LEAD [illegible] ASSOCIATION
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METALLIC LEAD PRODUCTS DIVISION

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Two papers of decided interest to the lead industry were presented at the January 24, 1950 meeting of the New York Section of the Society of Naval Architects and Maintenance Engineers. The papers were entitled:

"Recent Experiences with Corrosion and Erosion of Copper Circulating Piping in Ship's Machinery Spaces" by D. C. MacMillan, chief engineer, George G. Sharp, Naval Architect, and

"Corrosion of Copper Piping in Salt Water Service" by Paul Mfield, superintendent of development and research, Shipbuilding Division, Bethlehem Steel Company.

Following are some of the salient features from these papers. They will be of particular importance to those interested in learning about the actual performance of copper in salt water service and how lead alloy may be used to overcome its deficiencies.

SPECIFIC CASE HISTORIES

The operators of "C" type cargo ships were and in many cases still are experiencing considerable trouble and expense due to the rapid wastage of copper circulating pipe. This problem is an especially serious one for on many of these ships portions of the auxiliary circulating system cannot be removed or replaced unless the entire electrical plant is put out of operation. This means that the repairs must be done on a piece-meal basis in order not to interrupt the ships schedule and cargo commitments. One owner has reported that the repair of copper circulating piping is the largest item of maintenance on his ships. Here are two typical case histories quoted from MacMillan's paper.

Case Number 1

"A C3 ship had 6 sections of copper piping varying from 8 to 14 inches in diameter and from 8 to 12 feet in length repaired approximately three and one-half years after commission. At this time the sections were removed, sand blasted and sprayed with lead 0.045 inches thick and then sprayed with a bituminite finish. Since this treatment the ship has been in service about one year and has given no further trouble."

Case Number 2

"A C3 ship has been in commercial service since commissioning and after approximately two years of operation began to experience trouble with copper circulating piping. This ship, like many others built during the war and immediately thereafter was fitted with copper circulating lines which were untinned and not wiped with lead or solder. Internal examination revealed numerous spots of various sizes, from tiny pitting to areas 1/2 inch in diameter, eroded to a paper-thin thickness. At this time, one new section of 8 inch diameter auxiliary condenser discharge piping was renewed with copper pipe tinned and lead wiped.

"Two months later, the two remaining sections of 8 inch piping were renewed with copper pipe which had been tinned and lead wiped throughout to a thickness of 1/8 inch.

"Four months later, or thirty-eight months after commissioning, the 12 inch diameter combined discharge from the 8 inch line was leaking badly and had to be renewed. Also, the first piece of 8 inch discharge line that has been renewed fourteen months previously is now leaking at three locations. This piece of 8 inch renewed pipe was examined internally and externally and at all three leaks, lead lining, tinning and copper wall had broken down. In three other locations on the bottom side of the pipe, the copper was checked and very hard. Probing these three areas with the blade of a pen knife, the copper wall is easily penetrated. However, the lead lining appeared in good condition, the holes were plugged and the 30 psi cold water test was applied. No leaks appeared at the points where the copper was penetrated by the knife blade."

Corrective Measures Tried and Tested

In practically all cases steps were taken to insure that the cause of these failures was not due to electrolysis. In some operators' opinions the damage was caused by a combination of high velocity and the presence of entrapped air. They tried various methods of eliminating the air and reducing erosive action but it still did not stop the trouble. Monel piping has been tried and appears to perform successfully but is prohibitive costwise for most operators. Rubber linings and rubber lined steel has also been used. The cost of the rubber lining not including metal pipe and flanges is about $15 per foot for 24 inch pipe, plus $45 for a pair of attached flanges.

Copper companies do not recommend that copper pipe be rubber lined unless the expensive synthetic rubber, neoprene, can be used.

Early Failures Reported, Copper Called "Overrated"

The author of the second paper points out with quotations from earlier literature that failures of copper piping in sea water have been in evidence for as many years as copper piping has been used for this particular service. He describes in detail experiences of the Imperial German Navy during the period 1903-1905.

On the basis of past performance, Ffield has this to say:

"Copper is a most versatile metal and it has many desirable characteristics, but it looks as though it is also the most overrated material for salt water piping on ships. It has a history of unpredictable service to the point where it can only be classed as unreliable unless it receives suitable protection."

Many Causes and Cures Investigated

The author discusses in some detail the effects of and experiences with electrolysis, galvanic effects, effect of flow and aeration and contamination by bilge water. Methods that have been tried for protecting the copper, in most cases by forming a protective film, were not too successful. These include asphalt, hard rubber, pitch, marine glue, elastic lacquers, etc. Such schemes failed and were discarded because the films were subject to damage and contributed to valve failures. Other attempts at electrolytic protection were unsuccessful.

Lead-Tin Alloy Offers Best Solution

This is what the author had to say about using lead-tin alloys for protecting coppers

"All copper piping for use with salt water should be lined with lead-tin for its protection. With proper application results are good although some of the earlier investigators felt otherwise. A 60 per cent lead and 40 per cent tin alloy is generally used.

"There are two methods of applying lead-tin coatings to copper, namely by hot dipping and by wiping. In the former, a very thin (approximately 0.001 in.) coating is applied by dipping the object in a bath of molten lead. Where corroding conditions are severe, these dipped coatings are of questionable protective value because the lead-tin coating becomes contaminated or alloyed with the copper. Unfortunately, either the lead-tin-copper alloy or its corrosion film is cathodic to the base copper and will cause galvanic corrosion if pinholes occur in the coating. Furthermore, the higher the temperature of the bath, the greater will be the alloying effect of copper and despite care in maintaining the bath at the lowest practicable temperature, the molten metal will be continually picking up copper and thus contaminating the bath. Coatings applied by the dip process are inadequate for the protection of copper.

"Wiped coatings are formed by torch heating the copper and the lead-tin mixture to a temperature at which the lead-tin alloy is not molten but is mushy. In its mushy state, this alloy can be spread and wiped on the copper to a thickness up to 0.125 inches. While there is a minor alloying effect at the bond between this coating and the copper, the copper-rich alloy is very thin and

completely covered by a dense lead-tin coating. The uncontaminated coating is anodic to copper and offers galvanic protection as well as having good resistance itself to fast flowing aerated sea water."

Results of Experiments

Experiments with various types of coatings were conducted and the results compiled. The tests involved exposure to jet impingement by sea water and also to varying rates of flow. The results may be summarized as follows:

a. Dip coatings do more harm than good.
b. Wiped coatings afford complete protection.
c. Sixty per cent lead - 40 per cent tin is the best alloy.
d. Sprayed lead coatings look good.
e. The severity of attack increases with increasing temperature.

Service experience has confirmed "a," "b" and "e" but Ffield has had no experience to corroborate "c" and "d."

In his conclusion the author states:

"The work of others and the author's efforts to stem copper salt water pipe corrosion point to only one conclusion for this paper, namely, copper is unsuitable for salt water service unless it is protected by lead-tin wiping."

Conclusion

There are obvious inconsistencies and inconclusive results in some sections of these papers. We intend to make further investigations to clarify the situation. Nevertheless it is conclusive that copper alone does not give satisfactory service in salt water and that the use of lead definitely does improve the performance and increase service life.

It is understood that the magazine "Pacific Marine Review" plans to publish either in abstract or in full both of the above papers in their March issue. "Marine News" magazine plans to publish one of the papers in their April issue. In either case, the Association plans to obtain reprints for the benefit of its members.