Organizational Results Research Report

September 2007
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Effectiveness of HDPE Pipe Currently Installed in Missouri
(Phase 1)

Prepared by
Missouri Department of Transportation

Final Report

RI07-038A

Effectiveness of HDPE Pipe Currently Installed in Missouri
(Phase 1)

Prepared for the
Missouri Department of Transportation
Organizational Results

by
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Missouri Department of Transportation

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The opinions, findings, and conclusions expressed in this publication are those of the principal investigators and the Missouri Department of Transportation. They are not necessarily those of the U.S. Department of Transportation, Federal Highway Administration. This report does not constitute a standard or regulation.

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16. Abstract

A review and assessment of the effectiveness of HDPE pipe currently installed on Missouri DOT's system and of the specifications as written. This report will concentrate on the first request with only minor mention of the specification changes made in 2004; a future report will address more fully the specification.

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EXECUTIVE SUMMARY

A review and assessment of the effectiveness of High Density Polyethylene (HDPE) plastic pipe currently installed on the Missouri Department of Transportation (MoDOT) system and of the specifications as written was requested. This report will concentrate on the first request with only minor mention of the specification changes made in 2004; a future report will address more fully the specification.

A review was made of the double wall HDPE culvert pipe placed on a construction project completed in 2005. This was the first project that allowed crossroad pipe on a highway with Average Daily Traffic (ADT) over 3500. It added 20.5 miles of an additional two lanes on US 63 in Macon and Adair counties to make this a divided highway.
All 162 runs, totaling 13,400 linear feet, of HDPE pipe were inspected in 2005 during construction. Inspections documented the location of pipes with any deficiency of the following five requirements of Standard Specifications, section 730.3.5 with no:

(1) Misalignment greater than 15 percent.
(2) Deflection greater than five percent.
(3) Settlement greater than 1" (25 mm) at five percent or more joints.
(4) Evidence of being crushed or buckled at any location.
(5) Evidence of joint separation.

One pipe out of the 162, a 42" d. pipe failed deflection test at first inspection. Prior to acceptance, it was dug up and re-backfilled and passed. Another 42" d. pipe had a small crack on the very end of the pipe but was accepted the cracked end is inside the connection to a concrete drop inlet and the crack should not grow. A total of 811 linear feet of 42" d. pipe p

During a follow up inspection in August 2007, all 162 runs again passed the deflection test, and also passed the other 4 criteria called for in standard specification 730.3.5. This included a total of 811 lnear feet of 42" d. pipe. The only question raised on the whole inspection was a minor and secondary one about the durability of the HDPE flared end sections.

A second project through a Value Engineering proposal substituted HDPE pipe for concrete pipe on storm sewers that run on both sides of the widened US 63. The contractor's price was reduced $ 40,000 from his original reinforced concrete pipe (RCP) bid. The pipes are not located under the pavement but were subject to construction and paving machine loads. All 14,608 linear feet of HDPE pipe were also inspected during construction but there were several problems. During construction, six locations had to be dug up and re-backfilled because of deflections greater than 5%, one of these had to have a cracked 20 ft. long section replaced. Approximately one year after the initial inspection of the pipe it was re-inspected which is normal procedure when MoDOT is using a product for the first time. This inspection in April 2005 found one 48"d. section had 3 circumferential cracks. ADS, Inc., the pipe supplier, repaired the cracked pipe by using 3 rubber gasket type seals. All of the pipes were re-inspected in 2007. While there was no problems found in the 36"d. and smaller pipe, there was a large section of 48" pipe that no longer met the 5% deflection criteria, they are now closer to 7.5%. Also, two cracks were found in a 60"d. section, one of which may have been caused by vandalism. The repairs to the 48" sections made with the rubber glands appear to be allowing water seep in the repair. It should be noted that MoDOT specifications do not require a water

tight seal. Also, the 778 linear feet of 42” d. HDPE pipe installed on the other side of the road from the subject 48” pipe still met the original construction specifications.

Two 60” HDPE pipe installed in 1999 and 2001 as a research project were inspected in 2007 because they are the oldest 60” pipe on MoDOT highways. At the location on Rt. B, St. Clair County the pipe had a deflection of 10%, this pipe had loose backfill. The other pipe Rt. FF, Franklin County used good backfill material and compaction, it has no appreciable deflection from the 5% when it was put in.

Maintenance crews have used HDPE pipe for many years to replace pipe that cross under rural low traffic routes, less than 3500 ADT. Pipe that had been inspected when installed were looked at in 2007. Several pipe inspected on routes in the North Central District were extremely out of line both vertically and horizontally. Some had large deflections, 8% all the way up to 37.5% in one 24”d. pipe. By contrast several pipe inspected in the Southwest District had good alignments and little deflection, with a maximum of about 5%. The installations were usually left with the squared end of the pipe in the ditch, and do get the ends damaged from mowing, and one had fire damage and most of the pipe had burned up and it had to be replaced.

From looking at many HDPE installations there appears to be a marked difference in quality of installation. HDPE pipe is not as forgiving as rigid pipe, concrete or steel. It will deflect in any direction if not backfilled carefully and may be damaged if not using good backfill material. The type of backfill material and the compaction must be done carefully to get a quality installation of HDPE culvert pipe either by the contractor or maintenance forces.
The contractor reduced his price by $40,000 dollars on materials cost by using the HDPE pipe on Rt. 63, Howell County. However, some additional time and labor was required by the contractor to perform the testing and few necessary repairs needed on this project by substituting HDPE pipe for Reinforced Concrete Pipe. As contractor’s gain experience using this product thier installation and inspection should be better and easier.

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Effectiveness of HDPE Pipe Currently Installed

Introduction

Construction and Materials requested that a review and assessment of the effectiveness of HDPE pipe currently installed on our system and of the specifications as written. This report will concentrate on the first request with only minor mention of the specification changes made in 2004; a future report will address more fully the specification.

Technical Approach

A field inspection of a sample of the existing pipes was made along with a review of specifications and up dates specifically focusing on the new 2004 specifications designating Group A, B and C classification.

1. A visual or remote video camera inspection was made. If indicated by the visual inspection the appropriate size mandrel was pulled through the length of pipe to test the inside diameter.
2. Inspections documented the location of pipes with any deficiency of the following five requirements of Standard Specifications, section 730.3.5 with no:
   (1) Misalignment greater than 15 percent.
   (2) Deflection greater than five percent.
   (3) Settlement greater than 1" (25 mm) at five percent or more joints.
   (4) Evidence of being crushed or buckled at any location.
   (5) Evidence of joint separation.

Also any environmental effects such as any weathering, ultraviolet light deterioration or fire damage were documented.

Figure 1: MoDOT Remote Video Camera

Figure 2: Typical mandrel used to check deflections (borrowed from Mark Joersz, ADS Pipe)

Observations of HDPE culvert pipe installed on Rt. 63, Macon & Adair Counties

This project was designed as alternate bid either concrete pipe or HDPE. This was the first MoDOT project where crossroad culvert pipe on a major route used HDPE.

- All 162 runs, totaling 13, 400 linear feet, of HDPE pipe were inspected for deflection in 2005 during construction. One end of a 42" d. pipe failed at first inspection, but was dug up and re-backfilled and passed. Another 42" d. pipe had a small crack on the very end of the pipe but was accepted.
- During this inspection in August 2007, all 162 runs again passed the deflection test, and also passed the other 4 criteria called for in standard specification 730.3.5. The only question raised on the whole inspection was a minor and secondary one about the durability of the HDPE flared end sections used on the 24" diameter and smaller pipe ends.

Observations of HDPE culvert pipe installed on Rte. 63, Howell County

This project substituted HDPE pipe for concrete pipe on storm sewers that run on both sides of the widened US 63. The contractor saved over $ 40,000 from his original RCP bid. The pipes are not located under the pavement but were subject to construction and paving machine loads.

- All 14, 608 linear feet of HDPE pipe used in the storm sewer was inspected after construction in 2005 and passed specifications, however:
  - Five areas of deflections or deformations of the pipe caused during backfilling operations or after the paving machine traveled over the pipe had to be excavated and the pipes re-backfilled a second time to pass specifications.
  - One 20 ft. section needed replaced.
  - One 48" diameter section was allowed to have cracks in three locations repaired with rubber gaskets.

- When re-inspected in 2007, none of the smaller diameter pipe (36” d. and smaller) showed any distress and passed standard specification 730.3.5.
  - One continuous run of 1538 LF of 48” HDPE pipe was inspected and portions of 20 sections or 400 LF had deflections 1” more than the 5% allowed by specifications (approx. 7.5% deflection).
  - The repairs to the 3 cracks made using rubber gaskets are in this same run of pipe and there is some concern they have water trapped under them, which was NOT present when they were inspected in 2005.
  - In 2007, 180 LF of 60”pipe was inspected. There were two circumferential cracks found in the liner at about the 3 o’clock position in one section, which were not there in 2005.

Installation and Initial Performance of 60” HDPE Pipes

A special research project documented two 60” HDPE pipe installed in 1999 and 2001; these were inspected in 2007 because they are the oldest 60” pipe on MoDOT highways. We were most interested in whether the pipes had deflected more since installed.

- The St. Clair Rt. B pipe was now 8 years and 2 months old. It had a vertical deflection of 10.0% compared to the last measurement six years ago at 26 months old of 6.5%, and at 42 days after installation of 7.3%. This pipe never met AASHTO or MoDOT’s specification of 5% after 30 days installed. The reason is most likely because of poor backfill material (1” clean graded rock) and no compaction done by maintenance forces when backfilled.
- Pipe 2, Rt. FF Franklin County was now 7 years old. The contractor used better graded fill material and compaction equipment when he installed it. In September 2001 the only time it was measured it had a deflection of 5.0%. It appears that it may have deflected some more but new measurements couldn’t be taken because of the high amount of sediment in the invert through its entire length.

Maintenance use of HDPE Pipe for Culvert Replacement

Maintenance has used HDPE pipe for many years to replace rusted corrugated metal pipe (CMP) that cross under rural low traffic routes. A culvert study started in 1986 in Materials and Research records HDPE being installed as far back as 1983. A study done in 2000 actually inspected the pipes as they were installed; some of these were inspected in this review in August 2007.

- Four pipes inspected in District 7, Bates County, had good alignments and minor vertical deflections.
- In District 2, of the 8 pipes looked at in Linn and Schuyler counties; 4 had large deflections of up to 2” and one 24” d. pipe had deflections of 5 ½” and 9” in the same section. The alignments were not very good either; some probably would not meet standard specification section 730.3.5 (1) of no “Misalignment greater than 15%.”
- Durability was a problem too as several sections had large longitudinal cracks in the inverts in the deflected areas. Mower damage was also prevalent at the ends.
- At least one report of losing a whole pipe from fire damage on Rt. U in Linn County was reported by the local Maintenance Supervisor.

Conclusions

On both US 63 projects, all of the 42”d. and smaller pipe remain in acceptable condition to pass all five requirements of the Standard Specifications section 730.3.5. The pipe had not deflected more than 5%.

On the 48” and larger pipe, which had passed sec. 730.3.5, two years ago about 400 ft. on the Rt. 63, Howell County job would not pass the deflection of less than 5% (they are now up to 7.5% in some locations). Additionally cracks in the 48”d. and 60”d. pipe were found. The cracking, although it was minor, raises questions of durability. Also, trapped moisture between the inside and outside walls of the cracked double wall HDPE pipe or gasket repaired plastic pipe that may let moisture in and could cause freezing damage in harsh winters.

From looking at many HDPE installations done by contractors and several not so good by maintenance forces, there appears to be a marked difference in quality of installation. This pipe is not as forgiving as concrete and steel pipes on less than good installation. The type of backfill material and the compaction must be done carefully to get a quality installation of HDPE culvert pipe either by the contractor or maintenance forces.

The contractor saved $40,000 dollars on materials cost using the HDPE pipe on Rt. 63, Howell County. It is probable on some jobs like that one with rocky backfill material, that the indirect costs of testing and repairs may offset the materials costs savings and at some point may no longer be economically advantageous.

Recommendations

It is recommended that for a project like Rt. 63, Macon & Adair County, with good backfill material and moderate backfill heights, that substitution of HDPE pipe for concrete pipe for crossroad culverts on major routes (Group A pipe) is a good application. A lot of costs were saved on this project.

From data obtained on Rt. 63 Howell County, if HDPE pipe is to be used under major highways or into Group A classification, the allowable deflection would have to be increased from 5 % to 7.5%. (Deflection of 7 ½% is allowed by some other states). Otherwise it would be necessary to limit the HDPE pipe to 42” diameter and less. This size of HDPE pipe appear, if backfilled correctly, to meet the current specifications and seems more durable.

The type of flared end sections being used on HDPE pipe runs needs to be looked at, especially the durability of the flared ends made of HDPE.

There is a need to investigate different gradations of fill material and compaction methods to allow quick replacements by maintenance forces of crossroad pipe using HDPE on lower traffic routes. With more care taken and standardized installation procedures HDPE pipe can be economical and still provide a good long lasting pipe replacement.

Appendix A
Work Plan

Research Work Plan

Date: June 13, 2007

Project Number: RI91-011 revised

Title: Effectiveness of HDPE Pipe Currently Installed and Review of Specifications

Research Agency: Organizational Results with help from the Construction Materials laboratory will perform the field inspections of the existing HDPE pipe and Organizational Results will review current specifications and write a report.

Principal Investigators: PI & Field - J.D. Wenzlick, P.E., Organizational Performance Engineer
Field - Michael Blackwell, Intermediate R&D Technician (or other experienced technician from Construction/Materials)

Objective: The verify the condition and effectiveness of HDPE pipe in field since 1983 and see if they still meet the construction specifications that they were installed under. Also recommendations for any change in design procedures or specifications will be given.

Background and Significance of Work: Some of the HDPE pipe have been installed for up to 24 years now, they are supposed to have a life expectancy of 75 years, so now is a good time to inspect some of them. New culvert specifications have been in effect since 2004 and they need verified and updated if necessary.

Action Plan: A field inspection of a sample of the existing pipes will be made along with a review of specifications and any up dates specifically focusing on the new 2004 specifications designating Group A, B and C classification.

- Do a physical and remote video camera inspection of the 61 HDPE pipe inspected in the 2000 Culvert Study Report along with a few newer applications. Also deflections will be physically taken if noted before or discovered during the inspection. Any change of alignment or separation of pipe sections will be identified. The data will be analyzed and if deemed necessary due to distress noted in the inspections, some of the locations will have additional tests for Electrical Resistivity, and pH of the soil backfill, to see if damage is due to special environmental effects. Any weathering, ultraviolet light deterioration or fire damage will be documented.
- Inspection data will be analyzed and a report on the condition of the HDPE pipe reported.
- Specifications will be analyzed and recommendations on whether they or design procedures need to be changed in light of the culvert inspection data.
- The deflection data, change in alignment and separation of pipes are the most important characteristics to identify the performance of these pipes. They along with any environmental effects will indicate the effectiveness of the HDPE pipe already installed, whether the pipes still meet MoDOT specifications and if any revision of the specifications is needed.

Literature Search: A look at records from past culvert studies done by Materials and Research and RDT and the most recent Culvert Study report from Research Investigation 91-11 and the August 2000 Culvert Study Report will be reviewed. Contact with area Maintenance Buildings may be necessary to get history on the pipe condition. If needed, additional information on the use of HDPE pipe in other states will be gathered.

Method of Implementation: Any recommendations will be passed on to Construction/Materials for their action.

Anticipated Benefits: Verification of the health of the existing HDPE pipe culverts will reinforce the effectiveness of the new Group A,B,C specifications. It is anticipated that savings will be realized in construction costs using the Group pipe classifications

Research or Evaluation Period: Inspections of the 61 pipe will take a minimum amount of time if no problems are found, 3 weeks. Depending upon the amount of secondary testing required an additional 3-6 weeks may be necessary. With compiling of data, waiting for possible lab tests and reporting the project could take 3-4 months to complete.

Potential Funding: Will be covered by SPR funds under new RI number or TR08BPTE, Bridge Technology Performance Evaluation.

Procedure:
Schedule

Time Period (weeks)	Task
1	Review of MoDOT records/reports/specifications
3	Inspect 61+ HDPE locations (visual and remote video camera
3-6	Secondary Testing at site if needed
2	Compile Inspection and test data
1	Finalize Report and Recommendations
TOTAL 10-13 weeks	

Staffing: PI & Field - J.D. Wenzlick, P.E., Organizational Performance Engineer
(Outside help will be needed and the following technician did many of the inspections while in RDT)
Field - Michael Blackwell, Intermediate R&D Technician (or other experienced technician from Construction/Materials)

Equipment:
OR equipment - Remote Video Camera, camera tractor, flexible cable and stiff cable (optional)
(may need to buy light bulbs, electrical connectors, videotape)
Possible costs - $500.00
Soils & Geology borrowed equipment - Soil Resistance tester, pins and box, sample jars for pH test.
Possible costs - $200.00

Budget: Total Budget depending on field work - $33,178.88 to $35,458.88
(See breakdown below)

Personnel: PI- Organizational Performance Engineer – 10-13 weeks
Staff Intermediate R&D Technician – 6-9 weeks

Salary/ Wages	Grade	Median Salary/ July 1, 2007 Salary Grid	Benefits Multiplier	No. of 40 hour weeks	Salary/ Wages	
PI	18	31.94	1.6	10-13	$20,441.60	$26,574.08
Staff	9	18.17	1.6	6-9	$6,977.28	$10,465.92
Total					$27,418.88	$27,418.88

Travel:

	Days	Average Cost	Cost	
Lodging	18-27	$75 x 2 rooms	$2,700.00	$4,050.00
Meals	18-27	$24 x 2	$ 864.00	$1,296.00
Car	6-9 weeks @ 500 miles/wk	$00.33	$ 990.00	$1,485.00
			$4,554.00	$6,831.00

Possible Equipment Cost -	*$500 + $700 = $1200*	*$1200.00*	*$1200.00*

Length of field work	6 weeks	9 weeks
Personell	$27,418.88	$27,418.88
Travel	$4,554.00	$6,831.00
Equipment	*$1200.00*	*$1200.00*
Grand Total	*$33,178.88*	*$35,458.88*

Total Budget depending on field work - $33,178.88 to $35,458.88

Appendix B

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, Job J2P0485, Rte. 63, Macon/Adair Counties

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, Job J2P0485, Rte. 63, Macon/Adair Counties

This project was to add a 20.9-mile long additional two lanes on US 63 between Macon and Kirksville. A request was made by the contractor to substitute HDPE pipe for concrete pipe on 162 runs of cross road or under the road culvert pipe, representing 13,400 ft. of plastic pipe. All of the pipes were inspected before the completion of the project by Dale Williams, Field Materials Engineer in June 2005. A representative from ADS, the pipe manufacturer, assisted by pulling a pipe mandrel of the appropriate size, 5% less than the inside diameter, through 100% of the HDPE pipe installed on the job. At that time 100% of the pipe passed the less than 5% deflection in Standard Specification 730.3.5. The only durability problem found was some small cracks at the end of a section of 42" D. pipe that was minor enough to be accepted.

All 162 runs of pipe were re-inspected from July 30 thru August 2, 2007.

1. Visual inspections of the crossroad culverts were made at locations on the new lanes of US 63. If outlets daylighted to a flared end section in the inflow, usually in the median, they were looked at there and at the outflow side and pictures were taken at each end. If there was a drop inlet at one end then the inside of the pipe was only viewed at one end.
2. If there appeared to be a noticeable deflection or any other problem the pipes were walked through if big enough or the departments tracked video inspection camera was sent through the pipe and a VHS recording made. Also the tractor camera was used to pull a string through to the next opening in order to check deflections by pulling a mandrel back through the pipe. Mark Joersz of ADS Pipe supplied the pipe mandrels and assisted on the inspections.

Visual Inspections showed no pipe with any deficiency of the five requirements of Standard Specification 730.3.5. There was no:

(1) Misalignment greater than 15 percent.
(2) Deflection greater than five percent.
(3) Settlement greater than 25 mm at five percent or more joints.
(4) Evidence of being crushed or buckled at any location.
(5) Evidence of joint separation.

- There was some minor deflection that it was deemed necessary to do a video inspection with the MoDOT crawler tractor video camera and run a mandrel through 3 of the locations, a 15" D. and 2 – 24" D. culverts, and they all passed.
- There was one 24" D. pipe that appeared slightly out of round but the build up of debris in the bottom wouldn't allow the camera or mandrel to go through. Visually it appears within the 5% deflection limit.
- There was some minor joint separation noticed, one between a flared end section and end of a 30" diameter HDPE pipe that was almost 1 1/2" but since there is a 6-inch bell on this diameter pipe it was deemed acceptable and is probably the same as when accepted in 2005.

- The small crack mentioned above from the 2005 inspection on a length of 42" D. pipe was discovered to be about 12" long in 2007 and is located at the end of the run at 1:00 – 3:00 o'clock on the inside liner of the pipe. Due to its location and the fact that it is out of the flow line it is acceptable at this time.
- There was some mower damage to the few pipes that used HDPE flared end sections and the outflows of these appear very thin walled. They move up and down quite a bit and the fact that they have only a 6" deep toe wall at the end makes it questionable whether they will be durable enough to resist wear if the fill dirt will be washed out from under them. There was no erosion under the one end that the toe wall was showing and it will probably have no affect on this job since the flow lines of the pipe and the ditches are low gradient in this area.

Conclusions and Recommendations

The fact that 2 years after the pipe was installed and that it is in such good condition speaks well for the HDPE pipe used on this project for cross road culverts. Some insights from the inspection are:

The flat terrain and good clean backfill material probably are partially responsible for this. There is sufficient fill height above the HDPE pipe but nowhere more than about 10 ft. load on these culverts, and care was taken when fill height was low not to run heavy loads which would cause deflections during construction. There was no initial deflections seen or cracks or deformations from rocky fill material seen in these pipe in 2005 like there was on the US 63 job in Howell County which had at least six repairs necessary before that project was accepted. There was only one section of pipe that didn't pass deflection testing the first time on this project. It was re-tested after re-compaction at that end section and passed in 2005 and showed no deflection in 2007.

Most of these had steel or concrete flared end sections used for the outflows. The few that had HDPE flared end sections (24" D. and smaller) don't appear durable enough to last the claimed 75 years off the HDPE pipe. Consideration might be given to not allowing them.

It is recommended that for a project like this with good backfill material and moderate backfill heights that substitution of HDPE pipe for concrete pipe for crossroad culverts on major routes (Group A pipe) this is a good application. A lot of costs were saved in this application. The amount of time and labor required to perform the testing and any necessary repairs, as it did with the use of HDPE pipe on the US 63, Howell County, job did not happen here. The same contractor did both of these projects. However, some additional time and labor was required by the contractor to perform the testing and few necessary repairs needed on this project by substituting HDPE pipe for Reinforced Concrete Pipe. As contractor's gain experience using this product thier installation and inspection should be better and easier.

Photos of Cross Road HDPE culvert pipe installed on Rt. 63, Macon & Adair Counties

Typical condition of HDPE pipe on Rt. 63, Macon & Adair Cos.

42" d., Crack described as small in 2005, 0n 8-2-07 was 12" vert.
crack that covered 1 to 3 o'clock on end of last stick of pipe, deflection ok.

Photos of HDPE culvert pipe installed on Rt. 63, Macon & Adair Counties, cont'd.

8-1-07, s-017, 18", Eroded around FLE

End of 24" pipe with HDPE Flared End section, also the band holding FE on to pipe is broken

Appendix C

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, Job J9P0497, Rte. 63, Howell County

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, Job J9P0497, Rte. 63, Howell County

This project widened the US 63 Bypass through West Plains and the culvert installation was completed and inspected in April 2005. Bross Construction was the prime contractor and proposed substituting the HDPE pipe for the initially required 14,608 linear feet (roughly 2.8 miles) of reinforced concrete pipe (RCP) of storm sewer drainage. The proposal was accepted and the contract price was reduced by approximately $40,000. Bross and the manufacturer, Advanced Drainage Systems (ADS), were required to conform to Sections 730 and 1047 of the 2004 Standard Specifications. Section 730 governs the installation and inspection of the pipe and Section 1047 governs the pipe itself.

According to Standard Specification Section 730.3.5, any of the following would constitute improper installation:

(1) Misalignment greater than 15 percent.
(2) Deflection greater than five percent.
(3) Settlement greater than 25 mm at five percent or more joints.
(4) Evidence of being crushed or buckled at any location.
(5) Evidence of joint separation.
Any section of pipe that meets any of the descriptions above must be repaired or replaced at the contractor's expense.

There was only one case of a joint problem on this project. The contractor exposed the pipe below the springline and the joint was realigned. This may have been caused by over compaction at the joint. It was found that HDPE pipe could deflect in any direction as a result of over compaction.

Both vertical and horizontal deflections occurred on this project and were the primary reason for repairs. The method used to repair pipe because of a deflection failure was to expose the pipe in the vicinity of the failure by excavating below the pipe's springline. In two cases a crack was found in the interior wall of a stick during inspection. The contractor completely exposed the pipe in the vicinity of the crack. In another case, the interior wall of an entire stick was rippled on one side. It was concluded that this stick was severely deformed and was replaced.

Table 1

Size of Pipe - In. (mm)	**Stationing**	**Length (ft)**
12" (300)	1335+76 to 1338+01 RT	226
18" (450)	1333+51 to 1335+74 RT.	223
24" (600)	1317+51 to 1319+24 RT.	173
30" (750)	1319+26 to 1321+24 RT.	198
12" (300)	1336+51 to 1338+02 LT.	151
15" (375)	1335+01 to 1336+49 LT.	148

A couple of these sections had previously been repaired because of deflection, joint or misalignment problems. Retesting of these sections was also an attempt to ensure that the previous repairs were effective. The 12 inch (300 mm) section of pipe on the right side of Rte. 63 was out of specification because the mandrel could not be pulled through in either direction. The weight of the paving machine combined with the shallow fill (roughly 18”), resulted in increased deflection at that point.

However, since the deformation occurs over a small, localized area and the pipe is encapsulated in concrete, the damage will not have a significant impact on the performance of the entire section.

HDPE pipe should be inspected no sooner than thirty days after installation. If the pipe is used as storm sewer drainage, as was the case on this project, it is strongly recommended that inspection be performed before pavement is placed directly above the pipe. If the pipe is within the limits of the roadway, it should be allowed to experience some construction loading. After this point, however, the timeframe for inspection is left to the engineer’s discretion.

Pipe with a diameter of 42 inches (1050 mm) and greater should be inspected with a fixed measuring device with a length equal to the nominal inside diameter of the pipe minus five percent, as this method is very efficient. Pipe with a diameter of 36 inches (900 mm) and less should be inspected with a mandrel. This method is extremely time consuming and labor intensive. However, after the first year and the contractors have gained installation experience, a minimum of 25 percent of the pipe will be inspected with a mandrel, as opposed to 100 percent, and this method may not be as time consuming.

Note: The specifications have changed since this job was let and by supplemental provisions that took affect on in January 2005 the “25%” was removed and replaced with “…the engineer will inspect <u>all</u> pipe locations for proper installation.” Visual inspection can be used in lieu of testing where appropriate field conditions exist. If deemed necessary the engineer will determine if mandrell testing is required.
Overall, 108 percent of the pipe on this project was tested or inspected. The extra eight percent is the total length of pipe that was retested after the concrete pavement had been placed (see Table 1). At the June 2005 inspection, 100 percent of the pipe on this project met specifications. The contractor’s methods of repairing or replacing damaged pipe appear to be acceptable. However, some additional time and labor was required by the contractor to perform the testing and few necessary repairs needed on this project by substituting HDPE pipe for Reinforced Concrete Pipe. As contractor’s gain experience using this product thier installation and inspection should be better and easier.

<u>August 2007 Inspection</u>:
Twelve locations were re-inspected some 2 years after the installation of the storm sewer pipe on the widened US 63 in West Plains. Since it is hard to access all the pipe and time didn’t allow re-inspection of the entire 14,608 linear feet the following approach was taken.

1. Visual inspections of the storm sewer were made at locations on both the right and left side of US 63. If outlets daylighted to a flared end section or ended in side of a box culvert, or had a manhole entrance they were easy to access but most ended in drop inlets in the gutter which have high velocity cast iron grates which had to be removed.
2. If there appeared to be a noticeable deflection or any other problem the pipes were walked through if big enough or the departments tracked video inspection camera was sent through the pipe and a VHS recording made. Also the tractor camera was used to pull a string through to the next opening in order to check deflections by pulling a mandrel back through the pipe.
3. All pipe locations noted to be retested during construction, see Table 1 above, were also re-inspected.
4. A certain amount of each pipe diameter was looked at as listed:

Left	Right
151' – 12"	226' – 12"
295' – 15"	169' – 15"
47' – 18"	181' - 24" HDPE (21" RCP on Plans)
151' – 24"	1,017' – 24"
1,538' – 48"	562' – 30"
180' – 60" (54" RCP on plans)	778' – 42"
	985' – 48"

2,362' Lt. + 3,918'Rt. = 6,280' Inspected 8/6-8/07

This amounts to 43% of the 14,608' of HDPE pipe on the project.

Generally all of the pipe less than 42" diameter as in good condition and showed no visual deformation. All six locations from Table I, where the pipe that had to be corrected during construction, were included. Video inspections of two locations were attempted but because of excess debris in the inverts at these locations, only one 12"d. pipe allowed the tractor to travel only 10 ft., and the other an 18"d. pipe just over 100 ft. No deflections or bad joints were noted in the videos. A 36" diameter section on one of the radii at the northeast quadrant of the intersection of US 63 and Broadway was crawled through by our inspector and the ADS representative. This 438 Ft. of pipe was in good condition and all of the six 15° bends to make the bend under intersection were still in fine condition. One section on a radius at the southwest quadrant Rt. CC and US 63 intersection had a rebar driven thru the top of it. It is imagined that this must have been used for forming the radius curb and gutter above the pipe.

There is a 1538 ft. run of 48"d. pipe and 180 ft. run of 60" (substituted for planned 54" concrete), on the left side of the roadway (adjacent to northbound lanes) from Rt. K to the box culvert just south of Broadway. Myself, Jeff Joens of the Materials Field Office, and Mark Joersz the ADS representative all walked through this section. Jeff Joens inspected the pipe in 2005 and found some cracks in the liner in a section of 48" pipe. He also re-inspected the repair, which consists of three rubber inserts placed over these cracks so

that the pipe didn't have to be removed and replaced. He noted that on the first 2 bands on the south end that there was some bulging and water under the rubber glands used for the repair. When installed in June 2005 there was no moisture in the pipe or repairs. Also, when it was inspected in 2005 there were no areas with greater than 5% deflection. One section of the 48" pipe, just past the manhole at Sta. 1360+05, had a 20 ft. section that measured just at 5% vertical deflection; 20 ft. further down it was deflected 1" more than 5% or about 7.5% deflected. This increased deflection continued, off and on, but at least some part of every other 20' stick of pipe until Sta. 1356+00 or a distance of 400 ft. Also on the 60" section, 20+ ft. up from the outlet, a couple of circumferential cracks 6"-7" long were found in the sidewall of the pipe which weren't there in 2005.

Observations from August 2007 Inspection

1. On the majority of the HDPE pipe, all of it 36"d. and smaller, the pipe was still in acceptable condition and passed all the requirements of Standard Specification Section 730.3.5. The pipe had not deflected more than 5%, the alignments were still acceptable, there was no settlement crushing or buckling and no joints were separated that we could see. To get this result took extra care in backfilling by the contractor and on six section repairs had to be made during construction to get them to pass inspection. It should be noted that these repairs are all still in good condition after 2 years in place.
2. The 48" and larger pipe, which had passed sec. 730.3.5, two years ago about 400 ft. would not pass the deflection of less than 5% (they are now up to 7.5% in some locations). It should be noted that AASHTO Section 30.5.6.2 recommends a 5% initial deflection limit and a long term criterion of 7.5% deflection. This pipe is only 2-3 years old. Additionally a couple of cracks in the 60" pipe were found in one 20 ft. section and two of the three repairs in the 48" section made in 2005 appear to have moisture in them. The cracking, although it was minor was at two locations in 3500 linear ft. of 48" and larger pipe. This cracking raises questions of its durability and also if it traps moisture between the inside and outside wall of the plastic pipe it could cause freezing damage in harsh winters.

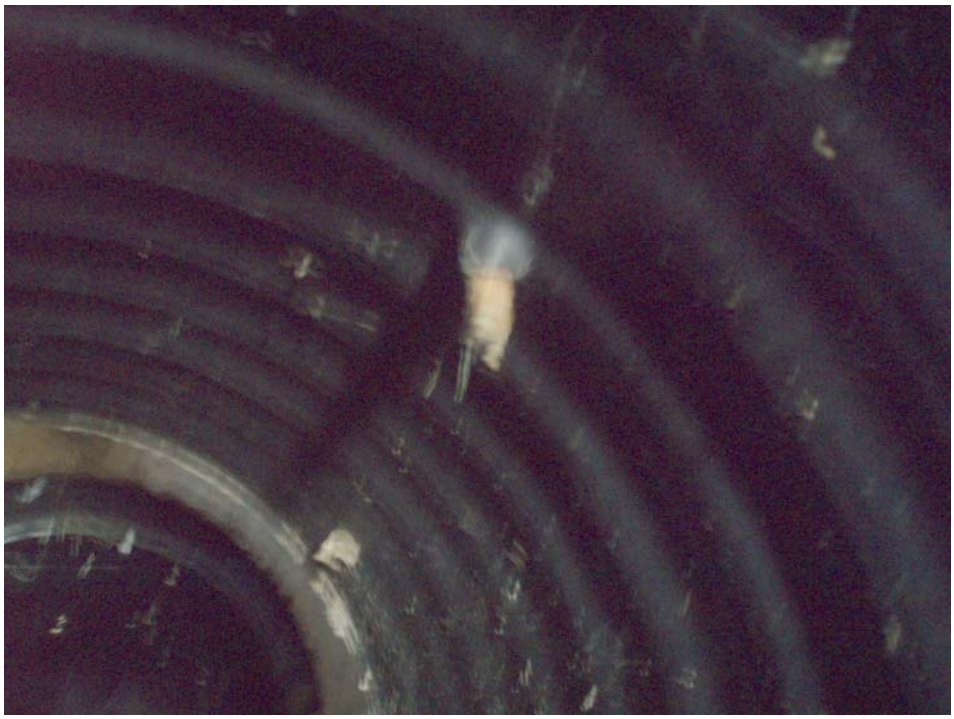
Lessons Learned from August 2007 Inspection

Based on the performance of this project the HDPE pipe that was substituted for reinforced concrete were used for storm sewers outside of the roadway. This is basically a Group B pipe and some locations barely passed specifications during construction. Two years after construction a small percentage will not pass specifications. There are some concerns about the durability of HDPE pipe after just 2 years; in a structure that it is claimed will last 75 years.

If allowing HDPE to be used under major highways or into Group A, the allowable deflection would have to be increased from 5 % to 7.5%, which is allowed by some other states. Otherwise it would be necessary to limit the HDPE pipe to 42" diameter and less. This size of HDPE pipe appear, if backfilled correctly, to meet the current specifications and seem more durable.

Photos of Cross Road HDPE culvert pipe installed on Rte. 63, Howell County

Typical condition 24” diameter HPPE pipe on US 63, Howell County project J9P0497



Rebar through top of 24” HDPE under radius curb and gutter

Photos of HDPE culvert pipe installed on Rte. 63, Howell County, cont'd.

Vertical Deflection about 1" more than stick cut at 5% for 48" pipe, (equals 7.5% +)

Repair to cracks on 48" pipe, 2 of these appeared to have water in them

Appendix D

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, 60” ADS HDPE Pipes and numerous Maintenance Installations, August 2007

Summary of Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, 60" ADS HDPE Pipes and numerous Maintenance Installations, August 2007

The two 60" d. HDPE pipe installations covered in the research report RDT02-007, Installation and initial Performance of 60" ADS N-12HC HDPE Pipes were installed in June 1999 on Rt. B, St. Clair County by District 7 maintenance crews and in August 2000 on Rt. FF, Franklin County by Krupp Construction.

Pipe 1, the St. Clair Rt. B pipe when inspected in August 2007, was now 8 years and 2 months old. It had a vertical deflection of 10.0%, compared to the last measurement at 8.5% when it was 26 months old and 6 years since inspected, and the 7.3%, 42 days after installed.. There was no physical damage noted on the pipe and only one location where there was about a 1" gap at one of the joints, it is assumed this was there when it was installed. The field notes are provided below:

60" HDPE Culvert, Inspected August 1, 2007		
St. Clair Co. Rt. B 3.0 miles west of Rt. 13		
60" DWP (pipe measured 58.27" d. before installed)		
Deflection measurements were taken at previously marked locations from the inlet to the outlet.		
Vertical	Horizontal	
None taken	None taken	At the inlet
55 3/8"	60 ¼"	Middle of first section
54 3/8"	62"	Prior to first joint
52 3/8"	63 ¼"	Past first joint
54 ¼"	63 ¼"	Middle of second section
55 ¼"	61 ¾"	Prior to second joint
54 ½"	61"	Past second joint
57 ¼"	60 5/8"	Middle of third section
58 5/8"	59 ¼"	Outlet
[Maximum deflection 58.27"-52.43"=5.84" or 10.0%]		

Pipe 2, the Rt. FF Franklin County pipe was inspected in August 2007; the pipe is now 7 years old. It appears that it has deflected some vertically but measurements couldn't be taken because of the high amount of sediment in the invert through its entire length. In September 2001 the only time it was measured it had a deflection of 5.0% at the downstream end.

It was believed that the reason Pipe 2 had deflected less than the Pipe 1 was because of the better backfill material used, well graded as opposed to 1" clean stone used with no fines and no compaction done. Until the pipe is cleaned out we will not know the current vertical deflection of Pipe 2. There was some joint separation noted in the report but it doesn't seem to have changed and there is no evidence of leaking, it was pointed out in the report that the bell on the pipe at the joint is 9.58" long.

Maintenance Pipe Installations

These locations are all culvert pipe replacements made with HDPE on cross road pipes on low traffic rural roads.

Four pipes were inspected in Bates County in District 7 on August 1, 2007. Visually the pipes looked good but one 24”d. pipe looked to have some deflection and another had too much vertical curvature to tell. There was some end damage on the pipes, but it should be noted that sometimes these are just stubbed out at the ditch line leaving a lot of pipe to be hit by mowers. Two 42” pipe were inspected and both were in good condition although one had a 2’ long horizontal split on the top on the outside on the exposed end on the roadway inslope.

Several pipes were inspected in Adair County in District 2 on August 3, 2007. All of these pipe were badly out of alignment and had deflections greater than 5% in several locations in the same pipe sometimes. The ends were sometimes squared off and some times cut at an angle to match the inslope but both types had some mower damage. I spoke with the Maintenance Superintendent Brad Gates and he was disappointed in the performance of the HDPE pipe and also told me of a fire that destroyed a small one, 15” d. on Rt. U in Linn Co., when a controlled burn done on some adjacent government land got off into the ditch The fire pretty well consumed the pipe only a few square foot piece was found when maintenance forces dug it up to be replaced. I told him the manufacturer claim that very seldom is there a hot enough fire to start the plastic burning and that a pipe larger than this one will not draft itself and be consumed like this one was. His reply was that what concerns him is a collapse of the roadway if one of these pipes burns or collapses for some other reason causing a van full of children to hit the hole left and crash or run off the road. This is a remote possibility but perhaps a valid concern.

Conclusions and Recommendations

From looking at many HDPE installations done by contractors and several not so good by maintenance forces there appears to be a marked difference in quality of installation. This pipe is not as forgiving as concrete and steel pipes on less than good installation. The type of backfill material and the compaction must be done carefully, following all specifications closely, to get a quality installation of HDPE culvert pipe.

Installation and Initial Performance of 60” HDPE Pipes

Dist. 7, St. Clair Co. Rt. B. 60’ HDPE installed by Maintenance in 2000 Research Project

8-1-07, Rt. B 3.0 miles west of Rt. 13, 60” DWP (pipe measured 58.27” d. before installed)

Maintenance use of HDPE Pipe for Culvert Replacement

Bates County, Rt. O , HDPE Pipe installed by Maintenance

8-1-07, Rt. O 5.4 miles south of Rt. 52, 24” DWP, Couldn’t get a good look inside the pipe, too much curvature.

Good maintenance installation

Maintenance use of HDPE Pipe for Culvert Replacement cont'd.

30" d. pipe , Rt. W, Schuyler Co.deflected and cracked top and bottom, out of alignment

Cut off end to avoid mower damage

Appendix E

Photographs of All Inspections on Corrugated High-Density Polyethylene (HDPE) Culvert Pipe, August 2007