TECHNICAL INFORMATION ON BUILDING MATERIALS

FOR USE IN THE DESIGN OF LOW-COST HOUSING TIBM - 50

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THE NATIONAL BUREAU OF STANDARDS
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CORROSION OF NONFERROUS METALS UNDERGROUND

The corrosion of ferrous metals underground is discussed in TIBM-29, "Corrosion of Ferrous Metals Underground."[1] It describes the investigation of such corrosion by the National Bureau of Standards and is a digest of Research Paper RP883, "Soil-Corrosion Studies, 1934. Rates of Loss of Weight and Pitting of Ferrous Specimens," by Kirk H. Logan.[2] When the work was started in 1922 most of the metals studied were ferrous. As the study progressed, it was found that in certain soils the corrosion of iron and steel was very severe. This suggested the desirability of investigating the durability in these soils of other metals frequently used underground, such as copper and lead alloys, like brass, or metallic coatings for iron and steel, such as lead and zinc. Through the cooperation of manufacturers, representative pipe or sheet materials were obtained, and these were buried in various soils, usually at times when the ferrous metals under test were being removed. A Bureau report, Research Paper RP945, "Soil-Corrosion Studies, 1934, Rates of Loss of Weight and Penetration of NonFerrous Materials," by Kirk H. Logan,[3] showing the behavior of several nonferrous materials in various soils after two to ten years exposure, has recently been prepared and the findings of this report are the basis of this TIBM.

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[1]May be obtained, free of charge, from the Division of Codes and Specifications, National Bureau of Standards, Washington, D. C.

[2]May be obtained from Superintendent of Documents, Washington, D. C. (Price 5 cents)

[3]May be obtained from Superintendent of Documents, Washington. D. C. (Price 10 cents)

The important characteristics of soil corrosion and the features differentiating soil corrosion from atmospheric or submerged water corrosion are given in TIBM-29, previously referred to. Soil charactertistics, such as texture, drainage, salts present, composition of soil atmosphere, acid or alkaline character of soil water, water-holding power, and other factors peculiar to the soil environment, determine the nature and extent of corrosion of ferrous metals.[1] This has been found to be equally true for the corrosion of nonferrous metals. The Bureau investigations have also reached the point where it is possible in certain cases to examine an unknown soil in the laboratory for some of these characteristics and thus predetermine its corrosiveness toward nonferrous metals, as has been done for the ferrous metals.

All conclusions about the corrosion of nonferrous metals in soil are, at this time, somewhat tentative because; first, not enough samples have been investigated in all soils and because, second, the corrosion period in many cases is too short. With due allowance made for these restrictions, the following conclusions have been expressed on nonferrous metal corrosion in soils:

1. No one metal or alloy has been found superior to all others for all soil conditions, but for each condition some suitable metal is available.

2. With but few exceptions the rates of loss of weight and of penetration by pitting are less for the nonferrous specimens than for ferrous specimens in the same soil environment.

3. Lead in some soils pits badly, as a result of causes not fully known at this time. The presence of chlorides, bicarbonates, and particularly sulphates in soils favors the formation of films or deposits on the lead which tend to retard its corrosion. In such soils the corrosion rate generally decreases with time, but in other soils, such as marshes, the corrosion rate remains practically constant. Lead-coated steel pipes corrode much faster after penetration of the lead than uncoated steel pipes. (See TIBM-17, "Corrosion of Metals Used in House Construction; Atmospheric Corrosion of Galvanized Ferrous Sheet Metals,"[2] for an explanation of this behavior).

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[1]The Bureau report, (RP945) before mentioned, on the corrosion of nonferrous metals, contains a table giving numerical data on properties mentioned for several soils that were investigated.

[2]May be obtained, free of charge, from the Division of Codes and Specifications, National Bureau of Standards, Washington, D. C.

4. Copper and high-copper brasses corrode slowly in most of the soils studied. The corrosion of these metals is more uniform than that of ferrous metals in similar soils, and there is less change in the rates of corrosion than for those of ferrous metals. The soils most destructive to copper or brass are those containing sulphides.

5. The brasses of lower copper content show a distinct tendency to "dezincify" i.e., a selective dissolving away of zinc. This is shown particularly in Table 2, page 5. Because such corrosion results in porosity and marked reduction in strength, it is to be considered very detrimental for many uses of the pipe (or fittings) such, for instance, as conveying water under high pressure.

6. Comparison of pitting rates, of galvanized as against non-galvanized steel, Table 1, page 4, shows that, in four out of the five soils tabulated, pitting was much less for galvanized steel.

From these conclusions it will be noted that the commonly used nonferrous metals generally corrode differently in the same soil. This is in decided contrast to ferrous metals, all of which corrode similarly in a given soil (See TIBM-29).

Table 1 gives details of the ten-year test, Table 2 of the two-year test, and Table 3 contains a brief description of the metals included in the tests.

TABLE I

METALS BURIED IN SOILS FOR TEN YEARS
YEARLY RATES OF WEIGHT LOSS AND PENETRATION BY PITTING
(Description of Materials Listed Below Given in Table 3)

Materials	Thickness	Soil Type and Location									
		Very Fine Hanford Sandy Loam, Bakersfield, Cal.		Muck, New Orleans, Louisiana		Susquehanna Clay, Meridian, Miss.		Tidal Marsh, Elizabeth, N. J.		Alkali Soil, Casper, Wyo.	
		Weight Loss[1]	Pit Depth[2]	Weight Loss[1]	Pit Depth[2]	Weight Loss[1]	Pit Depth[2]	Weight Loss[1]	Pit Depth[2]	Weight Loss[1]	Pit Depth[2]
	Inches										
Lead	0.250	0.037	1.7	0.51	1.3	0.18	2.5	0.076	1.2	0.088	1.8
Copper Sheet	.050	.015	M	.12	S	.044	P	--	--	.015	M
Brass Sheet	.050	.077	M,D	.15	M	.051	M,D	.010	M,D	.074	M,D
Steel Sheet	.062	f	6+	.69	6+	.54	5.9	f	6+	f	6+
Galvanized Steel Sheet	---	.036	R	.44	2.6	.07	1.2	.58	5.9	.16	0.5
Lead Coated Steel Sheet	---	.064	5.4	.69	6.3	.09	4.6	.73	18.8	.20	9.2

[1] Loss per square foot per year, in ounces.

[2] Penetration per year of the deepest pit in mils.
(D) Dezincification; (f) Failure by one or more perforations; (M) Roughening of surface, but no pitting; (R) Rusting; (S) Uniform corrosion of surface rather than pitting.

TABLE 2

CORROSION OF COPPER AND BRASS PIPE BURIED APPROXIMATELY TWO YEARS IN VARIOUS SOILS
(Description of Materials Listed below Given in Table 3)

Soil Type and Location	Deoxidized Copper		Red Brass		Admiralty Metal		Brass		Muntz Metal	
	Weight Loss[1]	Penetration[2]	Weight Loss[1]	Penetration[2]	Weight Loss[1]	Penetration[2]	Weight Loss[1]	Penetration[2]	Weight Loss[1]	Penetration[2]
Acadia clay, Spindletop, Texas	0.20	M	0.17	M	0.16	M, d	0.17	M, D	0.35	M, d
Cecil clay, loam Atlanta, Ga.	.061	F	.060	4.1	.070	6.1, d	.052	5.1, d	.097	F, d
Hagerstown, loam, Baltimore, Md.	.075	F	.068	6.3	.079	11.6	.094	5.8	.10	5.3, d
Lake Charles clay, El Vista, Texas	.051	M	.054	M	.040	M, d	.042	M, d	.072	d
Merced clay adobe, Tranquillity, Calif.	.0062	U	.0054	4.2	.0061	F, d	.041	M, d	.24	M, d
Muck, New Orleans, La.	.082	M	.061	M	.096	F, d	.11	M, d	.10	F, d
Peat, Plymouth, Ohio	.76	5.2, S	.76	7.8	.59	5.2	.89	9.4	.90	7.8, d
Sharkey clay, New Orleans, La.	.062	F	.12	F	.18	8.4, d	.12	10.5, d	.17	F, d
Susquehanna clay, Meridian, Miss.	.079	4.1	.077	5.2	.11	8.8	.12	F, d	.17	F, d
Tidal marsh, Charleston, S. C.	.55	M	.27	F	.12	M	.021	F	.069	M
Unidentified alkali soil, Cholame Flats, Calif.	.74	S	.17	12.0	.13	13.1, d	.30	F, d	2.11	F, D
Alkali Soil, Wilmington, Calif.	.90	S	.27	5.2	.16	18.3	.72	M, d	1.27	M, D
Mohave sandy loam, Phoenix, Ariz.	.15	6.3	.092	F	.12	M, d	.18	M, d	.33	F, d
Cinders, Milwaukee, Wis.	1.97	21.8	1.66	14.9	2.75	25.7	8.20	Z	Destroyed	Z

[1] Loss per square, foot, per year, in ounces.
[2] Penetration per year in mils. (d) Localized dezincification (D) General dezincification (M) Shallow metal attack (F) Pits not deeper than 0.006" (S) Severe uniform corrosion (U) No apparent corrosion (Z) Destroyed by dezincification.

TABLE 3

DESCRIPTION OF METALS

Metals Shown in Table 1

Metal	Form	Dimensions	Composition
		Inches	Percent
Lead	Cast	6 x 2 x 0.25	99.9 Pb, .07 Cu, .005 Ag
Copper	Sheet	6 x 2 x .05	99+ Cu
Brass	Sheet	6 x 2 x .05	70 Cu, 30 Zn
Steel	Sheet	6 x 2	Copper bearing steel, approx. 0.2 Cu
Galvanized Steel	Sheet	6 x 12	Coating of 1.62 oz. zinc per sq. ft. of sheet. Base metal: C .07, Mn .37, P .097, S .067, Si .01, Cu .008
Lead Coated Steel	Pipe	1 1/2 x 6	Pb coating between .001" and .002" thick

Metals Shown in Table 2

Metal	Form	Dimensions	Composition
		Inches	Percent
Deoxidized Copper	Pipe	1.7 diam., .144 wall, 13 long	99.94 Cu, .018 P
Red Brass	Pipe	1.7 diam., .143 wall, 13 long	85.18 Cu, 14.8 Zn, 0.01 Fe
Brass	Pipe	1.7 diam., .145 wall, 13 long	66.5 Cu, 33.06 Zn, 0.42 Pb 0.02 Fe
Admiralty Metal	Pipe	1.7 diam., .143 wall, 12 long	71.28 Cu, 27.39 Zn, 1.3 Sn, 0.01 Pb, 0.02 Fe
Muntz Metal	Pipe	1.7 diam., 0.08 wall, 12 long	60.06 Cu, 39.58 Zn, 0.36 Pb, trace Fe