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LEAD INDUSTRIES ASSOCIATION, INC.

292 MADISON AVENUE

NEW YORK, N. Y. 10017

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October 20, 1964

Subject: RESEARCH REPORT ON CALKED LEAD JOINTS

To Members of the Lead Industries Association, Inc.:

Attached please find a copy of a paper entitled "The Performance of Calked Lead Joints in Cast-Iron Soil Pipe Under Hot Water Discharge" by H. A. Montgomery, Asst. Professor of Mechanical Engineering, Purdue University, Lafayette, Indiana. The paper was presented on October 7, 1964 at the annual meeting of the American Society for Sanitary Engineering held in Philadelphia, Pa.

The paper reports on the results of research performed by Prof. Montgomery and sponsored by the International Lead Zinc Research Organization. It will appear in the printed proceedings of the A.S.S.E. which will be published sometime next year at which time the Association will secure reprints. In the meantime, copies as attached, will be distributed to the plumbing industry wherever possible.

We shall be glad to supply members upon request up to 25 copies of the attached free of charge and above this quantity at our reproduction cost of 15 cents per copy.

Sincerely yours,

David H. Borcina

David H. Borcina
Secretary

DHB:so
Att:

Look Ahead with Lead

THE PERFORMANCE OF CALKED LEAD JOINTS IN CAST-IRON

SOIL PIPE UNDER HOT WATER DISCHARGE

By

H. A. Montgomery
Asst. Professor of Mechanical Engineering
Purdue University
Lafayette, Indiana

INTRODUCTION

Lead-oakum joints have been used in bell and spigot cast-iron pipe for water supply and waste lines for more than a century with excellent results. Currently, over 70,000 tons of lead per year (U.S. Bureau of Mines records) are used in this application. This joint type continues to be the unquestioned leader in water supply lines.

With waste systems, however, the greater use of automatic appliances which require high temperatures and large volumes of water have raised doubts as to this joint's effectiveness at the operating temperatures involved. A lack of proper engineering data has resulted in substitutions of other piping systems or methods of joining cast-iron soil pipe.

To establish performance criteria for the guidance of the plumbing industry, the International Lead Zinc Research Organization has sponsored a research program to determine, through laboratory tests, the operating conditions under which standard lead-oakum joints in asphaltic coated cast-iron soil pipe would not leak under pressure-temperature fluctuations. Another consideration was to test an experimental lead-oakum-neoprene ring joint for high temperature use where the lead-oakum joint might prove unsatisfactory.

JOINT AND EQUIPMENT DESIGN

Fig. 1 illustrates a conventional lead-tarred oakum joint, showing the relative positions of the joint components.

The test joints were prepared by pouring and calking in the conventional manner, with two five-foot lengths of 4 inch service weight, single-hub, coated cast-iron pipe held in a clamping jig in a vertical position. The bottom pipe rested on a concrete floor which gave solid backing for the calking.

Care was taken to center the spigot in the bell section, and to obtain axial alignment of the two pipe sections. The three strands of the oakum were separated and a single strand (3/8 to 1/2" in diameter) used for calking. This is standard practice and facilitated packing the oakum firmly in place. The oakum was laid

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in the joint and packed in layers until 1" to 7/8" of space was left from the oakum to the top of the bell. All packing was done with standard yarning and calking irons. A hammer weight of 1-1/2 lbs. was used with short, sharp swings to do all calking. Lead used for calking met the requirements of the American Water Works Association, Specification C600-54T.

The lead was melted on a plumber's pot slowly, to a temperature of between 780° and 825°F and poured into the joint until level with the top of the bell. The inner circle was calked first and then the outer circle. A second calking pass was made on each joint to assure an even distribution of pressure around the joint.

The oakum used in the joints tested consisted of three types: tarred oakum single-strand dry oakum, and white jute. In making joints, white jute was the most difficult of the three to pack firmly. The tarred oakum and the single-strand dry oakum were equally easy to calk. In designing the test rig, rigid clamping of pipe ends was provided to simulate a very extreme field condition. Careful observation of the clamped pipe was maintained to insure that no longitudinal movement of the pipe in the clamp occurred during the test run. Lateral movement of the pipe was not restrained and averaged about 1/16-inch at the joint during each thermal cycle.

Fig. 2 is a schematic of the test system which was arranged to permit the flow of either hot or cold water under pressure through the test specimen. A three-way valve, shown in the lower center of the illustration, served as the key control valve. Pressure and temperature are recorded on gages located between the three-way valve and the test specimen. The pressure gage and the thermometer were checked and calibrated so that they would accurately indicate the temperature and pressure at the joint of the test specimen. Pressure is controlled by valves on the discharge end of each flow circuit. Hot water is recycled, cold water discharged to drain, and the temperature of the water controlled through the steam heat exchanger. A hot water heater is used to bring the water to within a few degrees of the test temperature. Control from that point is rapid and positive. Bleed-off from the pump was necessary to prevent cavitation in the 200°F plus range of temperatures.

JOINT TESTING

Test procedures were as follows:

1. Fill test system with room temperature water at 10 psi for 20 minutes to simulate conventional, on-the-job testing procedure.

2. Circulate hot water at 10 psi until the joint reaches test temperature. The temperature is measured on the outer surface of the hub by a tempstik, a device accurate within reasonable limits as determined by other checks made during pilot runs.

3. Introduce room temperature water into the system to replace the hot water and circulate until the joint reaches room temperature.

4. Continue to run alternate hot and cold cycles of water at 10 psi until 20 cycles are completed, or until a leak occurs.

The initial pressure placed on the joint assembly in the test rig simulates on-the-job testing to determine whether the joint is pressure tight under the prescribed pressure, usually 5 psi. Pressures used were 10 psi for the standard joint series and 25 psi for the lead-oakum-neoprene ring series. If a leak occurred during this test period, recalking was done in place on the test rig, and the joint again pressurized. If the joint leaked, it was rejected according to field procedure. A recalked joint that is pressure tight is as good as one that is pressure tight on the initial calking if no defects that cause initial leaks are present (such as cracked hubs, etc.).

A complete test run of 20 cycles would mean the joint was under a test pressure of 10 psi for 6 hours and 40 minutes, had reached maximum lateral deflection 20 times, and had undergone thermal cycling 20 times. The time required after water temperature was changed for the joint to reach 160°F from room temperature, (74°F) was 3 minutes and 45 seconds. Cooling time, from 160°F back to room temperature, was 4 minutes. There were a few seconds of variation from specimen to specimen.

TESTS RESULTS

Lead-Tarred Oakum Joints Tests show that the lead-tarred oakum joints provide excellent performance at temperatures of 160°F at 10 psi. Another series of tests were run with the temperature increased to 170°F at 10 psi; again results were excellent. Additional tests were undertaken at 180°F at 10 psi which showed conclusively that this was too high a temperature and that the limit of the lead-tarred oakum joint with coated pipe was reached at 170°F.

The leaks at temperatures above 170°F appear to be caused by the softening of the pipe coating. In almost every instance of water leakage, it was noted that tar seepage first occurred at the leak site. On some pipe the coating is uneven and lumpy. Leaks would occur in such areas of excess coating. It was noted that at a surface temperature of 140°F the coating begins to get tacky and at 160°F the coating can be moved about under finger pressure. It was also noted in other tests conducted with untarred oakum, which precludes oakum as the source of tar, that tar seepage first occurred which lends credance to the belief that the pipe coating is a factor in leakage at high temperatures.

Additional testing indicated that the joint will withstand higher pressures at 170°F. Further testing is necessary to establish how much the pressure can be increased before leakage occurs. Some joint specimens of the lead-tarred oakum have been held at 25 psi for periods of from 20 to 120 minutes without leaking. Thus, temperature, not pressure within limits, appears to be the critical factor.

Lead Single-Strand Dry Jute Joints. On the lead-single strand dry jute joint series, failure of the joints occurred within the first ten cycles of the test at 160°F. Leaks would usually occur on the side of the joint that was in tension during the hot cycle. There is no definite pattern, however, as to exactly where the leak will occur or the number of leaks. The inside of the joint, however, showed the most leaks.

Lead-White Jute Joint. In tests on lead-white jute joints, the failure of the joint occurred within the first fifteen cycles and on the hot water cycle at 160°F. Once water seepage started on the hot cycle, leakage increased progressively. Again there was no specific pattern for leakage.

Lead Oakum Neoprene Ring Joint (Experimental). Fig. 3 illustrates the structural arrangement of the components of the experimental lead-oakum-neoprene ring type joint. Triangular in cross-section, the ring is placed in the joint with the pointed edge down. It is then packed with a yarning iron to the bottom of the joint so that the top of the ring is flat. The neoprene ring is thus compressed evenly between the belland spigot around the bottom of the joint. Subsequently, oakum is packed on top of it in the standard manner to provide further seating of the ring. The ring shape used offered some trouble in placement, but when properly located gives excellent results. An improved ring design is being evaluated.

The neoprene ring type joint was tested using coated pipe with each of the three types of jute previously described. The lead-white jute and neoprene ring joint proved the best of these combinations when tested at a temperature of 200°F at 25 psi. No leaks occurred, and only on one hot cycle did a tar bubble form with very minute water seepage. This seepage dried up within one minute. During this test the temperature of two joints was moved up to 210°F at a pressure of 40 psi with no leaks occurring over a 20 minute pressure-temperature hold. For these tests the pipe was selected to provide a clean, even coating on the outside of the spigot end and the inside of the bell end.

This experimental joint thus offers promise for the prevention of leakage at the maximum elevated temperatures and pressures likely to be encountered in service.

Sag Measurements

Sag measurements were made on a number of soil pipe specimens placed on knife-edge supports set 9-feet apart (Fig.4). Sag at the midpoint of the joint was measured in thousandths of an inch by a dial indicator. Tests were conducted at $70°F \pm 5°$.

The amount of sag varies from specimen to specimen, with an average of 0.016-inch in 24 hours, but very little sag from that time on. To obtain extremely accurate results would necessitate finding the exact axial center of the pipe assembly. This becomes difficult due to the tolerance allowance of the soil pipe which prevents perfect alignment of the joints. The sag movement stops after a relatively short time so exacting measurements are not significant; particularly in view of the fact that sag test specimens were subsequently tested under pressure-temperature conditions with no initial leakage. It was also noted that the lateral movement under the pressure-temperature test far exceeded that under sag test conditions and the movement was repeated up to 20 times without causing leakage.

General Comments on Making Good Joints

The question is often raised as to how hard the lead should be calked. This is difficult to evaluate but, in general, the lead should be calked hard enough to be seated firmly on top of the oakum and to enable expansion against both bell and spigot section of the pipe. The lead ring should be about 1" in depth from the surface of the bell and be well set into the calking groove. The lead seems to work best if poured at between 780°F and 825°F, but it makes little or no difference whether it is calked cold or hot. Calking the inside section of the joint first seems preferable.

Careful workmanship should, of course, be used in all joints, especially when high temperature conditions are anticipated. The author should point out however that he is not a plumber, yet was able to calk joints with a very small percentage of initial leeks. Thus, when proper techniques are utilized, a qualified plumber will have no difficulties.

It must be emphasized that the oakum should be packed firmly and evenly to provide a good seat for the lead and prevent it from sinking down below the level of the hub when the lead is calked.

There are a number of other things that must be considered in making a good joint. First, the pipe must be of sound quality with no pin holes or blows, within dimensional tolerances and with an even coating. However, the effect of the pipe coating on high temperature leakage still remains to be determined. Second, the oakum must be of a good quality and readily workable. Very little trouble was encountered in this phase. Third, the assembly and calking of the joint must be done firmly and evenly so the pressures induced in calking the oakum and lead are evenly distributed within the joint to prevent the joint hub from cracking. Finally the lead must meet recognized standards for calking lead, such as the AWWA specification.

Influence of Time on Joint Temperature

It should be pointed out that the time it takes under test conditions for the pipe to reach test temperature is of the utmost significance from a practical viewpoint. For example, the time involved for the joint to reach 160°F was 5 minutes 45 seconds and to reach 200°F, 6 minutes and 30 seconds. The quantity of water flowing through the 4-inch pipe would be approximately 1000 gal/min. at a 10' head, or 1400 gal/min. at a 20' head to completely fill the pipe and get the same effect as obtained in the test. Test conditions were such that the pipe was placed at a 30° angle so that the whole inner surface would be in contact with the heated water, under pressure. In this way the most severe conditions were obtained.

Furthermore, it is unlikely in most installations that there would be a great enough volume of water discharging in a system at temperatures in excess of 170°F to bring the temperature of the joint itself up to the critical 170°F point and raise the pressure to 10 psi.

In view of this, even though a 170°F limit resulted from these experiments, it by no means indicates that higher temperature waters can not be tolerated under service conditions.

Conclusion

The extensive tests conducted on lead joints have confirmed their suitability for producing leak-tight joints in coated cast-iron pipe in both waste line and water supply systems. In all cases simulated test conditions were at least as severe as would be encountered in on-the-job field situations.

In summary the following conclusions are advanced:

1. Lead-tarred oakum joint in coated pipe can withstand temperatures of 170°F at 10 psi without leakage under the severe test conditions used in this study.

2. Tarred oakum is superior to single-strand dry and white jute in standard joints in coated pipe under high pressure-temperature conditions.

3. Pipe coating appears to be a significant factor in leakage at high temperatures. Further tests on uncoated pipe are indicated.

4. A repeated lateral deflection of 1/16-inch at pipe joints, which results from thermal cycling, does not appear to cause leakage in standard lead-tarred oakum joints.

5. If standard practices are used in making joints, there is no problem in consistently producing lead-tarred oakum joints which will meet the great majority of service temperature and pressure condition without leakage.

6. A modified lead-oakum joint containing an experimental neoprene ring offers promise for achieving leak-tight joints in coated pipe at temperatures and pressures of at least 200°F and 25 psi. This joint type would require no change in (1) present pipe configuration or (2) the basic method of making calked joints and (3) would meet the requirements of plumbing codes throughout the country, since it remains essentially a calked joint.

7. While 170°F is the limiting temperature for lead-tarred oakum joints in coated pipe under the test conditions used, it is extremely remote that in conventional installations there would be a sufficient volume of even hotter water discharge into the system to raise joint temperature to 170°F.

It is hoped that these data will serve as a practical guide for making calked lead joints in cast-iron soil pipe for elevated temperature service.

CAPTIONS

Fig. 1 - Conventional lead-tarred oakum joint.

Fig. 2 - Schematic of system used for testing joints. A three-way valve monitors flow of both hot and cold water. Pressure is controlled by valves on the discharge end. A heat exchanger enables varied temperature conditions.

Fig. 3 - Experimental lead-oakum-neoprene ring joint. This joint offers promise for achieving leak-tight joints at elevated temperatures of at least 200°F.

Fig. 4 - Schematic of system used in making sag measurements. Amount of sag in lead-oakum joint specimens was measured between 9-foot centers.

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