METAL PIPE COUPLING STUDY

Final Report

by

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ABSTRACT

The specific aims of the study were: (1) to establish a standard design for the watertight coupling systems for the various kinds of metal culvert pipe and to evaluate the test methods for determining watertight systems, (2) to evaluate the method of fabricating different type metal culvert pipe (the wall connecting method, seam), and (3) to evaluate some of the various coupling systems commercially available.

This was accomplished by: (1) searching the literature, (2) running a series of hydrostatic tests on each type of metal culvert pipe using various sizes and systems of gasket materials as set up in a test program, (3) reviewing policy decisions for pipe usage, and (4) reviewing new product evaluations affecting this study.

Principal findings or conclusions reached on the study included the following: (1) the Department's present Standard Specifications were found to be adequate regarding round, annular corrugated metal culvert pipe for watertight conditions, (2), rivet locations are a source of some leakage, (3) for metal culvert pipe, the deflection part of the hydrostatic test described in Paragraph 8 of AASHTO Designation: M 198, and referred to in our specifications, needs further review along with the method of application because of difficulty in application, and (4) it was found exceedingly difficult to achieve a watertight system for arched annular corrugated metal culvert pipe, primarily due to the nature of the coupling system and the shape of the pipe and bands.

Principal recommendations included the following: (1) study results indicated only round, annular corrugated metal culvert pipe should be used for specified watertight conditions, (2) a further review should be made in the Department's Standard Specifications when referring to Paragraph 8 of AASHTO Designation: M 198 for use with metal culvert pipe, and (3) the seams of metal culvert pipe should be continuously welded when applicable to insure watertightness, if required.

IMPLEMENTATION

Some recommendations made in this study have already been implemented or are in the process of bing implemented. More implementation by the Department is expected to be accomplished in the near future. Revisions in the Department's Standard Specifications and Special Provisions, recommendations for further review in the test procedure for checking for watertight conditions, and qualifications for New Products acceptances have been made; and guidelines or requirements for pipe usage in this State have been established through policy decisions.

METRIC CONVERSION TABLE

Inches to Centimeters	Multiply by 2.54
Feet to Meters	Mutiply by 0.3048
Ft. Lbs. to Kg. M	Mutiply by 0.13826
Lbs. per sg. in. to Kgs. per sq. cm.	Mutiply by 0.0703

INTRODUCTION

The Louisiana Department of Highways has been using the conventional test method AASHTO Designation: M 198, "Joint for Circular Concrete Sewer and Culvert Pipe, Using Flexible, Watertight, Rubber Gaskets," for hydrostatic tests on corrugated metal culvert pipe. This test method was primarily intended for concrete pipe using compounded gasket material and may not necessarily be the best suited for metal pipe system evaluation. Consequently, the test method for evaluation of watertight systems on metal pipe needed review and evaluation, with a standard design being established for the coupling systems for the various kinds and sizes of metal culvert pipe.

The State's Standard Specifications (9) includes a section on culverts and storm drains and a subsection on joints for flexible conduit (ferrous metal) with requirements for different watertight systems. In addition to evaluating the test method and the various coupling systems required, a look at some of the promising flexible plastic gasket material in metal pipe coupling systems was warranted.

Other associated evaluations that were desirable to undertake included the wall connecting method (seams) and the various coupling systems commercially available.

Numbers in parenthesis are numbered references in the Selected Bibliography at the end of the report.

PURPOSE AND SCOPE

The specific aims of the study were: (1) to establish a standard design for the watertight coupling systems for the various kinds of metal culvert pipe and to evaluate the test method for determining watertight systems, (2) to evaluate the fabrication of different type metal pipe (the wall connecting method, seams), and (3) to evaluate some of the various coupling systems commercially available.

The scope of the study included: (1) compiling information from a literature search including reviewing policy decisions on pipe usage, (2) reviewing new product evaluations and other miscellaneous information which influences the results of the study, and (3) running hydrostatic tests necessary on each type of metal culvert pipe using various sizes and systems of gasket materials to provide relative information for evaluation.

METHODOLOGY

The first step in the research study was to conduct a literature search. The literature search was needed to determine what other states use for their metal culvert pipe construction requirements, to obtain information to support policy decisions on pipe usage, to compile records from previous pipe tests, and to search out possible new applications of materials or coupling systems.

In order to accomplish the specific aims of the research study, a metal culvert pipe testing program was set up, primarily for the determination of watertight coupling systems for the various types of metal culvert pipe and the collection of other information to support possible policy decisions or recommendations on pipe usage.

Certain types of new products that were being considered for evaluation by the Department's New Products Evaluation Committee were fitted into the research plan as supplementary information. These products were tested in conjunction with the regular test program to determine their effectiveness and possible use in the future.

Several basic types of metal culvert pipe were evaluated in the study. Table 1 on the following page lists the basic testing design with the various types and sizes of pipe tested. Several different types of bands and tightening systems were used in the study, the type primarily depending on the size and type of metal culvert pipe being tested, the recommendations of the manufacturing companies, and/or the requirements of AASHTO Test Procedures.

The existing facilities at the Department's Materials Laboratory (rail and carriage facilities for handling metal pipe and an apparatus for the application of hydrostatic pressures) were used to test the metal culvert pipe and to determine the possible watertight coupling systems. Since the end of the test program, newer and better testing facilities have been constructed.

TABLE 1

LIST OF PIPE EVALUATED

BASIC TESTING DESIGN
(TESTING PROGRAM)

MATERIAL	PIPE SHAPE	CORRUGATION	SIZE	TYPE COUPLING SYSTEM
Aluminum	Round	Helical	18"	Helical Connecting Band
Aluminum	Round	Helical	30"	Helical Connecting Band
Steel Galv.	Round	Helical	18"	Helical Connecting Band
Steel Galv.	Round	Helical	30"	Helical Connecting Band
Steel Galv.A.C.	Round	Annular	18"	Circumferential Tension Bolt
Steel Galv.A.C.	Round	Annular	30"	Circumferential Tension Bolt
Steel Galv.Abs. Bonded A.C.	Round	Annular	18"	Circumferential Tension Bolt
Steel Galv.Abs. Bonded A.C.	Round	Annular	30"	Circumferential Tension Bolt
Steel Galv.A.C.	Arched	Annular	29"X18"	Angle Lug
Steel Galv.A.C.	Arched	Annular	43"X27"	Angle Lug
Steel Galv.Abs. Bonded A.C.	Arched	Annular	29"X18"	Angle Lug
Steel Galv.Abs. Bonded A.C.	Arched	Annular	43"X27"	Angle Lug
Steel Galv.A.C. Smooth Lined	Round	Annular	30"	Circumferential Tension Bolt

Larger size pipe of each type was tested first, and any need for further tests was predicated on these results.

Some 24" pipe were used for evaluation instead of 18" pipe because of availability or results from previous testing.

In conjunction with the literature search and the testing program, there was a need to examine the existing metal culvert pipe requirements as outlined in the Department's Standard Specifications[9] and the test procedure, AASHTO Designation: M-198, "Joints for Circular Concrete Sewer and Culvert Pipe, Using Flexible, Watertight, Rubber Gaskets." Special Provisions to the Standard Specifications also affected the study.

Essentially this test procedure was for the testing of circular concrete pipe, but was adapted for use in testing metal culvert pipe. The applicable hydrostatic tests referred to in the test procedure are found in paragraph 8 of AASHTO Designation: M-198. This test procedure and other appropriate specifications or requirements quoted are found in the Appendix.

Each basic type of metal culvert pipe was tested by placing one piece of 1-inch (2.54 cm) gasket material in the first corrugation on either side of the joint. If failure occurred, the size of gasket material was increased to 1-1/2 and then 1-3/4 inches (3.81 and 4.44 cm) if the 1-1/2 inch test failed, and tests performed. When these sizes of gasket material did not give satisfactory watertightness at this configuration, then testing proceeded to a configuration of two pieces of 1-inch (2.54 cm) material, one in the first corrugation, and one in the second corrugation on either side of the joint. Again testing proceeded through the 1-1/2 and 1-3/4 inch (3.81 and 4.44 cm) gasket material, respectively.

If a watertight system was accomplished at any point in the testing, then the testing on that type of pipe was ceased. Generally the larger size of metal pipe of each type was tested first (although there were some exceptions) and if it passed the test, then testing ceased on that type of pipe. The basic testing design (testing program)that was set up was considered to be the most practical means of accomplishing the aims of the study. Evaluations of coupling systems and the wall connecting method (rivets, welds, etc.) were made with any further testing predicated on those results.

Judgements as to the necessity of tests and/or size of metal pipe or gasket material used varied because of the conditions present at the time.

Upon application of gasket material in the appropriate corrugations with the band tightened snug, the apparatus for application of the hydrostatic pressure was attached to two small pipes which were fitted into the welded metal plate bulkhead on one end of the metal culvert pipe. The opposite end of the metal culvert pipe was a solidly welded metal plate bulkhead with no openings.

The pipe section was then filled with water and checked for leakage, especially at the joint and the seams or rivets. With the metal pipe sections in a straight alignment, hydrostatic pressure was applied until 10 psi*(0.703 Kgs. per sq. cm) was reached, with the pressure being maintained for 10 minutes. If leakage occured at the joint during this time or pressure was not maintained, then failure was recorded. If the metal pipe sections passed the test with no leakage or loss of pressure, then the same test was applied with the pipe sections in a deflected mode with 1/2-inch deflection. Leakage at the seams or rivet locations was also checked. Failure was recorded only when leakage occurred at the joints.

Some of the pipe, especially helical, was set on end with the welded bulkhead down, filled with water, and left for 24 hours. During and after 24 hours, observations were made as to any leakage and where the leakage occurred. This was done for the new products evaluation and for an evaluation of the fabrication (wall connecting methods, seams) of the pipe.

The seams of the metal culvert pipe were checked on each test and the different types of seams were evaluated, especially as to effectiveness, and the size and type of metal culvert pipe on which these types of seams would be allowed. Here policy decisions or recommendations were made after meeting with appropriate personnel to discuss the test results, the general observations, the

* See footnote on page 7.

historical data, and the comparisons of the different types of seams.

Throughout the regular testing program, one type of flexible plastic gasket material was used in the testing of the coupling systems. However, while the study was progressing, another flexible plastic gasket material was approved for state usage and put on the Qualified Products List. Except for the approval testing of this new material through the New Products Evaluation Committee as reported herein, this new material was not used on the study. A comparison of products or evaluation of gasket material was not intended, as such, on this study; only an evaluation of the test procedures and the watertight coupling systems was an objective of this study.

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* Since this study began and testing was performed using 10 psi hydrostatic pressure, AASHTO M 198 has been revised to require a hydrostatic pressure of 13 psi for straight alignment test. A copy of AASHTO Designation: M 198-74 is found in Appendix C.

DISCUSSION OF LITERATURE SEARCH

For this study important questions asked were, "What are other states doing or requiring, and what is the industry recommending, in regard to metal culvert pipe, coupling systems, and/or requirements for watertight systems?" In searching through the HRIS listings, compiling miscellaneous information from literature sources and in reviewing some of the other states' specifications, much was found about metal culvert pipe and the coupling systems; however, very little was said concerning the requirements for watertight systems.

Some of the states whose standard specifications were reviewed in the literature search were Arkansas, California, Florida, Georgia, Illinois, Mississippi, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Texas, and Virginia. Some variations in requirements were found. Most states reviewed followed the AASHTO requirements and most states reviewed did not have any requirements on watertight systems or a test for checking this. However, some states reviewed did go into some detail on their metal culvert pipe specifications, among these were California, Pennsylvania, and Georgia. Of course, changes in specifications are always being made.

Ohio did not use corrugated aluminum pipe in their highway construction and also they were considering disallowing the use of dimple bands. Ohio also did not have a maximum allowable leakage requirement, but they did use corrugated metal pipe that had circular riveted seams, continuous lock or welded seams, as per AASHTO M-36.

Two of the states (California and Florida) did allow use of "O" ring gaskets in some way in their pipe specifications. California had it as an alternate for field joints with circular coupling bands. California, Georgia, and Pennsylvania were some states that had continuous helical welded seams allowed in their specifications, while here, the Louisiana Standard Specifications originally did not allow

this. However, since this study began, the specifications have been revised to allow for use of continuous helical welded seams. In Virginia, requirements were that the coupling bands be coated.

A good industry publication that is recommended is the Handbook of Steel Drainage and Highway Construction Products[5]. The flexible plastic gasket manufacturer's recommendations are generally considered closely in this state's specifications on metal culvert pipe, coupling systems and watertightness. Of course there are always some variations. In this study some will be mentioned in the Discussion of Test Results.

DISCUSSION OF SPECIFICATIONS

In a discussion of results, an important contribution has to be a discussion of this state's Standard Specifications. This study was undertaken partly because there were some reservations or questions about the adequacy or references in the Standard Specifications concerning metal culvert pipe.

Several questions should be answered in considering the Standard Specifications, in reviewing other state's specifications, in comparing Louisiana's specifications with other states and in considering the recommendations of the industry. Some of these questions are: "In considering Standard Specifications on metal culvert pipe, its coupling systems, and test procedures and requirements for watertight systems, are they practical? Are they possible to do? Are they efficient? Are they economical? Are they effective? Will there ever be a perfect watertight system, or is one really needed, and if so, under what conditions?"

Since the beginning of this study, some policy decisions have been made to cover use of metal culvert pipe and in revising our Standard Specifications on the above considerations. These revisions have been forthcoming, partly from results of this study, its test results and observations and partly out of a review of the conditions present in the state and historical data of pipe conditions. There will be a continuing re-evaluation of the state's needs and requirements in usage of metal culvert pipe, coupling systems, watertightness, and tests for checking these.

Generally speaking, the state's Standard Specifications concerning metal culvert pipe have been found to be adequate; however, some revisions were needed and made. Also some recommendations for revisions were enumerated. Principal areas were in reference to the laboratory performance test for watertightness, the use of helical pipe, and the types of seams allowed for use.

DISCUSSION OF RESULTS

Discussion of Test Results

Testing included regularly scheduled hydrostatic testing of a series of types, sizes, and shapes of metal culvert pipe as outlined in the Methodology and new products testing both on flexible gasket material and on different types of coupling systems. Some previous test results were helpful in looking at the overall evaluation of the different systems. All regular test results are found in Appendix B. The basic testing design (testing program) that was set up was considered to be the most practical means of accomplishing the aims of the study. This study was not a statistically oriented study.

The first tests were conducted on round, annular corrugated metal culvert pipe, which included 30" (76.20 cm.) steel galvanized asphalt coated, smooth-lined culvert pipe; 30" (76.20 cm.) steel galvanized asbestos bonded, asphalt coated culvert pipe; and 30" (76.20 cm.) steel galvanized asphalt coated culvert pipe. Overall test results on round, annular pipe indicated that an adequate watertight coupling system design would be possible using the present specifications and special provisions for specific projects. At present, most leakage occurs at the rivet locations; asphalt coated, asbestos bonded metal culvert pipe here would help eliminate any leakage at rivet hole locations.

Figures 1 and 2 show test setups on round, annular corrugated metal culvert pipe.

The standard design for round, annular corrugated metal culvert pipe should be for flexible gasket materal to be placed in two corrugations on each side of the conduit connections. The size of flexible plastic gasket material would depend on the depth of corrugation recess on

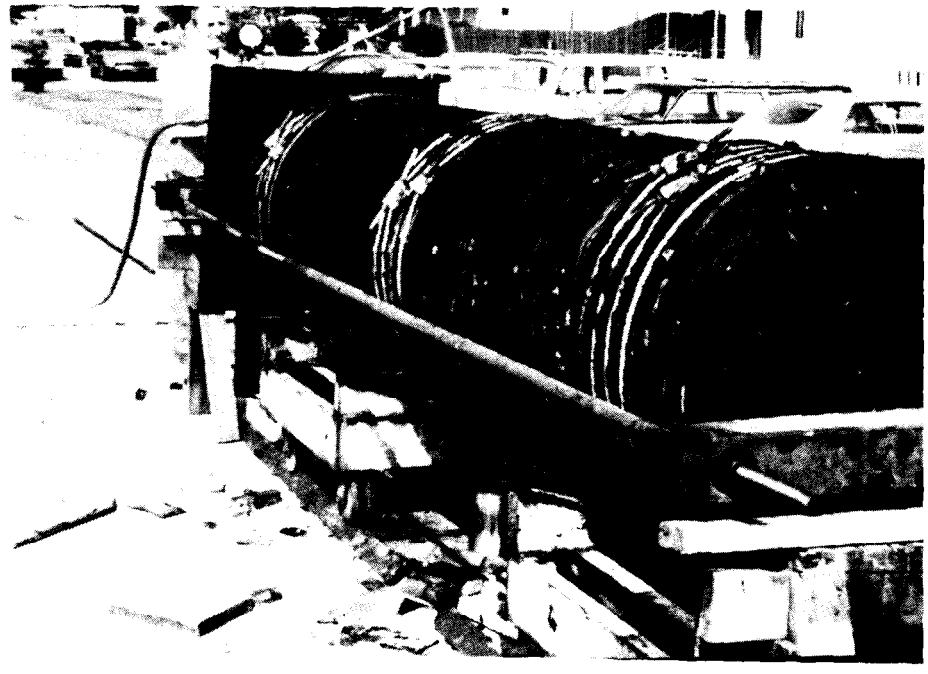

Figure 1
General View - Test Setup
Round, Annular Pipe

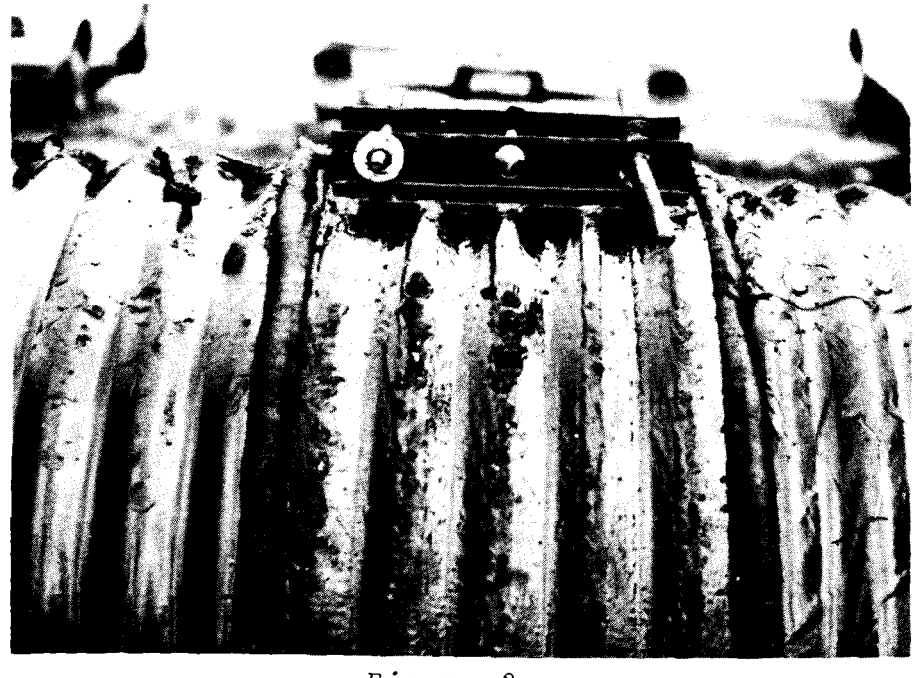

Figure 2
Coupling Setup, Round, Annular Pipe

the particular metal culvert pipe. Minimum sizes of gasket material are specified in the Department's Standard Specifications (Subsection 701.06 b) for depth to corrugations. In this study, only 1/2-inch (1.27 cm.) corrugation depths on the various types and sizes of metal culvert pipe were used. One-inch (2.54 cm.) gasket material was found to be the size to use on 1/2-inch (1.27 cm.) corrugated depth metal culvert pipe. Fexible plastic gasket material shall also be placed across each band connection in such a manner that there will be no leakage. Subsection 701.06 of the Standard Specifications remains adequate for the banding and watertight requirements for this connection. When watertight conditions are required on any project, they have to be specified, for that particular project, on the plans and in the contract.

Arched, annular corrugated metal culvert pipe represented another situation entirely. Although the same requirements seemed logical, upon laboratory testing it was found exceedingly difficult to achieve a watertight system. This was primarily due to the nature of the coupling system and the shape of the pipe and bands. Figure 3 shows a setup on arched, annular metal culvert pipe.

The tightening process and drawing up of the bands with the bolts was less than adequate, especially if the shape of the band did not match that of the two abutting pipe sections. To have any chance of a complete watertight system the band and pipe sections should match; and to achieve this, the bands would need to be pressed with the pipe sections in the fabrication process.

Except for one set of arched, annular pipe used for new products evaluation, all hydrostatic tests for arched, annular pipe failed to some degree under all the configurations and sizes of flexible plastic gasket metal. In every case, it was because the band could not be drawn up tight enough over the entire circumference of the band and joint. Again, leakage occurred at some of the rivet locations. Here too, some of this rivet hole leakage could be eliminated by use of asphalt coated, asbestos bonded metal culvert pipe.

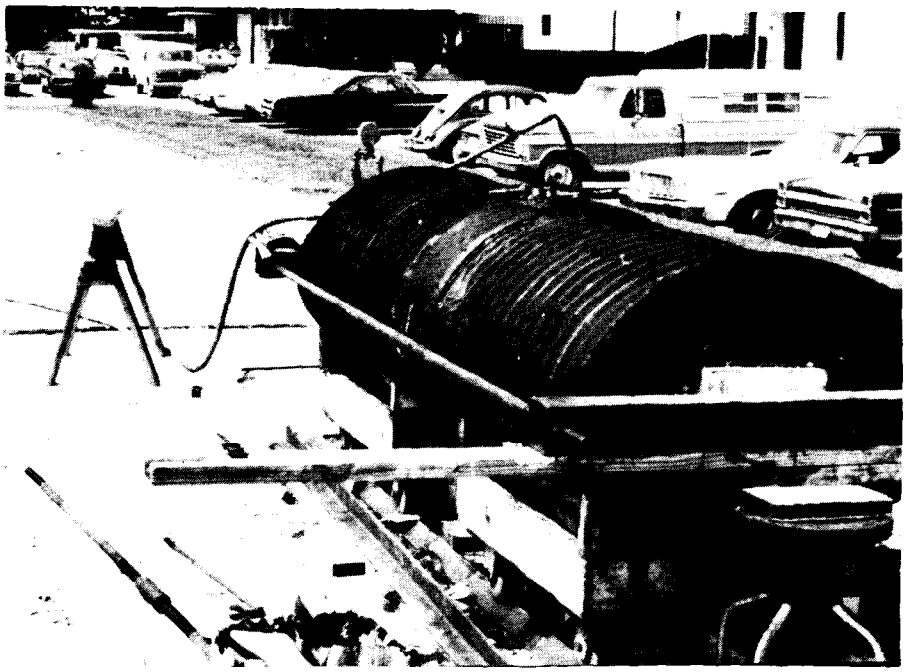

Figure 3
General View - Test Setup, Arched, Annular Pipe

If a nonwatertight system is used, then the present specifications and procedures are adequate.

Helical corrugated metal culvert pipe (either aluminum or steel galvanized) represents yet another situation. When the study began, the use of helical corrugated metal culvert pipe was not allowed by our Standard Specifications; however, revisions have been made to allow the use of this type of pipe, with certain restrictions.

For nonwatertight conditions, helical corrugated metal culvert pipe with continuous lock or welded seams may be used in accordance with the requirements of AASHTO Designation: M 36 with the following exceptions. The pipe shall have annular ends for jointing purposes (in which case, annular corrugated bands or "O" rings could be used) and the exposed ends of the seams shall be spot welded. Pipe with helical ends accompanied with an approved band may be used when specifically

allowed by the Department's Material Section. Flat bands or helical corrugated bands could be used in this case wtih helical corrugated metal culvert pipe in nonwatertight conditions. Helical corrugated aluminum culvert pipe has similar allowances.

For watertight conditions, at present the only type helical corrugated (metal or aluminum) culvert pipe being allowed is one with annular ends and a coupling system using annular corrugated bands and flexible plastic gasket material. If another type coupling system for helical pipe looks promising, then testing will have to be done and approval given by the Department's Materials Section for the coupling system to be allowed for use in watertight conditions.

Generally speaking, at present, most metal culvert pipe used for watertight conditions are round, annular corrugated metal culvert pipe. In this case when allowing riveted metal pipe, then asphalt coated, asbestos bonded round, annular corrugated metal culvert pipe should be used in order to reduce any leakage possible at the rivet hole locations, plus have an acceptable watertight coupling system.

Additional Discussion

In new products evaluation testing, a small round, helical corrugated, asphalt coated metal culvert pipe with round, annular ends was hydrostatically tested with the coupling system of two "O" rings with a flat band. Although the coupling system on this test did not pass, the results looked promising; and this type system may be considered in the future for any watertight system requirements on specific projects. Of course, the normal round, annular corrugated band setup with plastic gasket material has already passed hydrostatic testing and should provide watertight system requirements, if needed on the above type pipe.

Figures 4, 5 and 6 following show a typical pipe setup, a view of the round, annular ends and "O" rings for this setup.

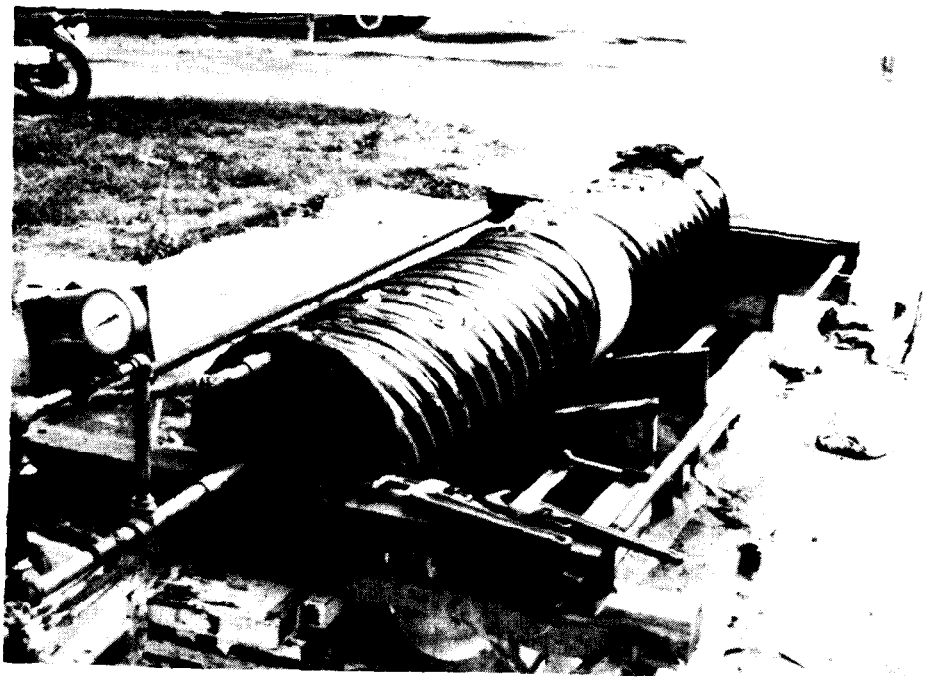

Figure 4
General View - Test Setup
Helical Pipe with Annular Ends

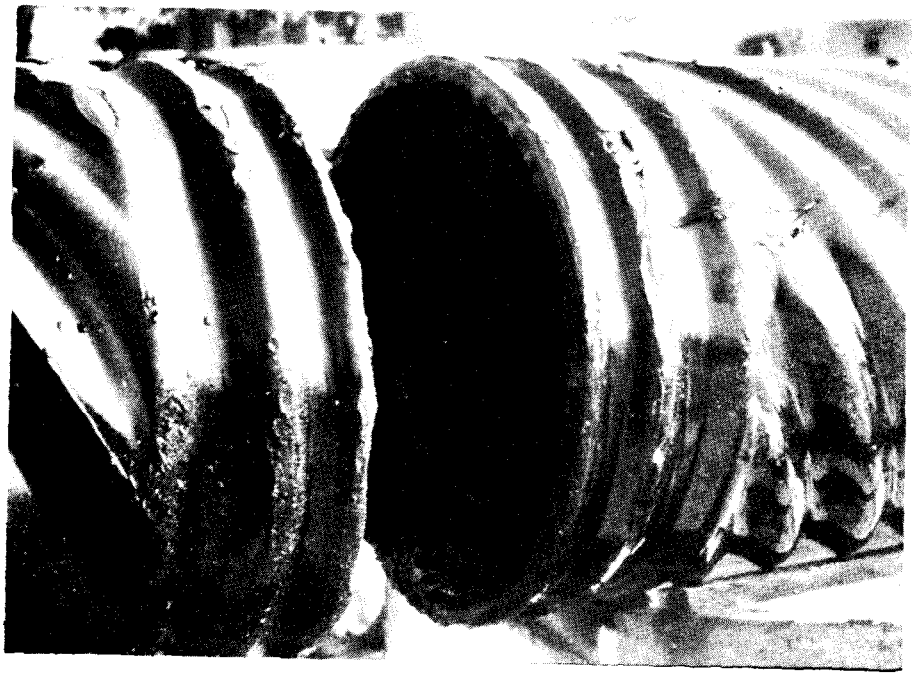

Figure 5
View of Annular Ends
to Helical Pipe

Figure 6
"O" Rings and Pipe Joint Lubricant
for Helical Pipe with Annular Ends

Another type connection that was considered and checked is called the Thermofit heat shrinkable coupler; however, tests on this product have been unsuccessful. Any further testing on other type connections besides the normal setup in the specifications or requirements will be handled through the New Products Evaluation Committee and the Qualified Products List. Of course, new products evaluation is always a continuing process in determining whether any of these new products will perform as advertised.

In all drainage situations using corrugated metal culvert pipe under watertight requirements, three facts stand out. First, the fabrication process or the manufacture of the corrugated metal culvert pipe or bands is very important. Pricipally it is important in the type of seam construction and the banding, the pressing of the corrugated metal sheets for matching pipe sections and bands, especially in arched

corrugated metal pipe, and in the coating of the pipe. Second, handling of the metal pipe, both in shipping and installation, is important. Third, the actual installation is very important. Assuming that a good watertight condition can be obtained in the laboratory under supposedly ideal conditions, then in the field one gets only as good a watertight coupling as the aforementioned situations will allow; the end result depends on the installation crew and the inspectors. With all the laboratory testing and checking for watertight coupling systems, the final test is what happens in the field. Even near perfect conditions do not guarnatee that the field installation will be watertight. At present, this state has no test for checking for watertight conditions in the field. Visual inspections are all that is required. Then too, how watertight should the installation be?

Field checking for watertightness, especially a practical test method, is one area where research needs to be done; and continuing effort is needed to achieve this end.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Findings and Conclusions

1. The Louisiana Department of Highways present Standard Specifications, in reference to gasket material and the coupling system for round, annular corrugated culvert pipe, were found to be adequate for normal watertight requirements.

2 A number of rivet locations on some corrugated metal culvert pipe, whether round or arched, leaked from time to time when tested for watertight conditions. Asphalt coated, asbestos bonded corrugated metal culvert pipe (round or arched) appears to be the best type to be used to control leakage of this type.

3. When applying the laboratory performance test (as described in Paragraph 8 of AASHTO Designation: M 198) for watertight coupling systems on corrugated metal culvert pipe, a further review of application of the deflection part of the test was deemed necessary because of difficulties in application of the test.

4. Although testing on helical corrugated metal culvert pipe resulted in a failure to get a watertight condition with the present coupling systems, it is possible in the future. If one is found and testing confirms the watertightness, then the Department's Material Section would have to approve the use. In the meantime, use of helical corrugated metal culvert pipe with continuous lock or welded seams in nonwatertight conditions is being allowed.

5. For arched, annular corrugated metal culvert pipe (although the same requirements as for round, annular corrugated metal culvert pipe seemed logical), it was found exceedingly difficult to

achieve a watertight system, primarily due to the nature of the coupling system and the shape of the pipe and bands.

6. Thus far no arched or helical corrugated metal culvert pipe coupling system has been found to be watertight, except in the case of helical pipe where you use annular corrugated ends.

Recommendations

1. Study results indicated only round, annular corrugated metal culvert pipe should be used at present for specified watertight conditions, using the Department's present Standard Specifications and coupling design, and checked in the laboratory using the present test procedure.

2. A further review should be made in the Department's present Standard Specifications when referring to Paragraph 8 of AASHTO Designation: M 198 on testing for watertight systems with corrugated metal culvert pipe. Paragraph 8b (deflection part of test) should be reviewed further, with the method of application of the test the prime subject of review because of difficulties in application.

3. The seams of metal culvert pipe should be continuously welded when applicable to insure watertightness, if required.

4. Helically corrugated metal culvert pipe with continuous lock or welded seams may be used in nonwatertight conditions in accordance with the requirements of AASHTO Designation: M 36. Pipe with helical ends accompanied with an approved band may be used for nonwatertight conditions when specifically allowed by the Department's Materials Section. The helical fabricating process should not be allowed for asbestos bonded, corrugated metal culvert pipe and pipe arch.

5. If a nonwatertight system is used, then the Department's present Standard Specifications and procedures for use of arched, annular corrugated metal culvert pipe are adequate.

6. The use of "O" rings on annular ends of helically corrugated metal culvert pipe is promising and should be investigated further.

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13. "Standard Specifications for Joints for Circular Concrete Sewer and Culvert Pipe, Using Flexible, Watertight, Rubber Gaskets, AASHTO Designation: M-198," Standard Specifications for Highway Materials and Methods of Sampling and Testing, Part I Specifications. Adopted by The American Association of State Highway Transportation Officials, Washington, D. C., 1970. pp. 174-176.

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15. Standard Specifications for the following states: Arkansas, California, Florida, Georgia, Illinois, Mississippi, Missouri, New York, Ohio, Pennsylvania, Texas, and Virginia.

APPENDIX A

ORIGINAL SPECIFICATIONS WITH COMMENTS REVISIONS AND/OR RECOMMENDED REVISIONS

701.06 JOINING CONDUIT.

(b) Joints for Flexible Conduit (Ferrous Metal): Flexible conduit shall be firmly joined by coupling bands meeting the requirements of AASHTO Designation: M-36.

When special "Watertight Connecting Bands" are specified for joining flexible pipe, the following specifications shall apply.

(1) General: Watertight connecting bands shall be of the same material as the conduit and shall be fabricated from corrugated metal sheets. The coating shall be the same as used on the conduit. The gage of band may be 2 gages lighter than the conduit gage, but not more than 12-gage nor less than 18-gage thickness.

Bands shall lap up an equal portion of each of the conduit sections. The longitudinal seam under the connecting bands may be riveted or welded at the option of the contractor.*

Band joints shall be sealed with flexible plastic gasket material conforming to Subsection 905.07. Plastic gasket rope shall be placed in 2 corrugation recesses on each side of conduit connection. Plastic gasket material shall also be placed on each band connection in such a manner that there will be no leakage. The gasket material shall be a minimum of 3/4-inch diameter for 1/2-inch corrugation depth and a minimum of 1 1/2-inch diameter for 1-inch corrugation depth, as the case may be, and placed and overlapped in accordance with the manufacturer's instructions.

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* See footnote on page 28.

(2) Circular Pipe Section: Connecting bands shall be 12 inches wide for culverts less than 36 inches in diameter and 24 inches wide for 36 inches in diameter and greater. Bands shall be drawn tight by a minimum of 4 galvinized 1/2-inch steel rods and lugs. An equal number of rods shall be placed on each side of conduit connection with sufficient rods used to preserve the conduit alignment. Two steel rods shall be placed over the plastic gasket strips on each side of conduit connection. The galvanization of rods and lugs shall be in accordance with ASTM Designation: A-153.

(3) Arch Pipe Section: Connecting bands shall be 12 inches wide for pipe arch up to 36-inch-by-27*-inch arch and 24 inches wide for a 43-inch-by-27-inch pipe arch and greater. Bands shall be connected at the ends of approved angle or strap connections. Connecting bands used for 43-inch-by-27-inch pipe arch and above shall be 2-piece bands. Hardware shall be galvanized in accordance with ASTM Designation: A-153.

Conduits shall be inspected before any backfill is placed and any found to be out of alignment, unduly settled, or damaged shall be taken up and relaid or replaced at the contractor's expense.

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*The underlined parts are recommended for change as follows: (1) The longitudinal seam under the connecting bands should be continuously welded to insure watertightness, and (2) obviously the pipe arch quoted should be 36 inch by 22 inch. Comments were made in the Discussion of Specifications.

905.07 FLEXIBLE PLASTIC GASKET** The gasket sealing the joint shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents. The gasket joint sealer shall not depend on oxidizing, evaporating or chemical action for its adhesive or cohesive strength and shall be supplied in extruded rope form of suitable cross-section and of such size as to fill the joint space when the pipe are laid. The gasket joint sealer shall be protected by a suitable removable 2-piece wrapper. The 2-piece wrapper shall be so designed that 1/2 may be removed longitudinally without distrubing the other half.

The material shall be obtained from sources approved by the laboratory, and the approval will consist of full-scale pressure testing as required elsewhere herein and any additional tests deemed necessary by the Department.

When this type gasket is used as a contractor's alternate for "Flexible watertight Gaskets," the Department may, in addition to the requirements of this Subsection, require the performance test described in Paragraph 8 of AASHTO Designation: M 198.

Flexible plastic gasket shall meet the requirements as stated in the following table:

Composition	Test Method	Min.	Max.
Bitumen (Petroleum Plastic Content)...	ASTM-D4	50	70
Ash-Inert Mineral Matter	AASHTO-T 111	30	50
Volatile Matter	AST M-D 6	--	**2.0
Property	**Test Method**	**Min.**	**Max.**
Specific Gravity @77°F	ASTM-D 71	1.20	1.35
*Ductility @77°F(cm)	ASTM-D 113	5.0	-
*Softening Point.....	ASTM-D 36	320°F	
*Penetration @77°F(150 gms) 5 Sec. ...	ASTM-D 217	50	120

*Due to the nature of the material, each sample to be tested must be manually kneaded, in lieu of heating and pouring, into various molds suggested by ASTM Standards to reduce the void content and improve testing accuracy and reproducibility.

**The underlined parts were recommended for change and have been revised as shown in the Special Provisions Rev. 4/75.

FLEXIBLE PLASTIC GASKET: The requirements of Subsection 905.07 of the Standard Specifications are deleted and the following substituted therefor. The flexible plastic gasket material used shall be an approved product on the Qualified Products List maintained by the Department's Materials Section or a product that is approved for the Qualified Products List prior to use.

907.06 CORRUGATED METAL PIPE AND PIPE ARCH. These conduits and coupling bands shall conform to the requirements of Type 1 (culvert pipes, circular section) and Type 2 (culvert pipes, other than circular section) of AASHTO Designation: M-36 amended as follows:

(a) The zinc coated iron or steel sheets shall conform to AASHTO Designation: M-218.

(b) Helical corrugated pipe with continuous lock or welded seam construction will not be allowed.*

(c) The minimum gage or sheet thickness shall be in accordance with Subsection 701.02; however, sheets thicker than that specified will be acceptable when approved by the engineer.

(d) Special sections, such as elbows and flared end sections shall be of the same sheet thickness as the pipe or pipe arch to which they are joined and shall conform to the applicable requirements of these specifications.

(e) Shop-formed elliptical pipe and shop-strutted pipe shall be furnished when specified.

(f) The pipe, when used with "Watertight Connecting Bands," shall have connections conforming to the requirements of Subsection 701.06, Joining Conduit.

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* See footnote on page 31.

(g) When "smooth lined" pipe is specified by the plans or project specifications, the following requirements shall apply. The inside circumference of the pipe shall be paved with bituminous material to minimum depth of 1/8 inch above the crests of the corrugations. The paving shall be applied by centrifugal or other approved methods. The bituminous materials and methods of testing shall be in accordance with AASHTO Designation: M-190.

907.12 CORRUGATED ALUMINUM PIPE AND PIPE ARCH. Corrugated aluminum pipe and pipe arch shall be of the dimensions and gages specified and shall conform to the requirements of AASHTO Designation: M-196.*

11/75

SPECIAL PROVISIONS

METAL PIPE: Section 907 of the Standard Specifications is amended as follows:

Subsection 907.06, Corrugated Metal Pipe and Pipe Arch: The requirements of Heading (b) concerning helical corrugated pipe are deleted and the following substituted therefor.

> Helical Corrugated pipe with continuous lock or welded seams may be used in accordance with the requirements of AASHTO Designation: M-36 with the following exceptions. The pipe shall have annular ends for jointing purposes and the exposed ends of the seams shall be spot welded. Pipe with helical ends accompanied with an approved band may be used when specifically allowed by the Department's Materials Section. The helical fabricating process is not allowed for asbestos bonded corrugated metal pipe and pipe arch.

Subsection 907.12, Corrugated Aluminum Pipe and Pipe Arch: The requirements of AASHTO Designation: M-196 concerning helical corrugated pipe are amended as follows. The helical corrugated

* The underlined parts are revised as Special Provisions 11/75.

pipe shall have continuous lock seams with annular ends for jointing purposes. Pipe with helical ends accompanied with an approved band may be used when specifically allowed by the Department's Materials Section.

APPENDIX B

TEST RESULTS

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 4/16/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated Asbestos Bonded Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/23" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- watertight design w/2 circumferential threaded bolts on each side and band
2-- two strips of 1" RAM-NEK placed in first two corrugations of each joint
3-- asphalt coated band
4-- two "cans" on outside ends of pipe
5-- 50 ft/lb torque on nuts, bolts

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure was applied, 10 psi maintained for 10 minutes-straight alignment
3-- pipe seams leaked, joint did not leak
4-- pipe was deflected 1/2", then 10 psi water pressure applied and maintained for 10 minutes, no leakage at test joint, but same leakage at seams of pipe
5-- pressure increase at 19 psi, 3 minutes after 10 psi test finished, no leakage at test joint, but bolt holding ends of pipe sheared

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup before test
2-- test joint before test
3-- 10 psi water pressure reading on gauge
4-- leakage at pipe seam
5-- slight leak at seam on underside
6-- leakage at seam by test joint, outside at 7 minutes into test
7-- set up of jack and deflection at 1/2" with 10 psi water pressure for 10 minutes

I. PEOPLE PRESENT:

1-- C. Lafleur, LDH
2-- L. Tullier, LDH
3-- S. Baker, LDH
4-- A. Lobell, LDH
5-- S. Vaccaro, LDH
6-- S. Law, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 4/19/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- watertight design w/2 circumferential threaded bolts on each side of band
2-- two strips of 1" RAM-NEK placed in first two corrugations of each joint
3-- asphalt coated band
4-- two "cans" on outside ends of pipe
5-- 50 ft/lb torque on nuts and bolts

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied, 10 psi maintained for 10 minutes straight alignment
3-- pipe seams leaked, test joint did not leak
4-- pipe was deflected, 1/2", then 10 psi water pressure applied and maintained for 10 minutes, no leakage at test joint, but same leakage at seams of pipe

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- coupling
2-- overall fiew
3-- 10 psi pressure on gauge
4-- seam leak
5-- another seam leak
6-- jack and 1/2" deflection
7-- jack and 1/2" deflection
8-- seam leak again

I. PEOPLE PRESENT:

1-- L. Tullier, LDH
2-- S. Baker, LDH
3-- S. Vaccaro, LDH
4-- S. Law, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 4/24/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" x 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES
1-- watertight design w/2 circumferential threaded bolts on each band
2-- one strip of 1" RAM-NEK placed in first corrugation of each joint
3-- asphalt coated band
4-- two "cans" on outside of pipe
5-- 50 ft/lb torque on each and bolt

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied and maintained for 10 minutes straight alignment
3-- pipe seams leaked - test joint did not leak
4-- pipe was deflected 1/2" and 10 psi water pressure was applied
5-- test joint began to have small leak after 5 minutes, at RAM-NEK overlap on top of test joint, then failed

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup befofe test
2-- test joint before test
3-- 10 psi water pressure reading on gauge
4-- 1/2" deflection before test

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- S. Law, LDH
3-- L. Tullier, LDH
4-- J. Harris, LDH
5-- B. LeBlanc, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 4/29/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- watertight design w/2 circumferential threaded bolts on each band
2-- one strip of 1-1/2" RAM-NEK placed in first corrugation of each joint
3-- asphalt coated band
4-- two "cans" on outside of pipe
5-- 50 ft/lb torque on nuts, bolts

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied-straight alignment
3-- after 5 minutes small leak started at overlap on top of test joint, then failed

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup
2-- test joint before test
3-- 10 psi pressure reading on gauge

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- L. Tullier, LDH
3-- J. Harris, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/16/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- watertight design 2/2 circumferential threaded bolts on each band
2-- one strip of 1-3/4" RAM-NEK placed in first corrugation of each joint
3-- asphalt coated band
4-- two "cans" on outside of pipe
5-- 50 ft/lb torque or nuts, bolts

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi pressure applied-straight alignment, pressure maintained for 10 minutes
3-- pipe deflected 1/2" and 10 psi pressure applied, began to leak at 3 minutes into test, then failed

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup
2-- test joint before test
3-- 10 psi pressure reading on gauge
4-- crew working
5-- deflection setup

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H. Cade, LDH
3-- R. Henderson, LDH
4-- P. Lobell, LDH
5-- R. Shaffett, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/18/74

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated Aspestos Bonded Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- watertight design w/2 circumferential threaded bolts on each band
2-- one strip of 1-3/4" RAM-NEK placed in first corrugation of each joint
3-- asphalt coated vand
4-- two "cans" on outside of pipe
5-- 50 ft/lb torque on nuts, bolts

G. TEST RESULTS

1-- no leakage of joint when filled with water before pressure applied
2-- ten psi water pressure applied-straight alignment
3-- after 5 minutes at 10 psi pressure, the joint began to leak, then failed

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup
2-- test joint before test
3-- 10 psi pressure reading on gauge

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H. Cade, LDH
3-- R. Henderson, LDH
4-- P. Lobell, LDH
5-- R. Shaffett, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/26/74

B. TYPE OF PIPE TESTED - Arched, Annular Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 86"x22' Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) _____ Width (2) _____ Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated band
2-- 50 ft/lb torque on nuts, bolts
3-- two strips of 1-1/2" RAM-NEK placed in first and second corrugations of each joint

G. TEST RESULTS

1-- no leakage of joint when filled with water before pressure applied
2-- Ten psi water pressure applied-straight alignment
3-- after 3 minutes of 10 psi pressure, joint leaked and failed, also seams leaked under RAM-NEK and band
4-- pipe leaks very bad at several seams

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup
2-- test joint before test
3-- 10 psi pressure reading on gauge

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H. Cade, LDH
3-- R. Henderson, LDH
4-- J. Harris, LDH
5-- L. Tullier, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/26/74

B. TYPE OF PIPE TESTED - Arched, Annular Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 136" x22" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) _____ Width (2) 14 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated band
2-- 50 ft/lb torque on nuts, bolts
3-- two strips of 1" RAM-NEK placed in first and second corrugations of each joint

G. TEST RESULTS

1-- leakage at joint when filled with water before pressure applied
2-- pressure could not be applied, pipe and band does not line up, with gap in band even with food tightening
3-- pipe leak also at several seams

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of setup
2-- test joint before test

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H. Cade, LDH
3-- R. Henderson, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/24/74

B. TYPE OF PIPE TESTED - Arched, Annular Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER -

D. SIZE OF PIPE - (1) 36"x22" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" x 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 14 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated
2-- 50 ft/lb torque on nuts, bolts
3-- one strip of 1-3/4" RAM-NEK placed in first corrugation of each joint

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied-straight alignment
3-- after 7-1/2 minutes at 10 psi pressure, joint began to leak and failed

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of pipe setup
2-- test joint befofe test
3-- 10 psi pressure reading on gauge

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H. Cade, LDH
3-- R. Henderson, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 9/30/74

B. TYPE OF PIPE TESTED - Arched, Annular Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 36"x22" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) _____ Width (2) _____ Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated band
2-- 50 ft/lb torque on nuts, bolts
3-- two strips of 1-3/4" RAM-NEK placed in first and second corrugations in each joint

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied-straight alignment
3-- after 9 minutes of 10 psi pressure, joint began to leak and failed
4-- seams of pipe leaked very bad, band on pipe does not fit very well, 1-3/4" RAM-NEK is very irregular, some thick, some thin and some strips are wider than others, however on test only used good strips

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- general view of setup
2-- test joint befofe test
3-- 10 psi water pressure reading on gauge, straight alignment
4-- leaks at seams in pipe

I. PEOPLE PRESENT:

1-- S. Vaccaro, LDH
2-- H Cade, LDH
3-- R. Henderson, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
RESEARCH STUDY NO. 73-2G(B)
R & D AND MATERIALS SECTIONS
HYDROSTATIC TEST

A. DATE TESTED - 12/18/74

B. TYPE OF PIPE TESTED - Arched Annular Corrugated, Steel Galvanized, Asphalt Coated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 43"x27" Diameter (2) 12 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 24" Width (2) 14 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated two piece band
2-- 50 ft/lb torque on nuts, bolts
3-- two strips of 1" RAM-NEK placed in first two corrugations of each joint

G. TEST RESULTS

1-- no leakage at joint when filled with water before pressure applied
2-- ten psi water pressure applied straight alignment
3-- after 2 minutes at 10 psi pressure, joint began to leak and failed
4-- leak occurred where 2 pieces of band joined together
5-- due to difficulty of banding joining, further tests with arched pipe ended.

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

Pre-Test
1-- side angle view, whole setup
2-- corrugation bent on top band
3-- side view of band joining
4-- end view of entire setup
5-- side angle view of gauge, setup

After Test
6-- leak at overlap top
7-- leak on band (bottom)
8-- 10 psi pressure reading gauge
9-- leak at overlap of top, bottom band

I. PEOPLE PRESENT:

1-- S. Law, LDH
2-- S. Vaccsro, LDH
3-- A. Pittman, LDH

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (8/6/72)

B. TYPE OF PIPE TESTED - Aluminum Round, Helical Corrugated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Kaiser Aluminum

D. SIZE OF PIPE - (1) 12" Diameter (2) ____Gage (3) Locked Seam Type of Construction (4) _____ X _____ Corrugations.

E DIMENSION OF COUPLING BAND - (1) 6-1/2" Width (2) ____Gage (3) Type of Material _____ (4) How Band was Rolled _____

F. ANY OTHER PHYSICAL QUALITIES

1-- Locked Seam Construction
2-- Coupling band - Thermofit Heat-Shrinkable Couple

G. TEST RESULTS

1-- Coupling band failed at 2 psi
2-- No further leakage at 8 psi
3-- Coupling band was leaking at five different places at 12 psi
4-- Locked seam started leaking very slightly at 13 psi

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- Set up, prior to application of pressure and after pipe had been filled with water, observed a leak at each end where the locked seam jointed the welded plate, applied RAM-NEK to chennel the flow away from the leak so as not to interfere with test results
2-- Leakage at 8 psi
3-- Leakage at 12 psi

I. PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (8/6/72)

B. TYPE OF PIPE TESTED - Aluminum Round, Helical Corrugated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Kaiser Aluminum

D. SIZE OF PIPE - (1) 24" Diameter (2) 14 Gage (3) Locked Seam Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled _____

F. ANY OTHER PHYSICAL QUALITIES

1-- Locked Seam Construction
2-- Coupling band is same material as body of pipe
3-- Coupling band and jointed area of pipe covered with primer 24 hrs. before test
4-- Two strips of 1-3/3" x 3'5 RAM-NEK material placed in the first corrugation of each section of pipe
5-- Coupling band tightened with three bolts to a torque of 30 ft/lb

G. TEST RESULTS

1-- Prior to application of pressure the locked seam showed slight leakage
2-- At 2 psi locked seam leaked stadily at all points
3-- Held 10 psi for 10 minutes and the locked seam continued to leak while the coupling band section showed no signs of leakage
4-- Pressure increased in 20 psi with no additional signs of leakage

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- Application of primer and RAM-NEK material
2-- Jointed Section of Pipe
3-- Gage Showing 10 psi

I. PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (8/7/72)

B. TYPE OF PIPE TESTED - Aluminum Round, Helical Corrugated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Kaiser Aluminum

D. SIZE OF PIPE - (1) 30" Diameter (2) 14 Gage (3) Locked Seam Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled _____

F. ANY OTHER PHYSICAL QUALITIES

1-- Locked seam construction with neoprene strip insert
2-- Coupling band is same material as body of pipe
3-- Coupling band and jointing area of pipe c overed with primer 24 hrs. before test
4-- Five strips of 1-3/4 x 3'5" RAM-NEK material applied in the first two corrugations of each section of pipe

G. TEST RESULTS

1-- At 5 psi locked seam showed slight leakage
2-- At 20 psi coupling band started leaking where bolts are located
3-- Held 10 psi for 7 minutes and RAM-NEK reduced leakage of coupling band
4-- At 10 minutes still holding 10 psi, no further leakage sean
5-- At 15 psi coupling band had greater leakage
6-- At 20 psi no further leakage of locked seam was evident

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- Jointed section of pipe
2-- (input Hose #1) (Gage #2) (Bleed Off Value #3)
3-- Shows leakage at coupling band for testing condition of 10 psi for 10 minutes
4-- Pipe under test condition of 10 psi for 10 minutes show leakage at weld
5-- Pipe under test condition of 10 psi for 10 minutes show leakage of coupling band
6-- At 20 greater leakage of coupling band but no further leakage of locked seam

I. PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (8/11/72)

B. TYPE OF PIPE TESTED - Aluminum Round, Helical Corrugated Metal Culvert Pipe

C. NAME OF MANUFACTURER - Kaiser Aluminum

D. SIZE OF PIPE - (1) 24" Diameter (2) 16 Gage (3) Locked Seam Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material Alumini, (4) How Band was Rolled _____

F. ANY OTHER PHYSICAL QUALITIES

1-- Locked Seam Construction
2-- Coupling band and jointing area of pipe covered with primer 72 hrs. before test for joint area of pipe and two hours before test for coupling band
3-- Two strips of 1-3/4" x 3'5 RAM-NEK applied in the first corrugation of each section of pipe

G. TEST RESULTS

1-- Slight leakage at locked seam before applying pressure
2-- At 5 psi leakage all along locked seam
3-- Pipe under test condition of psi for 2 minutes shows small leakage of coupling band
4-- Pipe under test condition of 10 psi for 9-1/2 minutes seal of RAM-NEK breaks at coupling band and pressure drops
5-- Pressure is increased to 21 psi and leakage continues more profusely

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- Shows application of primer and RAM-NEK material
2-- Jointed section of pipe
3-- Gage reading at 20 psi
4-- Pipe under test condition of 10 psi for 10 minutes show slight leakage at coupling band
5-- Leakage at 21 psi

I. PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (9/28/72)

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated, Asbestos Bonded Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 24" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" x 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- Band was not asbestos bonded
2-- Six strips of 1" x 2'5" RAM-NEK material placed in the first two corrugations of each pipe section

G. TEST RESULTS

1-- Two four foot sections of pipe were jointed together and put on end
2-- The pipe was filled with water to the eight foot mark (height)
3-- No leakage was evident after 15 minutes

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- Pipe prior to coupling, note the two strips of RAM-NEK on each joint of pipe
2-- Pipe after coupling and standing on end, note RAM-NEK squeeze out at coupling band and seal on bottom
3-- Pipe under test conditions, note personnel checking water level

I. PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (10/5/72)

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Asphalt Coated Asbestos Bonded Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham

D. SIZE OF PIPE - (1) 24" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) 12" Width (2) 16 Gage (3) Type of Material same (4) How Band was Rolled same

F. ANY OTHER PHYSICAL QUALITIES

1-- asphalt coated but not bonded band
2-- watertight design w/2 circumferential treated bolts
3-- two strips of 1" RAM-NEK placed in first two corrugations of each joint

G. TEST RESULTS

1-- pipe wall showed air leak prior to filling with water, this spot filled with bit.
2-- ten psi water pressure applied and RAM-NEK seal ruptured after 3 minutes, water flow was increased and 10 psi could be maintained
3-- after 6 minutes at 10 psi another leak was observed at the riveted seam (very slight)
4-- after 9 minutes at 10 psi the RAM-NEK seal and pipe wall (orginina leak) failed at a point where only 8 1/2 psi could be maintained

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- RAM-NEK
2-- Band applied
3-- Pipe before joining showing concrete plugs and gauge set up
4-- Point of original air leak
5-- RAM-NEK failure after 3 minutes
6-- Shows point of second wall leak at riverted seam
7-- & 8-- pipe under test conditions at 10 psi
9 & 10-- Pipe after 9 minutes at 10 psi, failed to a point where only 8 1/2 psi could be maintained

PEOPLE PRESENT:

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION
HYDROSTATIC TEST

A. DATE TESTED - Previous (10/27/72)

B. TYPE OF PIPE TESTED - Round Annular, Corrugated, Steel Galvanized, Asphalt Coated, Asbesto Bonded Metal Culvert Pipe

C. NAME OF MANUFACTURER - Anderson-Dunham Pipe and Armco Coupling Band

D. SIZE OF PIPE - (1) 24" Diameter (2) 14 Gage (3) Riveted Type of Construction (4) 2-2/3" X 1/2" Corrugations.

E DIMENSION OF COUPLING BAND - (1) ____ Width (2) ____ Gage (3) Type of Material same (4) How Band was Rolled Band rolled opposite to pipe

F. ANY OTHER PHYSICAL QUALITIES

1-- torch used to soften RAM-NEK for workability vecause of weather temperature (57°)
2-- coupling band and jointing area of pipe covered with primer 25 hrs. before test
3-- six strips of 1" x 2'5" RAM-NEK placed in first two corrugations of each pipe section
4-- four rods used, one in each corrugation of coupling band with 65 ft/lb torque applied
5-- no lubricant used to wipe over exposed portion of RAM-NEK for workability

G. TEST RESULTS

1-- no leakage when pipe filled with water
2-- slight leak present in the seam when pressure applied
3-- 10 psi reached in one minute and no further leakage evident
4-- coupling vand passed the test condition of 10 psi for10 minutes
5-- coupling band also passed the test condition of 20 to 23 psi for 10 minutes
6-- pipe was deflected in banded area 1/2" from the horizonal and 10 psi was applied for 10 minutes with no leakage evident.

H. PICTURES TAKEN DURING TEST REPRESENTS FOLLOWING:

1-- metal pipe jointed together with coupling band and four tightening ligs
2-- pipe alignment under test conditions
3-- tightening lugs with off set pattern and RAM-NEK squeeze out
4-- gauge showing 10 psi
5-- pipe under 10 psi for 7 minutes
6-- pipe under 10 psi for 10 minutes, no failure evident

I. PEOPLE PRESENT:

1-- K. T. Snyder, K. T. Snyder & Co.
2-- W. T. Burt, III, LDH
3-- W. Markum, LDH
4-- G. Smith, LDH
5-- E. J. Dantin, Jr., LDH
6-- C. Lafleur, LDH

APPENDIX C
SPECIFICATION, AASHTO M 198-74

Standard Specification for

Joints for Circular Concrete Sewer and Culvert Pipe Using Rubber Gaskets

AASHTO DESIGNATION: M 198-74
(ASTM DESIGNATION: C 443-72a)

1. SCOPE

1.1 This specification covers flexible watertight joints for circular concrete sewer and culvert pipe, using rubber gaskets, where infiltration or exfiltration is a factor in the design. The specification covers the design of joints and the requirements for rubber gaskets to be used therewith, for pipe conforming in all other respects to AASHTO M 86, Concrete Sewer, Storm Drain, and Culvert Pipe or AASHTO M 170, for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe, provided that if there is conflict in permissible variations in dimensions the requirements of this specification for joints shall govern.

NOTE 1. This specification covers the design, material, and performance of the rubber gasket joint only. Joints covered by this specification are normally adequate for hydrostatic pressures up to 13 psi (90 kPa), 30 ft (9.14 m) without leakage, when tested per Section 8. Infiltration or exfiltration quantities for an installed pipeline are dependent upon many factors other than the joints, and allowable quantities must be covered by other specifications and suitable testing of the installed pipeline and system.

2. BASIS OF ACCEPTANCE

2.1 The acceptability of the pipe joints and gaskets shall be determined by the results of the physical tests prescribed in this specification, if and when required, and by inspection to determine whether the pipe joints and gaskets conform to this specification as to design and freedom from defects.

3. MATERIALS AND MANUFACTURE FOR GASKETS

3.1 All rubber gaskets shall be extruded or molded and cured in such a manner that any cross section will be dense, homogeneous, and free of porosity, blisters, pitting, and other imperfections. The gaskets shall be extruded or molded to the specified size within a tolerance of ± 6 percent on any dimension, measured at any cross section. The rubber gasket shall be fabricated from a high-grade rubber compound. The basic polymer shall be natural rubber, synthetic rubber, or a blend of both acceptable to the purchaser and meeting the physical requirements prescribed in Section 4.

4. PHYSICAL REQUIREMENTS FOR GASKETS

4.1 The gaskets shall comply with the following physical requirements when tested in accordance with the methods prescribed in Section 7.

Tensile strength, min, psi (MPa)	1200 (8.27)
Elongation at break, min, percent	350
Shore durometer hardness:	
Min	35 (See
Max	65 note)
Compression set, max, percent of original deflection	25
Accelerated aging:	
Decrease in tensile strength, max, percent of original	15
Decrease in elongation, max, percent of original	20
Water absorption by weight, max, percent	10

Note 2—Allowable variation ± 5 from manufacturer's specified hardness provided the actual hardness is within the limits of 35 to 65.

4.2 If a splice is used in the manufacture of the gasket, the strength shall be such that the gasket shall withstand 100 percent stretch over that part of the gasket including the splice with no visible separation.

5. DESIGN OF JOINTS

5.1 The manufacturer shall furnish the purchaser with the detailed design of the joint or joints including design and durometer hardness of the rubber gasket proposed to be furnished under this specification.

5.1.1 The joint design shall consist of a bell or groove on one end of a unit of pipe, and a spigot or tongue on the adjacent end of the joining pipe.

5.1.2 All surfaces of the joint upon or against which the gasket may bear shall be smooth, free of spalls, cracks or fractures, and imperfections that would adversely affect the performance of the joint.

5.1.3 The joints of the pipe shall be of such design that they will withstand the forces caused by the compression of the gasket when joined, without cracking or fracturing when tested in accordance with Section 8.

5.1.4 The angle of taper on the conic surfaces of the inside of the bell or groove and the outer surface of the spigot or tongue where the gasket seats shall be not more than 3-1/2 deg measured from the pipe axis, except that tapers up to 5 deg may be used if proven adequate by plant tests as specified in Section 8 and approved by the purchaser. The conic surface on the spigot or tongue may be modified to properly contain and seat the gasket.

5.1.5 The annular space between the gasket-bearing surfaces of the assembled and centered joint shall be not more than 75 percent of the uncompressed thickness of the applied gasket including the manufacturer's tolerances of the joint and gasket. The joint design shall provide for the deflection of a pipe unit by opening one side of the outside perimeter of the joint 1/2 in. (12.7 mm) wider than the assembled position without reducing its watertightness. Where greater deflections are required than provided by the joint design, beveled joints or elbows must be provided.

5.1.6 The gasket shall be the sole element depended upon to make the joint flexible and watertight. The gasket shall be a continuous ring which fits snugly into the annular space between the overlapping surfaces of the assembled pipe joint to form a flexible watertight seal.

5.1.7 The gasket shall not be stretched more than 20 percent of its original circumference when seated on the spigot or tongue end of the pipe, except that on pipe 48 in. (1.22 m) in diameter and larger, but less than 72 in. (1.8 m) in diameter, the gasket shall not be stretched more than 25 percent and on pipe 72 in. in diameter and larger, the gasket shall not be stretched more than 30 percent.

NOTE 3—Joints in an assembled position are defined as joints in the position after assembly in accordance with the manufacturer's design.

6. PERMISSIBLE VARIATIONS IN DIMENSIONS

6.1 The planes formed by the ends of nonbeveled pipe shall not vary from the perpendicular to pipe axis by more than 3/16 in. (4.8 mm) for internal diameters 30 in. (762 mm) and smaller; or by more than 1/4 in. (6.4 mm for internal diameters 33 to 54 in. (838 to 1372 mm) inclusive; or not more than 3/8 in. (9.5 mm) for internal diameters 60 in. (1524 mm) and larger.

6.2 The manufacturer's tolerances for the width of the annular space between the gasket bearing surfaces shall not vary by more than ±10 percent of the uncompressed thickness of the applied gasket.

7. METHODS OF TEST FOR GASKETS

7.1 The physical properties of the gaskets shall be determined in accordance with the following methods:

7.1.1 *Tensile Strength and Elongation*—ASTM D 412, Tension Testing of Vulcanized Rubber.

7.1.2 *Hardness*—ASTM D 2240, Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer, with the exception of Section 4. The determination shall be taken directly on the gasket. The presser foot shall be applied on areas that are 1/4 in. (6.4 mm) or greater in thickness. If 1/4 (6.4 mm) or greater thickness is not available in the gasket, thinner samples may be piled up to obtain this thickness.

7.1.3 *Compression Set*—ASTM D 395, Test for Compression Set of Vulcanized Rubber, Method B. Test conditions to be 22 h at 70 C. Specimens shall not be prepared from laboratory prepared slabs or by direct molding.

7.1.4 *Accelerated Aging*—ASTM D 573, Test for Accelerated Aging of Vulcanized Rubber by the Oven Method. Test conditions to be 96 h at 70 C.

7.1.5 *Water Absorption*—ASTM D 471, Test for Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids. Use distilled water for the standard test liquid. When a 1-in. (25.4-mm) wide test specimen cannot be obtained, use the greatest width obtainable from the test sample. Test conditions shall be 48 h at 70 C.

8. PERFORMANCE REQUIREMENTS FOR JOINTS

8.1 The purchaser may require that assembled joints pass the following performance tests without leakage at the joints:

8.1.1 *Pipes in Straight Alignment*—Hydrostatic pressure tests on joints shall be made on an assembly of two sections of pipe, properly connected in accordance with the joint design. At the option of the purchaser a second such test may be required. Suitable bulkheads may be provided within the pipe adjacent to and on either side of the joint, or the outer ends of the two joined pipe sections may be bulkheaded. No mortar or concrete coatings, fillings, or packings shall be placed prior to watertightness tests. After the pipe sections are fitted together with the gasket or gaskets in place, the assembly shall be subjected to an internal hydrostatic pressure of 13 psi (90 kPa) 30 ft (9.14 m) pressure head for 10 min. Moisture or beads of water appearing on the surface of the joint will not be considered as leakage. At the manufacturer's option, the test period may be extended up to 24 h.

8.1.2 *Pipes in Maximum Deflected Position*—Upon completion of the test for pipes in straight alignment in 8.1.1, the test sections shall be deflected to create a position 1/2 in. (12.7 mm) wider than the assembled position on one side of the outside perimeter of each joint and shall be subjected to an internal hydrostatic pressure of 10 psi (0.69 MPa) for 10 min. Moisture or beads of water appearing on the surface of the joint will not be considered as leakage.

9. STORAGE

9.1 The gaskets shall be stored in as cool, clean, and shaded a place as practicable, preferably at 21 C (70 F) or less.

10. INSPECTION

10.1 The quality of the materials and the finished pipe joint and gasket shall be subject to inspection and approval by an inspector employed by the purchaser.

11. REJECTION

11.2 Pipe joints and gaskets shall be subject to rejection upon failure to conform to any of the requirements of this specification.

11.2 Gaskets shall be subject to rejection whenever they show surface checking, weathering, or other deterioration prior to installation in the work.

APPENDIX D
QUALIFIED PRODUCTS LIST

Louisiana Department of Highways

Qualified Products List 4

FLEXIBLE PLASTIC GASKETS

SOURCE	MATERIAL
1. Hamilton Kent Manufacturing Co. P. O. Box 178 Kent, Ohio 44240	KENT-SEAL No. 2
2. K. T. Snyder Company, Inc. 2100 Travis Street Houston, Texas 77002	RAM-NEK

NOTE:

All material, regardless of prior approval, shall be sampled in accordance with the Materials Sampling Manual and tested for conformance to the original specification. Any deviation in performance from the original sample submitted may result in disqualification of the product from the qualified products list.

No information contained in this list is to be used for promotional purposes.