Commonwealth of Kentucky
Department of Highways

REPORT ON STUDY OF PROPOSED
SPECIFICATIONS FOR BITUMINOUS COATED CORRUGATED METAL PIPE

by

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March, 1946
INTRODUCTION

On February 27 and 28, the author visited the Research Laboratories of the American Rolling Mills Company at Middletown, Ohio. The purpose of the visit was to investigate the technique and background of the new specifications for bituminous coated corrugated metal pipe as proposed by Armco with a view to changing the Kentucky Specifications (throughout this report "proposed specifications" will refer to the specifications recommended by the American Rolling Mills Company).

It is a rather evident fact, but the author wishes to point out that the short visit could furnish only an indication rather than a positive solution to the problem.

PROPOSED SPECIFICATIONS

For convenience, the present Kentucky Specifications and the proposed specifications are included in this report as Annex 1 and 2, respectively. Briefly, the changes recommended are as follows:

(1) Inclusion of three standard tests on asphalt taken from the delivered pipe.
   (a) Solubility in carbon bisulphide (ASTM-D4)
   (b) Loss on heating (ASTM-D6 or AASHO-T47)
   (c) Penetration of residue after heating as compared to penetration before heating (ASTM-D5)

(Present specifications call for the solubility test only).

(2) Inclusion of two "handling" tests.
   (a) Flow test to determine if bituminous material will flow
       if subjected prior to installation to summer heats.
   (b) Shock test to ascertain if bituminous material will chip
       and crack if handled during winter temperatures (prior
to installation).

(Present specifications call only for a different form of flow test.)

(3) Adhesion test to determine if bituminous material will adhere to the metal.

(Present specifications call for an "erosion test" similar in purpose to the adhesion test).

The present specification on imperviousness of bituminous material to sulphuric acid or sodium hydroxide has been incorporated in the proposed specification.

BACKGROUND

The tests were developed in the Research Laboratories of Armco at Middletown, Ohio by Messrs. George Hoover and Robert Baker. Unfortunately, Mr. Baker was not available during the author's visit. The laboratories have been studying tests for bituminous coated pipe for a period of ten to twenty years.

Mr. W. T. Adams, Specifications Engineer, informed the author that the American Railroad Engineers Association (ARRA) had recently adopted the proposed specification with only editorial changes.

According to Mr. Adams and Mr. Hoover, all the main producers of bituminous coated corrugated metal pipe are in accord in desiring to see the specifications accepted as proposed. They mentioned specifically the Republic Steel Company.

OBSERVATIONS

ADDITIONAL TESTS ON ASPHALT

Some state highway commissions have favored the additional tests on asphalt, and some had expressed the opinion that no asphalt tests were needed.
The tests were deemed advisable by Armco as a protection for assuring the purchaser that a good, uniform grade of asphalt was going into the product.

**HANDLING TESTS**

The new flow and shock tests were developed by Armco to insure that pipe could stand handling.

1. **Flow Test.** It will be recalled that the present flow test consists of: Cutting a section of coated pipe, drawing a line parallel to the corrugations (in the valley), standing the sample so that the line is horizontal in an oven at a temperature of 150°F for four hours, and then ascertaining the amount of drop in the line drawn.

The proposed method of test does not have the above mentioned advantage of direct testing. However, the making of the small asphalt pellets, the storing of the pellets in an inclined metal surface in an oven at a temperature of 150°F, and the observation of the flow of the pellets along the metal constitutes an easily executed test.

The amount of flow for failure was derived by correlation with the present flow test. The method of test was adopted from a test for roofing materials. The amount of new equipment is negligible consisting of only the small forms for the asphalt pellets (pellet size 3/8" diameter, 3/4" long) and a corrugated metal strip approximately 8" long and 1" wide.

2. **Shock Test.** The suggested shock test is a simple test procedure of dropping a small hammer from a height of 5-1/8 inches upon an asphalt disc (1-3/4" diameter by 3/8" thick) at a temperature of 30°F. Very little new equipment is necessary; the mold for the discs being the principal new piece. The hammer could be easily adapted from the present Proctor Compaction equipment.

3. **General.** It is the opinion of the author that the flow and shock
Tests are basically the same as the standard viscosity and ductility tests, respectively, run on asphalt materials in accordance with ASTM Standards D68-33 and D113-35. If such were the case, highway laboratories would be trained and equipped to handle the tests. With this in mind, the following questions were asked at Middletown.

Ques. Has there been any effort to correlate the flow and shock tests with a form of the standard viscosity and ductility tests?

Ans. Mr. Hoover knew of no such attempt.

Mr. Adams remarked that some highway engineers did not approve of the asphalt tests already recommended. In addition, Mr. Adams stated that while he was not too familiar with the viscosity and ductility tests, he believed that the tests recommended by Armco were as simple a set of tests as could be developed.

Ques. Do you believe such a correlation is feasible?

Ans. Mr. Hoover believed that it was at least a possibility and that he was interested in checking into it.

ADHESION TEST

Armco recommends the replacement of the erosion test with the adhesion test. The erosion test consists of placing a two-foot long section of typically constructed pipe 15" in diameter in a rotating device. An erosive charge and water (temperature 50°-55°F) test the ability of the bituminous material to adhere to the pipe. The adhesion test, as recommended, consists of cutting a triangular pipe from a section of the pipe delivered to the job. The sample is aged in a water bath by heating one side (bituminous material removed) while cooling the other side. After aging, an anchor is imbedded in the bituminous material and pulled free by a steady, uniform pull. If more than 25% of the area covered by the anchor is free of coating, the pipe fails to pass. The figure of 25% was arrived at by tests in specimens taken from
the field. The theory behind the water bath used as an aging device is the fact that all bituminous material loses a portion of its oil as it becomes aged in the field. The water bath draws the oil out of the asphalt to the metal, and the resultant bituminous coat has less adherence characteristics.

The new equipment needed for the adhesion test includes a special type water bath, anchors, and a form of load application apparatus that might be adapted from equipment in the testing laboratory.

The adhesion test is recommended by Armco to replace the erosion test for the following reasons:

1. The erosion test is cumbersome, while the adhesion test is more simply executed and requires about 1/10th the time to perform.
2. The erosion test required a specially prepared section of pipe which is bound to arouse some suspicion in the mind of the purchaser. The adhesion test does not require such a sample.
3. Pipe has passed the erosion test, but stripping has developed after installation. This failure has occurred in Armco as well as in their competitors’ products. No pipe has been known to pass the adhesion test and fail in the field.

It is the opinion of the author that the proposed test procedure is still too complex for a routine test procedure. In addition, information as to the effect of freeze and thaw is desirable. The following questions were asked by the author and answered by Mr. Hoover:

**Ques.** What is the relative effect of running an adhesion test without aging?

**Ans.** There appears to be less stripping action, but no direct correlation has been established.

**Ques.** What is the effect of freezing and thawing a specimen?

**Ans.** No such test has been tried, but it would be interesting.
to see the results.

Ques. In my opinion, there are still too many unknowns to accept the tests—what is your opinion?

Ans. It is true that there are some unanswered questions. However, the test is undoubtedly a "step in the right direction" and far less cumbersome than the erosion test.

CONCLUSIONS

The following are the author's conclusions based upon the foregoing observations:

(a) The routine asphalt tests should be of value in indicating the quality of asphalt used in constructing the pipe.

(b) The fundamentals behind the handling tests are basically sound. However, a form of the viscosity and ductility tests promise to give a test procedure more suitable economically to testing laboratories. The flow test proposed by Armco is superior to the test now included in Kentucky Specifications.

(c) The adhesion test is superior to the erosion test in that it is less cumbersome and more desirable since the section of pipe tested is selected by a representative from the State Highway Department from the pipe delivered for use. However, the method of aging the pipe has not been satisfactorily examined.

(d) The proposed tests are superior to the tests now included in the Kentucky specifications.

RECOMMENDATIONS

1. That the proposed specifications replace the specifications now in use in Kentucky, if further study is not desired and if additional changes within six months would not be objectionable; or
2. Make no change in the specifications until future research is complete. After further study, the following set of tests could very possibly be established:

(a) Routine asphalt tests as proposed by Armco.
(b) Handling tests run on asphalt taken from pipe delivered consisting of a form of the viscosity and ductility tests.
(c) A form of the adhesion test as proposed by Armco, but one which has considered the effect of freeze and thaw, and one which might eliminate the seemingly unnecessary aging by the water bath.
(d) Imperviousness test now included in the Kentucky specifications.
ANNEX 1

Commonwealth of Kentucky
Department of Highways

SPECIAL SPECIFICATION NO. 1-R

BITUMINOUS COATED CORRUGATED METAL PIPE

This Special Specification No. 1-R covers the material requirements for Bituminous Coated Corrugated Metal Pipe. It shall be applicable when indicated on plans, proposals, or bidding invitations. All specification references are to the Department's 1945 Standard Specifications for State and Federal Road and Bridge Construction.

BITUMINOUS COATED CORRUGATED METAL PIPE

1. GENERAL. Bituminous coated corrugated metal pipe shall comply with all the provisions of Article 7,8.4 of the Department's 1945 Standard Specifications, including galvanizing, and in addition shall be completely coated inside and cut with an asphalt cement, which will meet the performance requirements set forth herein.

(a) The asphalt cement shall be 99.5 percent soluble in carbon bisulphide.

(b) Thickness of Coating. The inside of the pipe shall be coated uniformly for three-fourths (3/4) of the circumference (top of pipe when installed) to a minimum thickness of .03 inch. The thickness shall be measured on the crests of the corrugations. The bottom quarter of the circumference shall be of such thickness as to comply with the Erosion Test hereinafter described.

2. PERFORMANCE REQUIREMENTS. The asphalt cement shall adhere to the metal tenaciously; shall not chip off in handling; and shall protect the pipe from deterioration, as evidenced by meeting the following tests successfully:

(a) Stability Test. The asphalt cement shall not lose its stability when subjected to the highest summer temperature, as indicated by withstanding the following test successfully.

Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant temperature oven, with the parallel lines in a horizontal position. The temperature of the specimen shall be maintained within 2 degrees F. of 150 degrees F. for a period of four hours. At the end of this time no part of any line shall have dropped more than one-fourth inch.

(b) Imperviousness Test. The asphalt cement shall be impervious to liquids as indicated by the following test.
A 25 percent solution of sulphuric acid, or a 25 percent solution of sodium hydroxide, or a saturated salt solution (such as sodium chloride) shall be held in the valley of a corrugation for a period of 48 hours, during which time no loosening or separation of the bituminous material from the galvanizing shall have taken place.

(c) Erosion Test. A representative sample consisting of a two-foot length of a fully coated pipe (with ends closed by suitable bulkheads) shall be revolved end over end about its transverse axis at a speed of 3.7 revolutions per minute and in such a manner that the erosive charge shall alternately roll along the inner surface of opposite sides of the pipe (inside top and bottom, as when installed in service). At least 75 percent of the sample shall be immersed, as it revolves, in a bath of water maintained at a temperature of 50°-55°F. The top three-quarters of the pipe, shall not show areas of bare metal more than two inches in length on four of the seven central corrugations after five hours of continuous testing (called a test period), and the bottom one-quarter shall not show a similar failure in nine additional periods of testing. A new erosive charge shall be used for each period of test. The erosive charge shall be 50 pounds of grade MW building brick, conforming to the requirements of the A.S.T.M. Serial Designation 062-44, broken up into pieces two or three inches in diameter, and three gallons of water.

3. PATENTED DEVICES, MATERIALS AND PROCESSES. The Contractor and/or vendor shall hold and save the State harmless from any and all claims for infringement by reason of the use of any patented device, material or process used in the manufacture of the pipe.

APPROVED NOVEMBER 24, 1945

T. H. CUTLER
STATE HIGHWAY ENGINEER

Specification
Mimeograph No. 79
ANNEX II
SPECIFICATION FOR BITUMINOUS PROTECTED
CORRUGATED METAL PIPE

GENERAL

1. Scope
These specifications cover bituminous coating and paving of galvanized corrugated metal pipe for use in culverts, undersdrains and sewors.

2. Types of Protection
Two types of coating and paving are described in Section 5. The purchaser shall specify in the bid invitation the type desired.

MATERIALS AND MANUFACTURE

3. Base Metal, Spelter and Fabrication
The latest revision of A.A.S.H.O. Specification W 36 shall apply in all particulars up to the point of applying the bituminous material, except as modified in the bid invitation.

4. Bituminous Material
After application to the pipe, the bituminous material shall meet the requirements of Section 7 of these specifications.

5. Application of Bituminous Material
Type A - Coated only.
The pipe shall be coated uniformly, inside and out, to a minimum thickness of 0.05 inches, measured on the crests of the corrugations.

Type B - Coated and Paved (Smooth Pavement)
The pipe shall be coated as for Type A, above. Additional bituminous material shall be applied in such a manner that a smooth pavement will be formed in the invert (bottom of pipe when installed) filling the corrugations for 1/4 the circumference of the pipe. The pavement, except where the upper edges intersect the corrugations, shall have a minimum thickness of 1/8 inch above the crests of the corrugations.

SAMPLING AND TESTS

6. Test Specimens
All tests on the bituminous coating shall be made on samples secured from pipe delivered to or about to be delivered to the Purchaser.
A five-ounce sample of the bituminous coating shall be obtained by gathering strippings from the inside top of one or more lengths of pipe. (Care shall be exercised in sampling to avoid contamination from sand or soapstone that may have been applied after dipping. Seamless metal "ointment boxes" are suggested as containers.)

From each of any two lengths of pipe there shall be cut, with a hacksaw or other suitable means that will not affect the physical characteristics of the bituminous coating, a triangular shaped sample of exactly 4 in. base width and 3-1/2 inch vertical height. The 4 in. dimension shall be along the periphery of the pipe.

7. Tests

A. General Requirements: The bituminous coating shall have the following properties:

<table>
<thead>
<tr>
<th>Test</th>
<th>Limit</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen soluble in cold carbon bisulphide</td>
<td>-</td>
<td>ASTM D4</td>
</tr>
<tr>
<td>not less than -</td>
<td>99.5%</td>
<td></td>
</tr>
<tr>
<td>Loss on heating to 163°C; not more than</td>
<td>-</td>
<td>ASTM D6, or AASHTO T47</td>
</tr>
<tr>
<td>Penetration of residue after heating, com-</td>
<td>85%</td>
<td>ASTM D5</td>
</tr>
<tr>
<td>pared with penetration of same sample be-</td>
<td></td>
<td></td>
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<tr>
<td>fore testing for loss on heating;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not less than -</td>
<td></td>
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</tbody>
</table>

B. Shock Test: The ability of coated pipe to withstand handling in cold weather is indicated by successfully passing the shock test.

Four test specimens shall be prepared in the form of disks 3/8 inch thick and 1-3/4 inch in diameter. Approximately 4 ounces of the material sample shall be heated over a low flame until it becomes fluid; then poured into a mold or molds. Care must be exercised to melt the sample at the lowest possible temperature. The sample shall be stirred thoroughly until it is homogeneous and free from air bubbles when poured into the molds. The material may be poured in one 1-3/4 inch diameter cylinder of such length that the four test specimens may be cut from it, using a wire cutter.

The four specimens shall be cooled in a brine of ice and salt at a temperature of 30 degrees F. for a period of at least one hour. The samples are then removed one at a time and quickly placed on the anvil of the test apparatus and centered under the plunger. The hammer is then tripped from a height of 5-1/8 inches. Not more than 8 seconds shall elapse from the time each specimen is removed from the brine until the hammer strikes the plunger.

For the material to be acceptable, not more than one of the four test specimens shall show a crack. If it is difficult to determine visually whether a specimen has cracked, remove it from the test apparatus and bend the specimen slightly.

*Use excess to prepare two samples for flow test.
C. Flow Test: The ability of the coating on the pipe to remain in place and not flow or sag at summer temperatures is indicated by successfully meeting the flow test.

Two test specimens in the form of cylinders each 3/8 inch in diameter and 3/4 inch in length are obtained by pouring the excess molten bitumen mentioned in Sec. 7 B into the amalgamated brass molds. Place each specimen in a corrugation of the corrugated slide (slide to be on the 45° slope) so that the lower end of each specimen will rest exactly along the line scribed 6 inches from the bottom edge of the slide. Place the test apparatus with the specimens in place in an oven maintained at 150 degrees F., plus or minus 2 degrees. After 4 hours, remove from the oven and cool to room temperature. Measure the distance from the bottom of the corrugated plate to the lower edge of the test specimens. This distance subtracted from 6 inches determines the amount of sag or flow. To be acceptable, the flow must not exceed 1/4 inch for either of the two specimens.

NOTE: Section 7 D shall not apply until it is possible to secure asphalts manufactured to pre-war standards.

D. Adhesion Test: The ability of the coating to retain its adhesion to the pipe is indicated by successfully meeting the adhesion test.

The bituminous coating shall be scraped from one side of each of the two triangular shaped specimens, and the specimens placed in the aging tank with the bare metal side in contact with the hot water of the middle compartment. A temperature differential of 100 degrees F. shall be maintained on the samples for 45 minutes. At least 20 minutes before the end of the aging period, the adhesion anchors shall be placed in an oven at 240 degrees F.

At the completion of the 45 minute aging period, remove the specimen from the aging bath and immediately place it in a 70° F. water bath, and allow the specimen to cool for 20 minutes. Then remove the specimen from the 70° bath and dry the bituminous surface either by blowing with air or wiping lightly with a paper towel or cloth. Remove one of the hot adhesion anchors from the oven and press it into the asphalt coating as far as possible. Again immerse the specimen in the water bath, with the adhesion anchor in place, and allow to cool for 5 minutes. Remove the specimen from the water bath and cut around the edge of the anchor with a knife blade or a cork borer. Place the specimen immediately in the pulling apparatus and pull the anchor. Immediately after the first anchor has been pulled another adhesion anchor shall be applied to the specimen following the routine given above. After the anchor has cooled for five minutes in the water bath, it is pulled and the procedure is repeated for the third test. The elapsed time for the three tests, including the initial 20 minutes in the 70° water bath, shall not be more than 45 minutes.

After the anchors have been pulled, determine for each exposed area on the specimen the percentage of that area free of coating. (Note: In some cases the coating may have been removed and a brown oily film remain on the metal. The area covered by this film shall be considered free of coating.) A ruled counter-class will aid in making an accurate determination of the percentage of area free of coating.

For the pipe to be acceptable, not more than one of the six areas tested on the two samples shall show as much as 25 percent of the area of corrugated metal free of coating.
E. Imperviousness Test: The imperviousness of the coating shall be determined by placing a 25 percent solution of sulphuric acid or sodium hydroxide or a saturated salt solution in the valley of a corrugation of the coated pipe for a period of 48 hours during which time no loosening or separation of the coating from the galvanizing shall have taken place.

If the purchaser prefers, this test may be conducted on the two test specimens prior to their use in the adhesion test.

F. Equipment for Tests

A. The equipment for the shock test is illustrated in Fig. 1. It consists essentially of a rigid metal anvil or base plate not less than 1/2" thick and resting on a solid foundation; a hammer weighing 2000 grams (4.4 pounds) arranged to fall freely in suitable guides against a plunger weighing 1000 grams (2.2 pounds) and sliding freely in a vertical sleeve. The lower end of the plunger is spherical in shape with a radius of 1/2 inch. The hammer is held in its guide by a trip mechanism at a distance of 5-1/8 inches above the plunger.

The split molds for preparing the specimens may be made of brass, with the surfaces amalgamated to prevent sticking, and held together by slip rings pressed on the slightly tapered outside surfaces.

B. The apparatus for the flow test is illustrated in Fig. 2. It consists essentially of a corrugated brass plate 0.03 inch thick, 6 inches long and 4 inches wide, with corrugations running the long way of the plate, and a metal support to hold the plate on a 45 degree angle with the horizontal. The corrugations have a crest to crest dimension of 5/8 inch and a depth of 3/16 inch. A line is scribed 6 inches from the lower edge. The split molds are similar to those used in the shock test.

C. Three pieces of apparatus are required for the adhesion test; an aging tank (Fig. 3), 6 adhesion anchors (Fig. 4) and a pulling device (Fig. 5) for testing the adhesion.

The aging tank is 5 inches wide, by 7 inches deep and 24 inches long and divided into three compartments. The center compartment is 12 inches long and the end one 6 inches. The test specimens are mounted on gaskets so as to form a part of the partitions between the compartments. A Bunsen burner or other suitable source of heat is used to heat the water bath in the middle compartment to a temperature 100 degrees F. higher than the water in the end compartments, and a stirring device is provided to keep the water temperature uniform. A means must be provided for keeping the water in each of the two end compartments at approximately 70 degree F. (The temperature differential between the middle compartment and the end compartments must be maintained at 100 degrees plus or minus 3 degrees. With the differential maintained, the temperature of the water in the middle compartment may be set as low as 150 degrees F. or as high as 180 degrees F.)

The adhesion anchor is a brass device with an area inside the retaining edge of 1/2 sq. inch, (approximately 0.8 inch diameter inside the retaining edge), with small holes drilled through the disk, shallow circular grooves cut into the bottom side of the disk and a holding ring, as shown in Fig. 4. At least six such anchors should be available.
The machine for pulling the anchors is shown in Fig. 5 and consists of a frame to support the test specimens, a scale and spring through which the pull is applied, and a source of power for supplying the steady pull to the scale.