LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE

NEW YORK 17, N. Y.

METALLIC LEAD PRODUCTS DIVISION

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To Members of the Metallic Lead Products Division:

Attached please find a copy of the paper entitled "Comparative Corrosion Study of Soil, Waste and Vent Pipe Materials" by John D. [illegible], Chief Plumbing Inspector, Department of Public Works, Fort Worth, Texas, which has been reprinted from the 1949 Yearbook of the American Society of Sanitary Engineering. This is the same paper sent to members in mimeograph form in M.L.P. Bulletin No. 44, October 7, 1949.

Extra copies of this reprint are available at our cost of 5¢ per copy.

As mentioned in previous bulletins on this subject, this paper can be of inestimable value to the lead industry in combating the in-roads being made by competing materials for plumbing business.

Sincerely yours,

Secretary

LIA09541

Comparative Corrosion Study of Soil, Waste and Vent Pipe Materials

by John D. Kane
Chief Plumbing Inspector
Department of Public Works
Fort Worth, Texas

Reprinted from Year Book - 1949
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COMPARATIVE CORROSION STUDY OF SOIL WASTE AND VENT PIPE MATERIALS

This study was undertaken to determine the relative rates of corrosion of the pipe materials used or suggested for use in the plumbing soil, waste and vent system.

The test specimens were sections of pipe made of lead, cast iron, red brass, galvanized wrought iron, galvanized steel, aluminum and copper tubing, all purchased on the open market.

The study was conducted under accelerated conditions found at the Fort Worth sewage disposal plant's aeration basin.

Examination of the two-foot test pieces for loss in weight was made after exposure periods of three months, six months and final examination after one year. Weight loss was progressive on all samples at the intermediate and final examinations, and final results showed the lead to be outstanding, with an expected life of more than six times the closest material.

The study was made after discussions with Mr. Robert A. Camp, formerly of the Lead Industries Association and now with the A. & M. College of Texas, because it was felt that very little practical data were available as to the useful life that could be expected of the materials customarily used for soil, waste and vent lines, such as lead, cast iron, brass, galvanized wrought iron and galvanized steel, and those materials suggested for use in the plumbing soil system such as copper and aluminum.

The actual observations were made by Mr. H. M. Bolbrook, consulting chemist of Fort Worth, and permission to use the Fort Worth sewage disposal plant as a test site was granted by Mr. W. S. Mahlie, city chemist for Fort Worth.

DESCRIPTION OF TEST

The test was set up as outlined below.

In order to accelerate the corrosive action as much as possible, the pipe sections, each approximately 2 ft. in length and conforming to established plumbing size specifications, were exposed in a manhole carrying the return sludge from the Fort Worth sewage disposal plant's aeration basin. The samples were supported by a 2 x 4 inch ladder-type wooden frame assembly. They were held in the rack by threaded couplings of the same material, except in the case of lead where a lead flange was used and a sweated fitting in the case of copper tubing. The only other material in contact with the samples was wood. This was then placed in the manhole at a depth that would allow the water line to run about 18 inches below the lower ends of the pipe sections. A test made with litmus paper showed the sewage to be alkaline and the condensed moisture on the upper portion of the test pieces acid. A lead acetate test showed that the atmosphere surrounding the specimens contained hydrogen sulphide.

The dimensions and original weight of the pipe samples undergoing tests are shown below:

ORIGINAL SPECIMEN DATA

Pipe Material	*Diameter in Inches Inside*	*Diameter in Inches Outside*	*Length In Inches*	*Orig. Wt. In Grams*
Lead	1.500	1.776	24½	3,214
Cast Iron	1.454	1.900	22	2,961
Brass	1.600	1.900	23½	2,537
Galvanized Wrought Iron	1.604	1.900	21¾	2,355
Galvanized Steel	1.610	1.900	21⅝	2,351
Copper Tubing, Type L	1.505	1.625	23½	1,085
Aluminum	1.374	1.660	22	653

These measurements were made before starting the test on June 11, 1948, and subsequent weighing and visual observations were made on August 25, 1948, December 14, 1948, and final examination made on June 11, 1949. After exposure and before weighing, the samples were cleaned by washing and scrubbing with a copper wool pad. Results showed that weight loss was progressive on all test pieces and the final results are indicative of those observed during the shorter period of exposure.

CORROSION RATES

The actual weight loss for each of the materials over the one-year test period was:

	Weight Loss In Grams
Lead	12
Cast Iron	165
Brass	359
Galvanized Wrought Iron	94
Galvanized Steel	148
Copper	665
Aluminum	17

This actual weight loss is not completely revealing because of the difference in density (weight per unit volume) of the test metals. To point this up more clearly, visualize, if you will, one ounce of lead, the test material with the highest density and one ounce of aluminum, the metal tested with the lowest density. It will be immediately apparent that the aluminum on a volume basis will represent more than four times as much metal as the lead. With this in mind, you can readily understand why the weight loss on a volume basis would be a much more accurate method of appraising the values of the test pieces. This conversion of the actual weight loss to a volume loss, expressed in inches penetration per year, is shown in the next slide along with the weight loss expressed in ounces per square inch per year:

Material	*Weight Loss Oz/Sq. In./Yr.*	*Volume Loss In. Penetration/Yr.*
Lead	0.00167	0.000259
Cast Iron	0.02510	0.003540
Brass	0.04910	0.009660
Galvanized Wrought Iron	0.01370	0.003022
Galvanized Steel	0.02160	0.004758
Copper Tubing (L)	0.10150	0.019720
Aluminum	0.00270	0.001825

These figures are arrived at by mathematical formula and are based on a uniform corrosion rate over the entire length of the samples. They do not take into account localized corrosion or pitting which were evident in all cases except lead, and which caused early complete failure in the case of copper.

The next slide is a table based on the above figures and showing the relative life that can be expected of these materials, again assuming that corrosion is uniform and that no pitting has occurred:

RELATIVE LIFE

(Lead = 100)

Lead	100.0
Cast Iron	6.5
Brass	2.9
Galvanized Wrought Iron	9.0
Galvanized Steel	5.6
Copper—Type L	0.6
Aluminum	14.6

The figures on the chart are not years, because years might vary under differing conditions and severity of service. The figures do show relative life, however.

As can be seen, the lead sample has approximately six times and more than the relative life of any of the other materials tested. Aside from the copper, all of the others are closely grouped and a longer test might reveal more significant differences.

VISUAL OBSERVATIONS

Visual observations, which are particularly revealing even without giving consideration to the corrosion rate figures just discussed, were made at more frequent intervals, and because of their importance, this phase of the investigation will be described in detail.

The first visual examination was made on June 14, 1948, after only a few days' exposure, to learn what changes had taken place. The turbulent flow in the manhole had caused some water to spatter and incrustation spots were found where water had evaporated on the pipe surfaces. Examination showed the lead pipe was little affected except for a few water spatter marks. The cast iron pipe showed some slight rust in evidence, the brass pipe had blackened, the galvanized wrought iron pipe showed very little change with some water marks due to spatter, and the galvanized steel pipe was about the same. The copper tubing was black and scaly in appearance and had some water spatter marks and the aluminum pipe showed no change except some white spots deposited by the water. At this time, the atmosphere in the manhole was tested for moisture with cobaltous chloride paper, and for hydrogen sulphide, with lead acetate paper. Both tests were positive indicating the presence of both moisture and hydrogen sulphide, constituents similar to those encountered in most soil, waste and vent systems. No attempts were made to determine the quantity of these constituents present over a given period.

On July 2, 1948, after approximately one month's exposure, the samples were again examined with the following observations:

PIPE	*CONDITION*
Lead	Discolored with no incrusting deposit.
Cast Iron	Rusted with no visible deposit.
Brass	Blackened and coated with a black deposit.
Galvanized Wrought Iron	Corroded and coated with grayish deposit.
Galvanized Steel	Corroded and covered with black flaky deposit.
Copper Tubing	Corroded and covered with black flaky deposit.
Aluminum	Whitish deposit on surface, no evidence of deep corrosion.

Even after only one month's exposure, it was almost possible to determine what material would hold up and what one would fail. This trend seemed to be confirmed on August 25, when the samples were again observed before cleaning and weighing with the following results:

PIPE	*CONDITION*
Lead	At top, slight crystalline corrosion.
Cast Iron	Rusty.
Brass	Corroded in large flaky scales on the outside.
Galvanized Wrought Iron	White scales on outside, threads rusty.
Galvanized Steel	White scale on outside.
Copper Tubing	Scaled heavily, outside and inside.
Aluminum	Whitish crust inside and outside. Threads corroded some.

On December 14, after six months' exposure, visual observation was made again after cleaning and washing, and the results were beginning to get conclusive.

PIPE	*CONDITION*
Lead	Dark discoloration, no noticeable corrosion or pitting.
Cast Iron	Black color with rust spots and pitting.
Brass	Badly corroded and pitted.
Galvanized Wrought Iron	Lower end of pipe (about half) galvanized coating completely gone with rusting and pitting.
Galvanized Steel	Lower end of pipe and parts of upper end, galvanized coating completely gone with rusting and pitting.
Copper Tubing	Badly corroded and pitted with several small holes in the pipe. Damaged beyond any use.
Aluminum	Small pitting the entire length with deeper pitting near the upper end.

On June 11, 1949, final visual observation of the samples were made after cleaning, and results were strongly pronounced for such a comparatively short period of exposure. Observations were as follows.

PIPE	*CONDITION*
Lead	Discolored but not pitted.
Cast Iron	Rusted and pitted markedly.
Brass	Corroded and pitted severely.
Galvanized Wrought Iron	Galvanizing entirely off about one half of lower end, and pipe pitted and rusted.
Galvanized Steel	About 80 percent of galvanizing removed and corroded with pitting almost entire length.
Copper Tubing	Badly corroded and perforated over entire length.
Aluminum	Small corrosion pits almost entire length with some larger corroded spots.

In the foregoing reports of visual observations, I have quoted the laboratory's reports exactly.

As can be noted from these visual observations, pitting occurred in all but the lead sample. As pointed out previously, this pitting which was not taken into account in determining relative life, would seriously shorten the useful life of the material so affected.

Inasmuch as these tests were conducted at an accelerated pace, it must be remembered that these materials under actual installation conditions would last a proportionately longer time than this study makes it appear. However, disregarding the fact that the corrosion rate was accelerated, actual installation conditions would approach those under which this test was made.

Visual observations of the test samples were made by myself and Mr. H. M. Bolbrook of Industrial Laboratories, 2061½ West 11th Street, Fort Worth, Texas, who supervised the test and determined the weight loss of each sample tested after examination.

The final observations were also witnessed by J. H. Sorrels, research engineer, Texas Engineering Experiment Station, and Robert A. Camp, Instructional Material Specialist, Plumbing and Pipe Fitting Extension Service, both of Texas A. & M. College.

CONCLUSION

A study of the results achieved under the accelerated conditions encountered in this test provides us with some positive data on which to base conclusions. As pointed out previously, the weight loss of the lead sample was considerably better than most of the other materials, however, the volume loss is a much more accurate method of appraising the resulting values, and on this basis, the performance of the lead sample was outstanding.

On the basis of relative life determined from the over-all corrosion losses of the test specimens, lead was shown to have a life many times that of any of the other materials tested. The other materials were closely grouped in this respect, except for failure of the copper, but further tests of greater duration might reveal more significant differences in their performances.

If pitting is also considered in addition to over-all corrosion, lead is even more outstanding, as it was the only material free of this type of corrosion. Again, except in the case of copper tubing, which pitted through, longer tests, or measurement of the depth of pitting, would be advisable to determine the relative performance of the other materials.