	21x	21x	22x	22x	21x	21x	22x	22x
22x	22x	22x	22x	24x	24x	22x	22x	24x	24x
23x	23x	23x	23x	25x	25x	23x	23x	25x	25x
24x	24x	24x	24x	27x	27x	24x	24x	27x	27x
25x	25x	25x	25x	21x	21x	25x	25x	21x	21x
26x	26x	26x	26x	23x10	23x12	26x	26x	23x18	23x20
27x	27x	27x	27x	↓	↓	27x	27x	↓	↓
28x	28x	28x	28x	→ ■ ←	→ ■ ←	28x	28x	→ ■ ←	→ ■ ←
30x	30x	30x	30x	↑	↑	30x	30x		
33x	33x	33x	33x			42x	42x		
34x	34x	24x	34x	26x10	26x12	43x	43x	26x18	26x20
35x	35x	35x	35x	28x	28x	44x	44x	28x	28x
36x	36x	36x	36x	30x	30x	45x14	45x16	30x	30x
37x	37x	37x	37x	33x10	33x12			42x18	42x20
38x	38x	38x	38x	⇊	⇊			⇊	⇊
42x	42x	42x	42x	→ ■ ←	→ ■ ←	■	■	→ ■	→ ■
■	■	■	■	⇈	⇈				
				34x10	34x12				
				35x	35x				
				36x	36x				
				37x	37x				
				⇊	⇊				
				→ ■ ←	→ ■ ←				
				⇈	⇈				
				38x10	38x12				
				42x	42x				

■ 4"x4" post

→ ■ Wire terminal to post for electrical measurements

⇉ ■ Wire terminals (galvanic couple) to post for electrical measurements.

Figure 2c. Order of Burial of Specimens at Test Sites (1972).

First Removal (1 Yr)		Second Removal (2 Yr)		Third Removal (4 Yr)		Fourth Removal (8 Yr)		Fifth Removal (X Yr)	
■	■	■	■	■	■	■	■	■	■
7x01	7x03	7x05	7x07	7x09	7x11	7x13	7x15	7x17	7x19
11	11	11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12	12	12
7x02	7x04	7x06	7x08	7x10	7x12	7x14	7x16	7x18	7x20
11	11	11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12	12	12
■	■	■	■	■	■	■	■	■	■

■ - 4"x4" post

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15. SUPPLEMENTARY NOTES

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

Corrosion data is presented for selected stainless steels exposed for up to two years in various soil environments. Test materials included coated and uncoated sheet specimens in the annealed and sensitized condition and uncoated welded tubing specimens. Systems studied were standard austinitic (200 and 300 series) alloys, ferritic and martensitic (400 series alloys, proprietary alloys (Cr and Cr-Ni) and composite (sandwich materials with outer layers of carbon steel metallurgically bonded to a stainless steel core (Type 304 or Type 430).

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Stainless steels; corrosion behavior; soil environments; field tests; coatings.

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