NBSIR 74-435

Progress Report on the Performance of Bituminous Coated Cast-Iron Pressure Pipe Buried in Various Soil Environments for Four Years

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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

Performance of Bituminous Coated Cast-Iron Pressure Pipe Buried in Various Soil Environments for Four Years

by

William F. Gerhold and Benjamin T. Sanderson

Reference:

(a) National Bureau of Standards Report No. 10,542, "Progress Report on the Performance of Cast-Iron Pressure Pipe Buried in Various Soil Environments for Two Years", dated May 11, 1971.

Introduction:

Manufacturers and users are not in agreement regarding the actual purpose of the bituminous coatings (shop coats) that are applied to commercially available cast-iron pressure pipe in accordance with Federal and AWWA (American Water Works Association) specifications. Some claim that the purpose of the coating is to protect the pipe during handling and storage. Others claim that the purpose of the coating is to protect the pipe from corrosion after installation in underground environments. There is reason to believe that the latter is not true.

An investigation was initiated to determine the degree of protection of the cast-iron pressure pipe from corroison that may be derived by using these shop coatings when they are applied in accordance with Federal Specification WW-P-421 and AWWA Specification C110-64. For purposes of this investigation sufficient sets of coated and uncoated cast-iron pressure pipe specimens were buried at each of six NBS soil corrosion test sites to allow for removal and evaluation at specified time intervals. The intervals selected were 1, 2, 4 and 8 years with an additional set to be removed at a later unspecified date. To date specimens have been removed from the various soils after burial for 1, 2 and 4 years. Reference (a) contains the results obtained from examination of cast-iron pressure pipe specimens after exposure for one and two years. This report contains the results obtained from examination of specimens exposed in the six soils for approximately four years.

Materials:

Pipe materials were procured from commercial sources and were representative of that manufactured by two major producers of cast-iron pressure pipe. The material used in these tests were as follows:

(a) 2.5-in OD, nominal 2-in, Class 150, cast-iron pressure pipe with a coal-tar-base bituminous coating.

(b) 2.5-in OD, nominal 2-in, Class 150, cast-iron pressure pipe with an asphalt-base bituminous coating.

(c) 2.5-in OD, nominal 2-in, Class 150, cast-iron pressure pipe with no coating.

Specimen Preparation:

Five sets of specimens consisting of four specimens each of coal-tar-base bituminous coated, asphalt-base bituminous coated and uncoated cast iron pressure pipe were prepared for burial at each of the six NBS scil corrosion test sites. Each specimen was approximately 12-in long with a nominal wall thickness 0.25-in. In order to obtain the loss in weight from corrosion due to exposure in the soil, the uncoated specimens were weighed prior to burial. All specimens, coated and uncoated, were capped and sealed at each end to confine the corrosion to the exterior surfaces.

Test Procedure:

The specimens were buried in the six soil environments during 1967. Four specimens of each system were buried approximately two to three feet below the ground line.

Soils at the Test Sites:

The physical and chemical properties of the soils at the test sites are given in Table 1. Descriptions of the soils at the test sites are as follows:

1. Site A. Sagemoor sandy loam is a well-drained alkaline soil with a resistivity of 400 ohm-cm and a pH of 8.8 and is typical of that found in vast areas of eastern Washington and Oregon. The site is located on the Yakima Indian Reservation near Toppenish, Wash. The soil is consistent in composition to a depth of at least 7 ft and supports abundant growth of sage brush.

2. Site B. Hagerstown loam 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 ft deep, underlain by a reddish-brown clay that extends 5 ft or more to underlying rock. The soil has a resistivity of 5,200 ohm-cm and a pH of 5.8. 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, will serve as a reference site in the correlation of data obtained for specimens in the present program with data obtained from the earlier tests.

3. Site C. Clay soil is located in a large clay pit on level land at Cape May, N. J. The soil consists of a plastic gray clay to a depth of 6 in., underlain by gray clay mixed with patches of brown clay to a depth of 12 in. This is underlain by a poorly drained very heavy plastic clay. The soil has a resistivity of 300 ohm-cm and a pH of 4.0.

4. Site D. Lakewood sand is a white, loose sand with some black streaks occurring in places. The site is located in a well-drained rolling area at Wildwood, N. J., which is not subject to overflow from the ocean except under unusual flood conditions. The sand, which supports the growth of beach grasses abundantly, has a pH of 7.3 and a resistivity of 30,000 ohm-cm.

5. Site E. Coastal sand 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, N. J., the sand is constantly saturated with salt water. The sand has a pH of 7.1 and a resistivity of 55 ohm-cm.

6. Site G. Tidal marsh is a soil typical of the poorly drained marsh soils that are found along the Atlantic and Gulf coasts. The site is located along a creek that empties into the Chesapeake Bay at Patuxent, Md. The soil is charged with hydrogen sulfide and has a resistivity of 300 ohm-cm and a pH of 7.1.

Results:

One set of pipe specimens was removed from each of the test sites after burial for four years. Visual examination of these specimens before cleaning revealed localized corrosion attack on the exterior surfaces on all of the specimens. The attack, in the form of pitting corrosion, was similar to, although generally more severe, than that noted on similar specimens buried for one and two years.

All specimens were hand scrubbed in hot-soapy water to remove soil particles. The specimens were then rinsed in clear water and dried. The coated specimens were immersed in varsol to remove the bituminous coatings. All specimens were then further cleaned ultrasonically, to remove the corrosion products, by immersion in a hot 10% ammonium citrate solution, rinsed in clear water and dried. If additional cleaning was required the specimens were wire brushed and the above cleaning procedure was repeated.

The uncoated specimens were then weighed to determine the weight loss from corrosion by exposure in the soil environments. Pit depth determinations were obtained for all specimens. These determinations are summarized in Table 2. For purposes of comparison, similar determinations are also given for specimens buried for one and two years.

The corrosion occurred as scattered localized pitting with some larger areas of general corrosion attack which appeared to initiate at corrosion pits. Figures 1 through 6 show the specimens removed from the six test sites after cleaning. The corrosion was shallow in depth on all (coated and uncoated) specimens buried for approximately four years at Sites D and E. The deepest penetration was observed on specimens exposed at Site C. One specimen at this site was perforated by corrosion. In terms of depth of penetration the most severe corrosion was noted on uncoated specimens exposed at Sites A, B, C and D and on coal-tar-base bituminous coated specimens exposed at Sites E and G. However, the differences in depth of penetration by corrosion on uncoated and bituminous coated specimens exposed at Sites D or E are not considered to be significant. Curves showing average depth of penetration for specimens exposed in the various soils are given in Figure 7.

Weight loss determinations for uncoated specimens show that the soil at Site C was the most corrosive and the soils at Sites A and B were the least aggressive. Curves showing the average weight loss for specimens exposed at the six NBS soil corrosion test sites are given in Figure 8.

Conclusions:

Examination of uncoated and bituminous (coal-tar base and asphalt base) coated cast iron pressure pipe specimens that had been buried for four years at each of the six NBS soil corrosion test sites revealed corrosion attack on all of the specimens. The corrosion was of a scattered localized nature varying only in degree on the specimens exposed at the different test sites. The clay soil at Site C was the most corrosive for the uncoated cast iron pipe specimens. There did not appear to be any significant difference in depth of penetration by corrosion on uncoated and bituminous (coal-tar base or asphalt base) coated cast iron pipe specimens buried for four years in lakewood sand (Site D) or coastal sand (Site E). The most severe corrosion in terms of depth of penetration occurred on uncoated specimens exposed at Sites A, B, C and D and on coal-tar-base bituminous coated specimens exposed at Sites E and G. However, as noted above the differences in depth of penetration by corrosion for coated or uncoated specimens exposed at Site E were slight.

While the coatings appear to provide some protection against corrosion in some of the soils after exposure for four years neither the coal-tar base or the asphalt base bituminous coating appeared to perform well in all of the soils. This may be due partially to the relatively short term of exposure in the environments. Studies on additional sets of uncoated and coated pipe specimens scheduled for removal from the soils after longer periods of exposure should provide additional information that may be considered more conclusive.

TABLE 1. Properties of Soils at Test Sites

Site Ident.	Soil	Location	Internal drainage of test site	Resistivity[a] (ohm - cm)	pH	TDS[b]	Composition of water extract (parts per million) Ca	Mg	Na + K as Na	CO_3	HCO_3	So_4	Cl	NO_3
A	Sagemoor sandy loam	Toppenish, 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	5,200	5.8	(c)	---	---	---	---	---	---	---	---
C	Clay	Cape May, N.J.	Poor	300	4.0	14,640	540	754	2,242	0.0	0.0	6,768	3,529	118
D	Lakewood sand	Wildwood, N.J.	Good	30,000	7.3	(c)	---	---	---	---	---	---	---	---
E	Coastal sand	Wildwood, N.J.	Poor	55	7.1	11,020	302	329	3,230	0.0	55	1,133	5,765	31
G	Tidal marsh	Patuxent, Md.	Poor	300	7.1	11,580	140	165	2,392	0.0	0.0	1,709	3,259	37
						(Milligram equivalents per 100 grams of soil)								
A	---	---	---	---	---	---	0.54	0.19	8.50	0.0	8.20	0.45	0.93	0.01
B	---	---	---	---	---	(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 with Shepard Canes.

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

(c) Analyses not made for soils at sites B and D because of the very low concentrations of soluble salts in these soils.

Table 2. Corrosion of 2-in., Class 150, Cast Iron Pressure Pipe After Burial up to approximately four years in the Soils at NBS Corrosion Test Sites.[a]

Exposure time, years	Weight loss[b] grams	Weight loss[b] oz/ft^2	None: Penetration, mils[c] Single deepest[d]	None: Average max.	None: Average 5 deepest	None: Average 10 deepest	Coal-tar base: Penetration, mils[c] Single deepest[d]	Coal-tar base: Average max.	Coal-tar base: Average 5 deepest	Coal-tar base: Average 10 deepest	Asphalt base: Penetration, mils[c] Single deepest[d]	Asphalt base: Average max.	Asphalt base: Average 5 deepest	Asphalt base: Average 10 deepest
Site A- Sagemoor Sandy Loam, Toppenish, Washington														
1.0	44.7	2.6	69	64	55	50	70	38	26	23	36	34	32	30
2.0	61.1	3.5	77	60	58	53	45	31	28	26	55	38	34	32
4.2	56.4	3.3	106	82	66	58	40	30	28	26	89	60	43	37
Site B- Hagerstown Loam, Loch Raven, Maryland														
1.1	47.6	2.8	56	46	44	42	49	42	29	22	45	36	33	31
2.1	58.0	3.4	57	49	46	44	63	55	51	48	55	52	44	39
4.0	61.6	3.6	141	97	75	68	101	73	60	54	68	56	51	47
Site C- Clay Soil, Cape May, New Jersey														
1.0	57.8	3.4	50	42	37	35	50	34	31	30	71	50	45	41
2.0	102.5	5.9	160	116	99	89	65	51	42	39	56	47	42	37
4.0	169.3	10.0	P[e]	159[f]	--	--	113	82	69	63	132	104	91	81
Site D- Lakewood Sand, Wildwood, New Jersey														
1.0	50.8	2.9	56	41	34	32	34	29	26	24	32	26	23	21
2.0	64.3	3.7	47	38	35	33	47	37	35	33	41	31	26	24
4.0	76.4	4.5	47	42	37	34	44	39	33	31	36	34	31	29
Site E- Coastal Sand, Wildwood, New Jersey														
1.0	54.0	3.1	40	33	31	29	48	40	35	32	87	48	45	42
2.0	63.8	3.7	56	51	42	39	49	38	31	28	47	36	34	33
4.0	79.5	4.7	53	44	38	35	56	51	45	42	64	47	43	41
Site G- Tidal Marsh, Patuxent, Maryland														
1.0	69.4	4.2	125	89	71	64	128	94	79	64	61	47	44	43
2.0	78.4	4.5	105	92	79	70	115	90	73	70	90	45	40	36
3.9	74.2	4.4	116	76	58	51	172	102	78	68	123	90	82	74

(a) Average for four specimens in each instance unless otherwise noted.
(b) Original weight for specimens was between 2400 and 2700 grams.
(c) Nominal wall thickness of pipe was 250 mils.
(d) Deepest penetration (mils) on any one of the four specimens.
(e) Perforation (total wall thickness).
(f) One specimen perforated by corrosion.

Uncoated

Coal-Tar-Base
Bituminous Coated

Asphalt-Base
Bituminous Coated

Figure 1. Cast iron pressure pipe specimens after exposure for four years in Sagemoor Sandy Loam (Site A). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

Figure 2. Cast iron pressure pipe specimens after exposure for four years in Hagerstown Loam (Site B). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

Uncoated | Coal-Tar-Base Bituminous Coated | Asphalt-Base Bituminous Coated

Figure 3. Cast iron pressure pipe specimens after exposure for four years in clay soil (Site C). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

Figure 4. Cast iron pressure pipe specimens after exposure for four years in Lakewood Sand (Site D). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

Uncoated

Coal-Tar-Base
Bituminous Coated

Asphalt-Base
Bituminous Coated

Figure 5. Cast iron pressure pipe specimens after exposure for four years in Coastal Sand (Site E). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

Figure 6. Cast iron pressure pipe specimens after exposure for four years in Tidal Marsh (Site G). Specimens shown after coatings were removed and after cleaning to remove corrosion products.

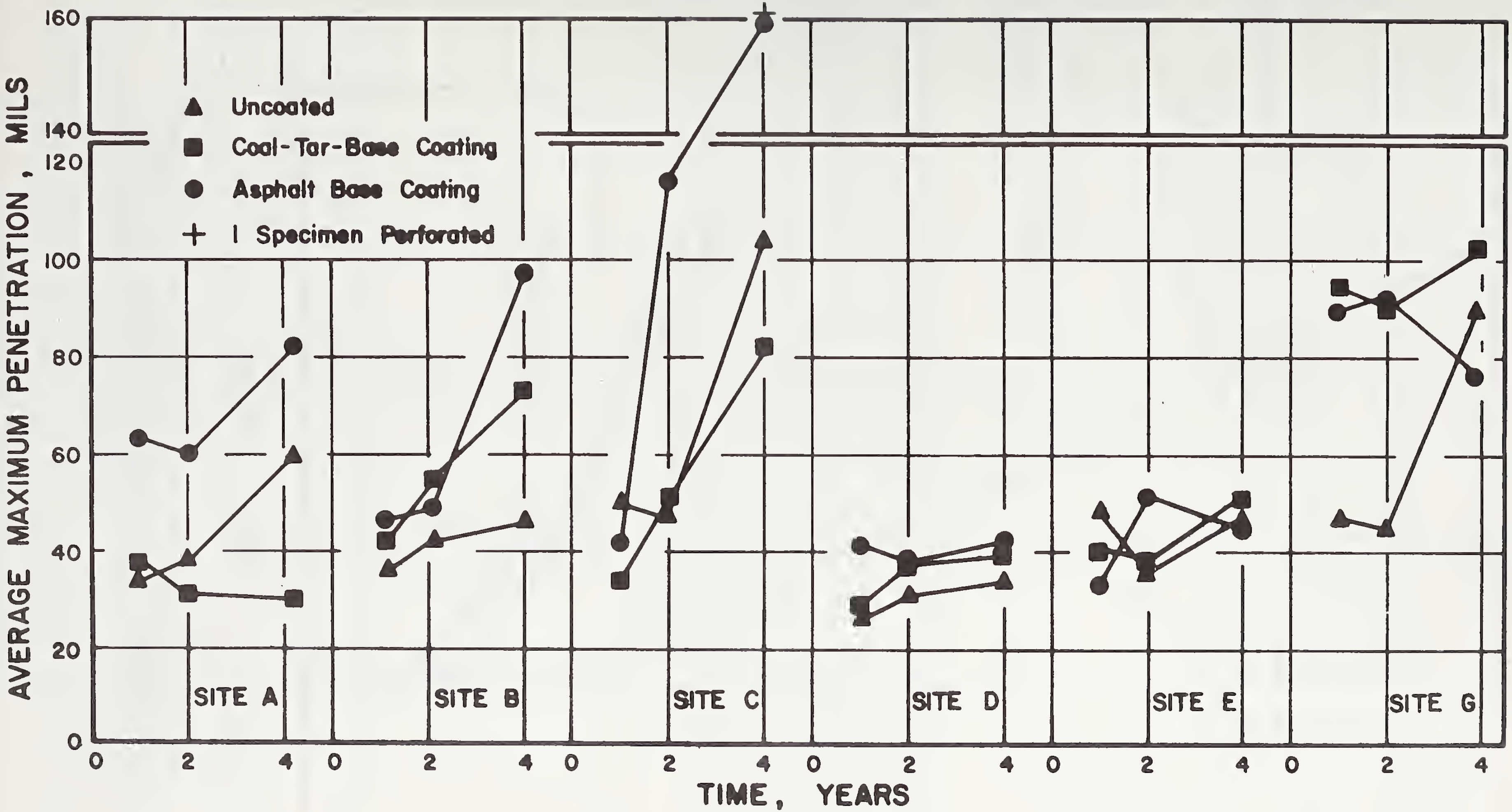

Figure 7. Average maximum depth of penetration (mils) for uncoated and coated cast iron pressure pipe specimens buried up to four years in the various soils at the NBS Soil Corrosion Test Sites.

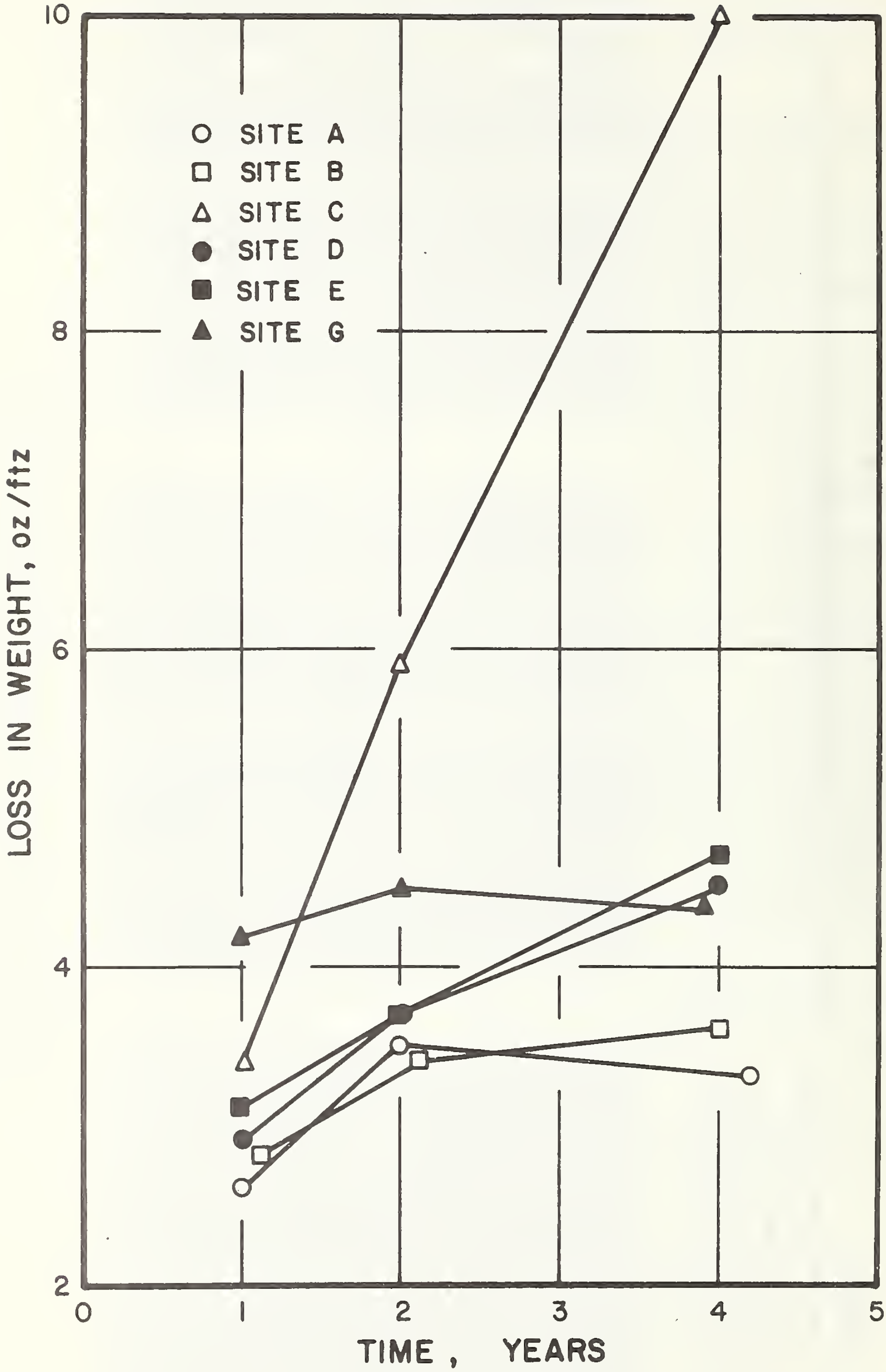

Figure 8. Average loss in weight (oz/ft^2) for uncoated cast iron pressure pipe buried up to approximately four years in the various soils at the NBS Soil Corrosion Test Sites.

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 74-435	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

Progress Report on the Performance of Bituminous Coated Cast-Iron Pressure Pipe Buried in Various Soil Environments for Four Years

5. Publication Date: January 1974

6. Performing Organization Code

7. AUTHOR(S) William F. Gerhold and Benjamin T. Sanderson

8. Performing Organ. Report No. NBSIR 74-435

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No. 3120449

11. Contract/Grant No.

12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*

Tri Services
Department of the Navy
Naval Facilities Engineering Command
Washington, D.C. 20390

13. Type of Report & Period Covered: Progress Report

14. Sponsoring Agency Code

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.)*

An investigation was initiated to determine the degree of protection from corrosion of cast-iron pressure pipe that may be derived using bituminous coatings. Sufficient sets of coated and uncoated cast-iron pressure pipe specimens were buried at each of six NBS soil corrosion test sites to allow for removal and evaluation at specified time intervals. The time intervals selected were 1, 2, 4, and 8 years with an additional set to be removed at a later unspecified date. To date specimens have been removed from the soils after exposure for 1, 2, and 4 years. This report summarizes the results obtained from these tests.

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)*

Bituminous coatings; cast-iron pipe; corrosion, underground.

18. AVAILABILITY	19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
[ ] Unlimited [X] For Official Distribution. Do Not Release to NTIS	UNCLASSIFIED	14
[ ] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 [ ] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151	20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price