

Inspection Manual For Pipe



2026

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1 Pipe Structures

Pipe Types

Pipe End Treatments

Pipe End Section

Pipe Anchors

Grated Box End Section

Concrete Headwalls

Structure Data Table

Material Summary Table

Cross-Section View

Computing Structure Length Using Elbows

Structure Field Layout

Staking Structures

Normal Layout

Laser Layout

Checking Grade

Laser Grade Control

GPS

CHAPTER ONE:

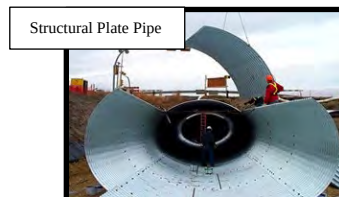
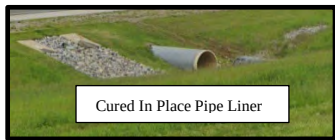
Pipe Structures

For additional reference information, see the GIFE Manual section 4, the Standard Specifications Section 715, 907 & 908 and Certified Tech Manuals CP I, Chapters 8 - 14, & CP II, Chapter 10.

Proper placement and backfilling of pipe structures is critical for maintaining the base support for the pavement placed over the pipe, and for providing correct loading of the pipe for structural integrity. In this chapter the installation methods for pipe and sewer work will be discussed.

PIPE TYPES

All pipes placed on INDOT Contracts must be manufactured and constructed as per the contract documents and plans including the applicable edition of INDOT Standard Specifications as indicated in the CIB. Pipe shall have all necessary certifications & tests, along with being from an appropriate manufacturer. Pipe shall be from a manufacturer that is Buy America and Build America certified.



Pipe is specified by types, according to the pipe use, as set out in the miscellaneous Standard Sheets and Standard Specifications 715.02. Type 1 is placed under mainline or public road approaches, Type 2 is used for storm sewers, Type 3 is placed under all drives and field entrances, and Type 4 is used for drainage tile and longitudinal underdrains. Type 5 pipe is used for broken-back pipe runs where coupled or joined pipe is desirable. In addition, Slotted Drain pipe, Slotted Vain Drain pipe, End Bent Drain pipe, Underdrain Outlet pipe, Grated Box End Sections, Pipe End Sections, Roadway Drain Casting Extensions, Drainage pipe through Masonry and Bridge Deck Drain Systems are commonly used Pipes.

E715	MPCA	01	Multiple Pipe Concrete Anchors	Multiple Pipe Concrete Anchors	1/2/98
E715	MPCA	02	Multiple Pipe Concrete Anchors	Multiple Pipe Concrete Anchor	1/2/98
E715	MPES	01	Metal Pipe End Section	Metal Pipe End Section	1/2/98

INDIANA DEPARTMENT OF TRANSPORTATION	
MULTIPLE PIPE CONCRETE ANCHOR	
JANUARY 1998	
STANDARD DRAWING NO.E 715-MPCA-02	
	DETAILS PLACED IN THIS FORMAT 7-27-99 /s/ Anthony L. Uremovich 7-27-99 DESIGN STANDARDS ENGINEER DATE /s/ Firooz Zandi 7-27-99 CHIEF HIGHWAY ENGINEER DATE ORIGINALLY APPROVED 1-02-98

Figure 1-1. Standard Drawing

Under each pipe type, the pipe materials that are required are indicated. These sheets also indicate the pipe material abbreviations which are used throughout construction in the plans and proposals (Figure 1-1). When pipes are listed by type, the Contractor may use any pipe material that meets the requirements of that type. If the item states a pipe material such as Reinforced Concrete Pipe, that is the material that is required to be used. When using the Standard Drawings, check for the effective date of the standards required for the contract. The effective date on a standard drawing is required to be the most recent September 1st prior to the contract letting date. In other words, if a contract is let on May 05, 2024, the effective date would be September 1, 2023. On the plans, this date appears on the same sheet as the general notes. In a proposal, the date is listed in the Standard Drawings.

Besides listing pipe materials, the Standard Drawings list notes for cover limits and other installation information. Standard Drawing **E 715-PIPE- 01** is checked for the pipe type listing table

PIPE END TREATMENTS

There are several different types of pipe end treatments being used. The Technician is required to know which type is required for each structure because some end treatments affect the length of pipe necessary for construction. The standard drawings indicate details for each type of end treatment. The end treatments used are as follows:

Figure 1-2. Metal Pipe End Section



Figure 1-3. Concrete Headwall



Figure 1-4. Precast Concrete Anchor

1. Metal pipe end sections (Figure 1-2)
2. Safety metal sections (Figure 2-5)
3. Concrete pipe anchors (Figure 1-4)
4. Grated box end sections (Figure 1-5)
5. Concrete Headwall (Figure 1-3)
6. Precast Concrete End Section



Figure 1-5. Grated Box End Section

Concrete Pipe Anchors do not affect the length of the pipe, however all other types of pipe do affect the length. The following drawings indicate how different pipe end treatments affect the pipe length.

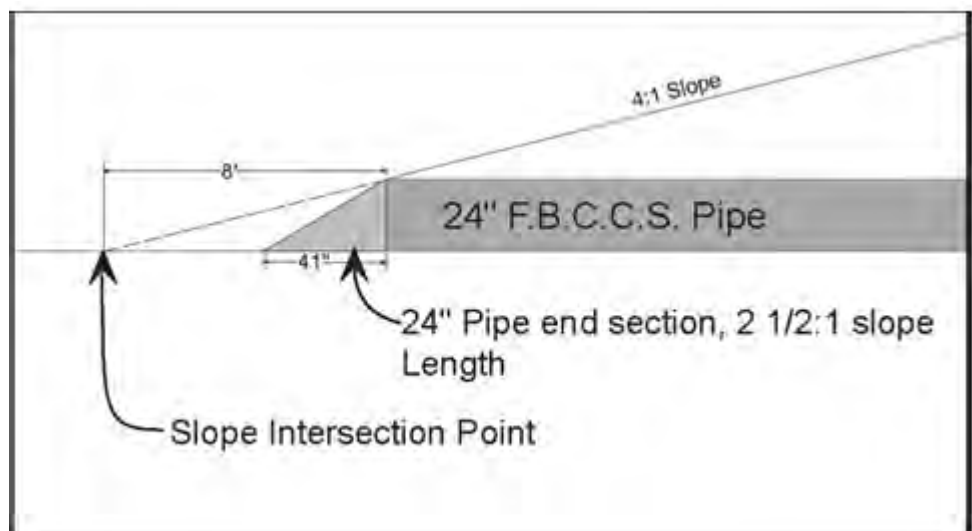


Figure 1-6

PIPE END SECTION

In the above layout, the end section of the pipe is controlled by the intersection with the foreslope.

GRATED BOX END SECTION

If a grated box end section (GBES) was being used on the same type of slopes, there would be 6 ft less pipe on each end of the pipe structure.

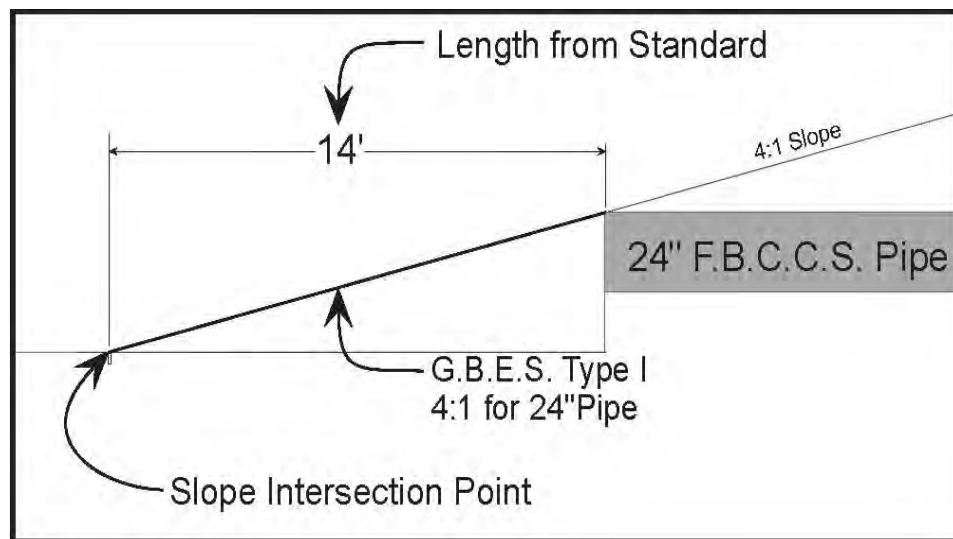


Figure 1-7

STRUCTURE DATA TABLE

The structure data table is a summary table at the end of the plan set that shows many important details for all the pipe structures on the project. Some of the details found in the table are:

1. Station
2. Diameter
3. Pipe Type
4. Structure Type
5. Pipe Length
6. Backfill Method
7. Backfill Quantity
8. Type of End Treatment
9. Cover Distances

Construction details shall be in accordance with the Standard Specifications Section 715.03. The inspector must review all of the pipe and structure locations to verify there are no errors in the table. Any possible problems should be reported to the PEMS.

In new construction, most structure lengths may be paid to the listed lengths in the structure data table after verifying in the field. Take special note of locating for Tees or Elbows.

In addition to the Structure Data Table most plan sets include a Pipe Material (Summary) Table that details the pipe structure number, pipe type, along with shape, class, D.01 Rating, whether the pipe is smoothwall and what the Max Dr rating is. Deviations from this plan page should be approved ahead of time by the Engineer.

The remarks column is used for special notes for a certain structure.

Structure lengths are affected by the following:

- 1) Pavement width
- 2) Slope
- 3) Horizontal skew
- 4) Vertical skew
- 5) Type of end treatment

On the following two pages are examples of how structure lengths may be affected. When calculating the length of required pipe, the final value is required to be rounded up. Assume that metal pipe end sections are being used.

CROSS-SECTION VIEW

Assuming no end sections are in place.

Figure 1-5 indicates an example of a cross-section view of a pipe.

The total pipe length would be 164.7 ft on a horizontal distance. On structures with significant fall, the slope length of the structure is also required to be determined and may be computed like a right triangle.

Flowline up 682.00 – flowline down 673.5 = 8.5 ft fall

$$\sqrt{(8.5)^2 + (164.7)^2} = 164.92 \text{ adjusted length}$$

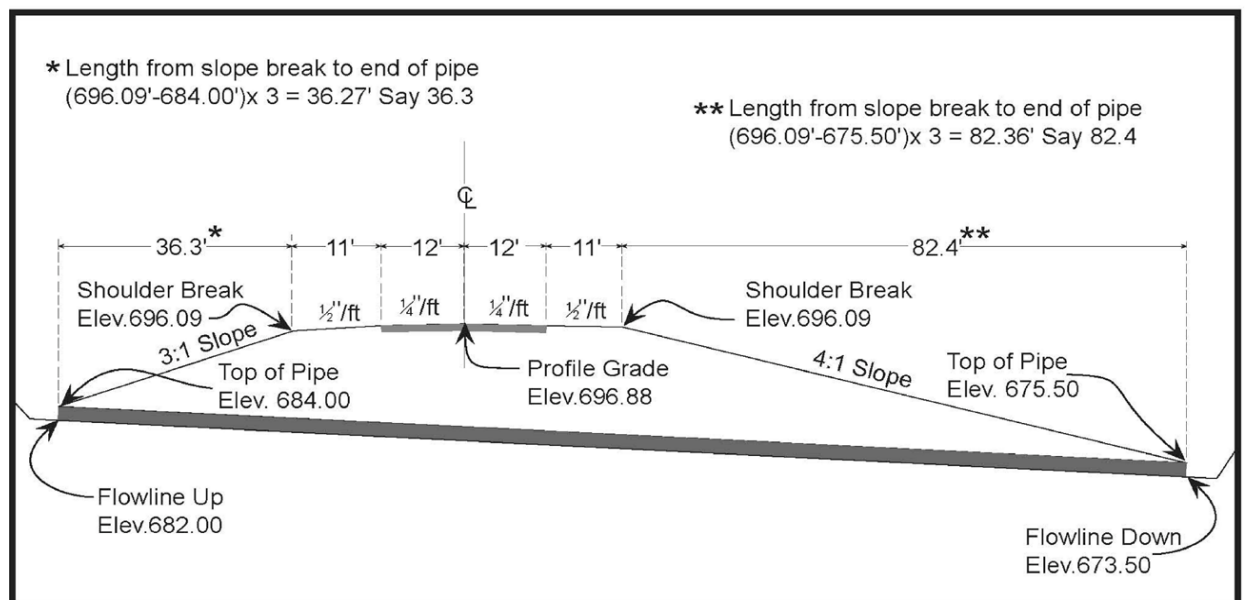


Figure 1-8. Pipe Cross Section View

Sometimes structures are placed on a skew rather than right angles to centerline. This placement adds another adjustment to the structure length computations.

Using the typical section in Figure 1-6, the effect of a skew on the structure is indicated below.

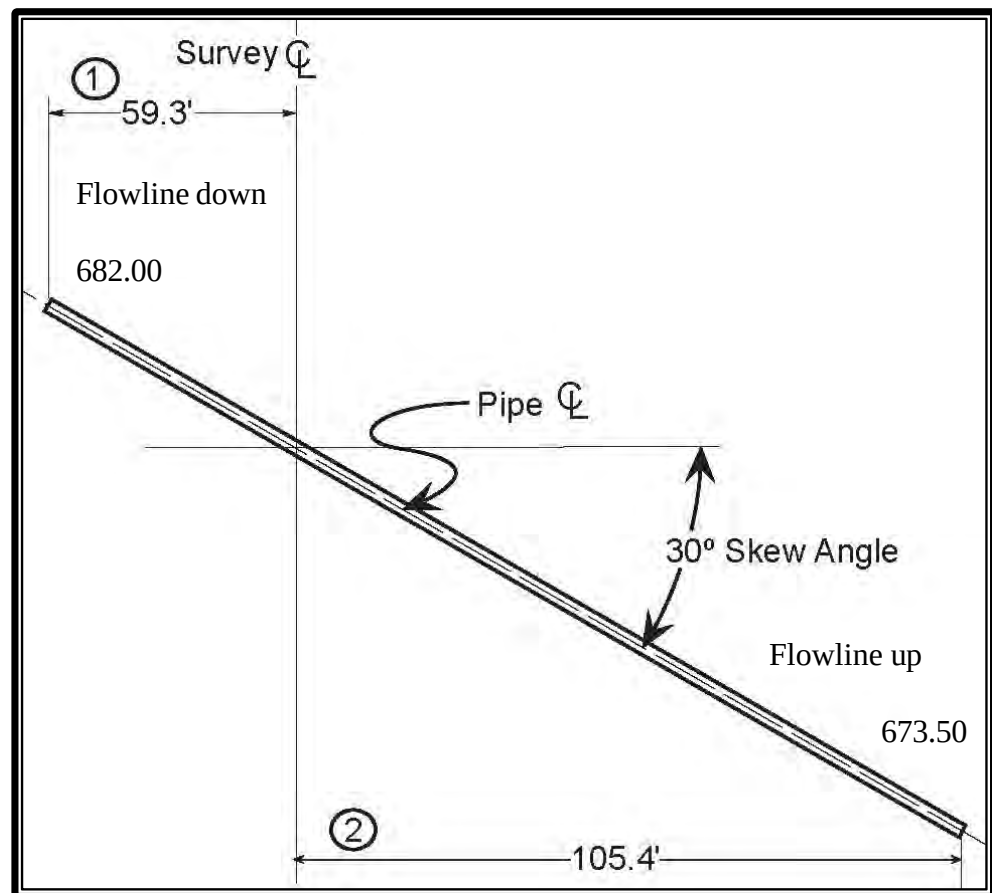


Figure 1-9

The length of pipe may be computed using trigonometric functions. In this example, the length is $C / \text{Cosine of the skew angle}$:

- 1) $59.3 \text{ ft} / \text{Cosine } 30^\circ = 68.47 \text{ ft}$ (Say 68.5 ft)
- 2) $105.4 \text{ ft} / \text{Cosine } 30^\circ = 121.7 \text{ ft}$ (Say 121.7 ft)

$$\text{Skew length} = 190.2 \text{ ft}$$

- 3) Adjustment for flowline fall:

$$\sqrt{\text{Adjustment for flowline fall: } ((8.5)^2 + (190.2)^2)} = 190.39 \text{ ft} - \text{Say } 190.4 \text{ ft}$$

PIPE MEASUREMENT

Pipes are paid for by the linear measurement as specified in Section **715.13** and measured from outside of manhole to outside of manhole. For pipes connecting to inlets and catch basins, the pipes are also measured to the outside face of the structure.

TEES, STUB-TEES, AND WYES

Tee, Stub-Tee, and Wye connections are measured along the centerline of the barrel. For making the connection, an additional 5 ft of the smaller pipe size is paid.

ELBOWS

Elbow connections are measured along the centerline of the elbow. An additional payment of 2 ft is allowed for each elbow connection.

OTHER CONNECTIONS

Other connections, such as size reducers, are measured for length and paid as the larger diameter pipe size specified.

ANCHORS

Pipe anchors are paid as each for the size. The reinforcing steel and/or straps are to be included in other costs.

PIPE END SECTIONS AND SAFETY METAL END SECTIONS

Pipe end sections, metal or precast concrete, and safety metal end sections are paid for each according to the diameter of the pipe the sections connect to. This is because 15" metal end sections are required to fit a 12" concrete pipe.

GRADED BOX END SECTIONS

Grated box end sections are paid for each, by the size, slope, and type specified.

COMPUTING STRUCTURE LENGTH USING ELBOWS

Sometimes structures use elbows or bends to decrease the depth of cut in large fills. The following example (Figure 10-1) displays the proper method for computing pipe lengths when bends or elbows are used.

EXAMPLE

E-7 Inlet inside measure = $2.5 \text{ ft} / 2 = 1.25 \text{ ft}$ on Φ to end of pipe

If elbows = 4 ft measured along Φ :

Section (1) = $36 \text{ ft} + 4 \text{ ft} + 12 \text{ ft} + 12 \text{ ft} + 11 \text{ ft}$
= 75 ft

Section (2) = 54 ft

Section (3) = $18 \text{ ft} + 8 \text{ ft}$
= 26 ft

Add Sections = $75 \text{ ft} + 54 \text{ ft} + 24 \text{ ft}$
= 155 ft

Elbow Length = 2 elbows @ 4 ft each + 2 connections @ 2 ft each
= 12 ft

Total Length = $155 \text{ ft} + 12 \text{ ft}$
= 167 ft

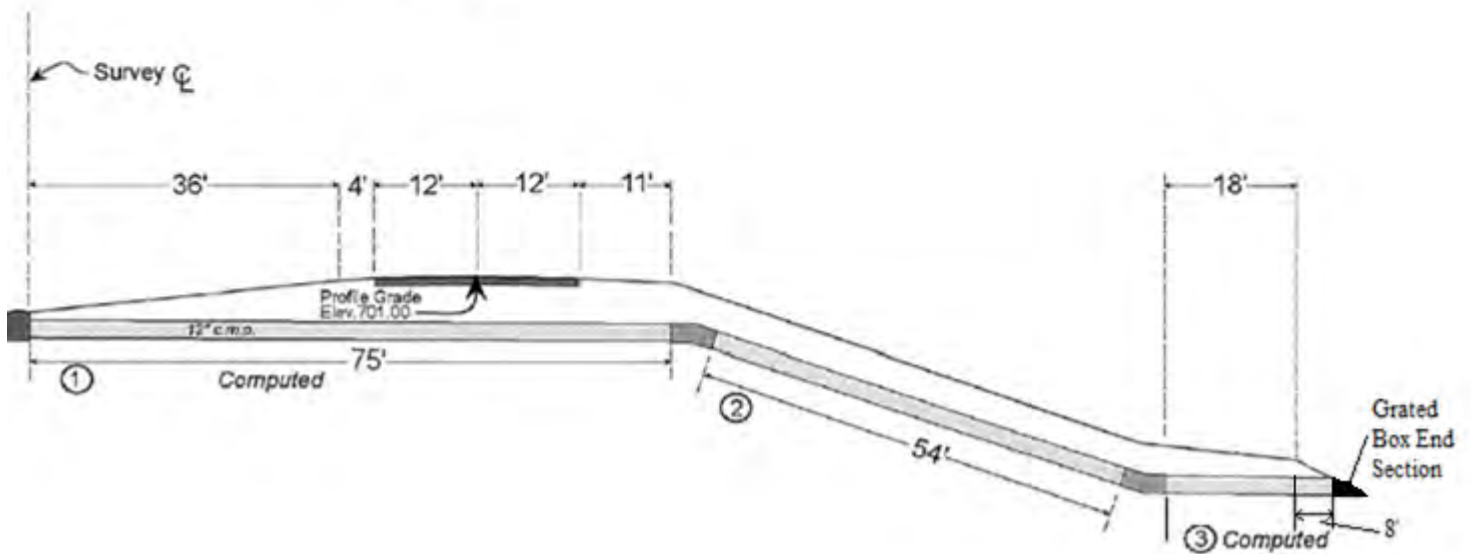


Figure 1-10

STRUCTURAL FIELD LAYOUT

STAKING STRUCTURES

Each structure is required to have a layout drawing showing the structure and the stake locations. The Contractor is required to indicate which method of grade control is planned. Laser grade control on long pipe or sewer runs is currently being used by some Contractors.

NORMAL LAYOUT

On normal staking layouts, the stakes are set on an offset line parallel to the pipe and spaced approximately every 25 ft, at an alignment change, or at a grade break. Stakes are set at a specified distance from the centerline of the pipe structure so that the centerline may be re-established as needed. Also, stakes are set where they are least likely to be disturbed. How the Contractor plans to place the structure is discussed before the layout begins. All Contractors work differently and sometimes one side of the structure may be preferred for placing the stakes.

After staking a structure, the layout is discussed with the Contractor and a copy of the layout provided. All stakes are labeled clearly so the layout may be easily followed. Stakes are marked for line only or line and grade offset. The position of the pipe relative to the survey centerline is clearly indicated.

LASER LAYOUT

When the Contractor uses laser grade control, the Technician is required to know the flowline fall expressed in "percent of fall". This value is computed by the formula:

$$\frac{\text{FL Elev. Upstream} - \text{FL Elev. Downstream}}{\text{Horizontal Length of Pipe}} \times 100\%$$

CHECKING GRADE

The different methods of checking the grade from structure stakes include the following:

- 1) 1. Level rod readings taken from structure stakes to excavation trench
- 2) 2. Total Station or BAD ELF for geospatial data collection
- 3) 3. Laser grade control

SURVEYING EQUIPMENT

The total station has taken the place of several traditional tools such as the theodolite and tape measures. Total stations allow a single surveyor to quickly record measurements that would traditionally take 2 people. They utilize various satellite systems like GPS and GLONASS to achieve base location accuracy within just a few centimeters. Once the surveyor has locked in the location of the station distance measurements are accurate to about 1mm for a 300m shot and angle measurements can be as accurate as 0.5 seconds which is 0.000139° . Measurements can then be uploaded into CAD software to create 3D models or used to verify accuracy of the construction progress.

ROBOTIC TOTAL STATION

The most common type of total station seen on INDOT projects is a robotic total station (Figure1-11). This type is almost always used in conjunction with a rover, and handheld controller. The rover is attached to a rod and has a series of prisms that allow the total station to automatically track it. The surveyor will setup the station on a tripod then takes the prism and controller with them and acquire the required measurements.

SCANNING TOTAL STATION

A scanning total station (Figure1-12) does exactly what its name implies. It can use its laser to automatically scan an area very quickly without the need for a surveyor to take individual shots with a rover. These are useful for measuring ADA ramps. Under the right conditions a scanning total station can measure all the ramps at an intersection in minutes after it is setup.



Figure 1-11 & Figure 1-12

LASER GRADE CONTROL

When using laser grade control, a known elevation point is first established, relative to the structure flowline. The laser is then set up a specified distance above that point and the percentage of fall dialed in. To check the grade anywhere along the flowline, the predetermined distance is measured down from the laser beam.

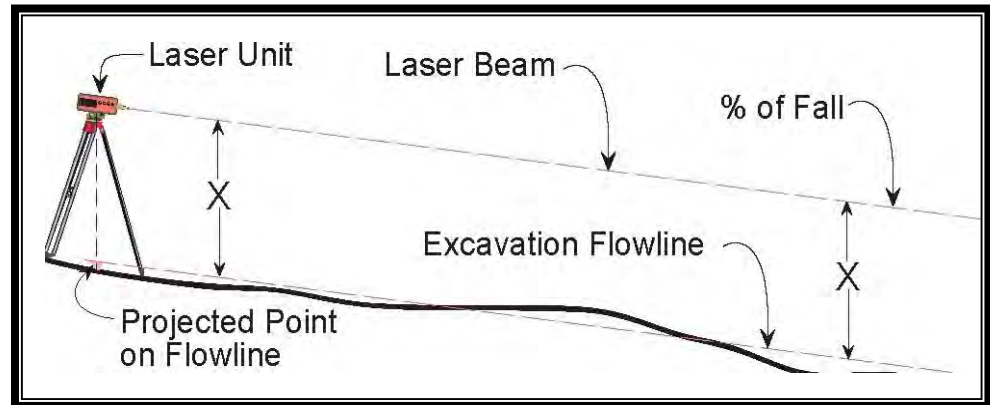


Figure 1-13



INDOT currently has several Bad Elf GPS data collection devices at each District to obtain very accurate elevation & location information. As these devices become more readily available, pipe inspectors should anticipate having to use them for measuring pipe length, obtaining flowline elevations and determining GPS coordinates. Accuracy of these units can be increased by purchasing additional subscriptions. They can be hand held or placed on a tripod as needed.

Figure 1-14

2 Pipe Placement

Excavation

- Rock Excavation*
- Unsuitable Material*
- Excess Excavation Payment*
- Removal of Existing Structures*
- Safety*

Laying Pipe

- Structure Bearing*
- Laying Concrete or Clay Bell Pipe*
- Thermoplastic Pipe*
- Metal Pipe*
- Multi-Plate Pipe*

Joining Pipe

- Joining Pipe with Collars*

Stub-Tee Connections

- Metal Pipe*
- Concrete Pipe*

Pipe End Treatments

- Pipe Anchors*
- Pipe End Sections*
- Grated Box End Sections and Safety Metal End Sections*

CHAPTER TWO:

PIPE PLACEMENT

EXCAVATION

Unless otherwise directed the trench cross sectional dimensions are paid in accordance with the neat lines shown on the plans. The trench bottom gives full support to the pipe. Recesses are cut to receive any projecting hubs or bells on concrete pipe.

Figure 2-1 indicates some basic trench requirements. These are also indicated on Standard Drawings **E 715-BKFL – 01** through **E 715 BKFL - 10**.

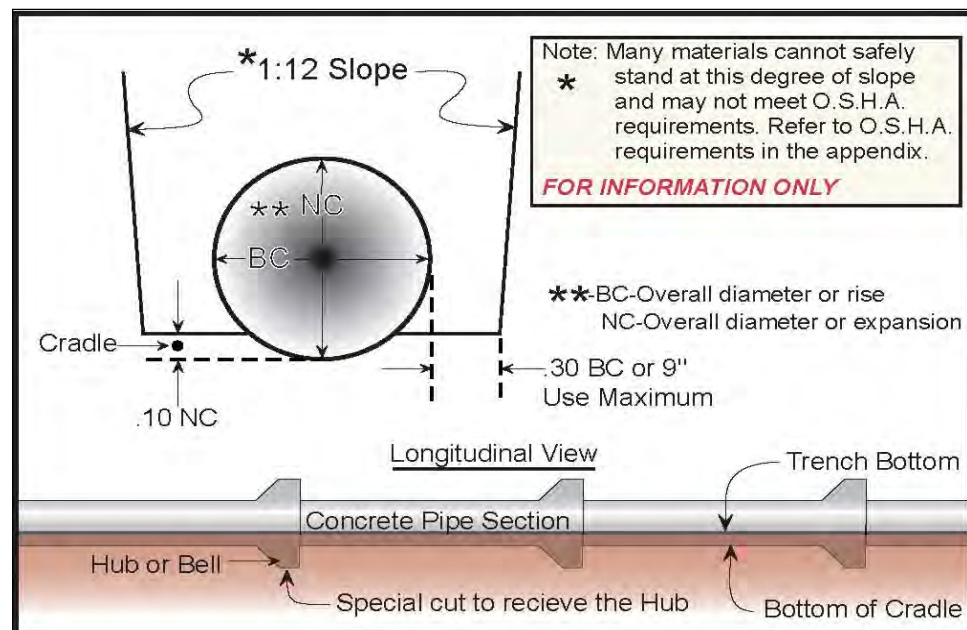


Figure 2-1. Pipe Excavation

Pipes in fill areas are excavated only after the fill elevation is to a height equal to the top of the pipe plus the minimum cover on the pipe.

Once the pipe trench is excavated, dimensions of the pipe should be in accordance with the following:

- Nc & Bc measurements can be found on the pipe manufacturer's website.
- Nc & Bc should be measured to the outside of the pipe.
- Consider whether the pipe has corrugations or a thick wall that might not be included in the item description. A 12 inch pipe might actually have a 12.75" outside diameter when determining the needed backfill amount.

- Designers utilize backfill software on INDOT's website located at: <https://www.in.gov/dot/div/contracts/standards/> with the title “Pipe-Backfill Calculation Software” determining the Planned backfill amount for culvert cross pipes. Trench pipes for storm drains require the calculations per neat lines as shown in the standard drawing E 715-BKFL-03.
- Pipe Inspectors should consider the Standard Drawings and what Backfill Method is required, while also using INDOT's calculator on the website to determine actual placed backfill amount.

The recommended cover, where heavy construction equipment crosses the pipe structure, is as follows:

- 1) Up to and including 18 in. diameter (Bc) or equal – 1 ft 6 in. cover
- 2) Greater than 18 in. diameter (Bc) up to and including 54 in. diameter (Bc) – 3 ft cover
- 3) Over 54 in. diameter (Bc) or equal – 4 ft cover

In addition to these cover requirements, INDOT Standard Drawing 715-PHCL should be reviewed for appropriate height of cover depths with regard to specific pipe types.

When the fill height is sufficient to provide the cover listed, the structure may be placed.

ROCK EXCAVATION

When rock is encountered during trench excavation at the flowline elevation, the trench bottom is required to be excavated at least 8 in. min. for fill height less than 16', 12" min. for fill height of 16' or more below the required elevation. The excavated area is then backfilled with B borrow to the proper grade and compacted to Specification requirements

UNSUITABLE MATERIAL

Any time soft or unstable material is found at the required flowline elevation, such material is required to be removed and replaced (Figure 2-2). B borrow may be used as the replacement material.



Figure 2-2. Removing Unsuitable Material

EXCESS STRUCTURE EXCAVATION PAYMENT

Cut volumes and B borrow for replacing soft areas are required to be recorded. If the quantity of excavation exceeds 10 yd³, the quantity is paid as shown in 206.11(a).

REMOVAL OF EXISTING STRUCTURES

Normally, removal of an existing structure is not included in the cost of a new structure item. This procedure consists of removing the existing pipe, head walls, box culvert and footings to outside the limits of excavation for the new structure and has pay items established for each removal.

SAFETY

A special concern for safety is required for deep pipe trenches. The Contractor is required to have the necessary safety equipment available such as safety boxes in deep pipe or sewer cuts and/or sheeting or shoring as directed by safety requirements.



Figure 2-3. Trench Box Safety

LAYING PIPE

STRUCTURE COMPACTION

Each section of pipe is required to be placed on a properly compacted foundation, providing a solid base for the entire length of pipe and be placed true to the line and grade. Any pipe that does not meet these requirements is required to be re-laid at no additional cost. No pipe is allowed to be placed on a frozen trench bottom.

LAYING CONCRETE OR CLAY BELL PIPE

When laying concrete or clay pipe, the hub or bell end is required to be placed up-grade with the spigot end fully inserted into the next hub and with all ends fitted together tightly.

Pipe joints designed to accommodate seals or pipe joints requiring seals are sealed with approved rubber type gaskets, caulking, asphalt mastic pipe joint sealer, electrometric material, or sealing compound.

If infiltration of water is a factor, each joint, regardless of the type used, is required to be sealed with an approved compression type joint sealer in accordance with the Specifications.

THERMOPLASTIC PIPE

If Thermoplastic Pipe is used, all joints are required to be installed according to the recommendations of the manufacturer.

METAL PIPE



Figure 2-4. Corrugated Metal Pipe

Prior to placing corrugated metal pipe, the sections are required to be checked for proper fit. If sections do not fit together properly, they may be rejected since they could easily leak. This may be a problem on spiral pipe because some manufacturers cut sections to lengths and the end cuts are not square cut. Pipe sections are joined with approved coupling bands.

When placing riveted corrugated metal pipe, the section laps are required to be placed downstream.

MULTI-PLATE PIPE

When placing and assembling Structural Plate Steel or Multi-Plate Structures, the Contractor is required to follow the lap of the plate sections as indicated on the shop drawings. The shop drawings are furnished by the manufacturer for proper fit and loading of the pipe structure. Special nuts and bolts may be used for assembly. These nuts and bolts may have crowned faces so they fit down into the corrugations. The proper bolts are always used.

JOINING PIPE

JOINING PIPE WITH COLLARS

When a satisfactory joint cannot be made, different types of pipe are connected, or an existing structure is extended, a concrete collar is required to be placed.

At the connection of two different types of pipe, the collars are required to be at least 18 in. wide and 6 in. thick.

If rigid pipe connections are of lesser strength than that of the main barrel of a pipe structure, these connections shall be encased in concrete at least 6 in. thick.

STUB-TEE CONNECTIONS

At locations indicated on the plans or where directed, a stub-tee connection of the size required is furnished and connected to the pipe type specified.

METAL PIPE

The stub-tee for corrugated metal pipe structures is required to be long enough to band to connecting pipes. The band may be a band-type tee or saddle type tee. The stub-tee is bolted or banded to the larger pipe.

CONCRETE PIPE

On concrete pipe, the tee connection may be factory made or field fitted. The stub for the tee is required to be at least 6 in. long and no more than 12 in. in length and be secured in place by a mortar bead or a concrete collar.

PIPE END TREATMENTS

The pipe end treatments that may be used include:

- 1) Pipe anchors
- 2) Pipe End Sections
- 3) Safety Metal End Section
- 4) Grated box end section
- 5) Concrete Headwalls



Figure 2-5. Safety Metal End Section

PIPE ANCHORS

Standard Drawings **E 715-MPCA – 01 & 02**, **E 715-PAHB – 01**, and **E 715-PASD - 01** indicate different sizes and measurements for pipe anchors. Pipe anchors are mainly used on larger pipe sizes. They are placed to prevent the water flow from undermining the ends of the pipe which could cause settlement or wash outs.

Cast in Place pipe anchors are poured in place using class A concrete and are held to the pipe by either anchor bolts or straps.

Precast anchors can only be used with reinforced concrete pipe and shall be in accordance with **E 715-MPCA -01 & 02**.

PIPE END SECTIONS

Standard Drawings **E 715-MPES – 01, 02, & 03** and **E 715-PCES -01** indicate different pipe end sections that are available in either metal or precast concrete. Metal pipe end sections connect to the pipe by a strap band or a ring type bolt that draws the end section tight to the pipe. These units have a toewall that is placed in a cut trench and backfilled. This toewall serves the same purpose as an anchor which is to keep water from undermining the pipe.

Precast concrete end sections are designed for use on concrete pipe. The inside of the end section is grooved to accept the spigot end of a concrete pipe. After the precast pipe end section is set in place, an anchor is poured using class A concrete. The anchor has hook bolts extending through the end section floor and is secured by nuts and washers.

GRATED BOX END SECTIONS AND SAFETY METAL END SECTIONS

Grated box end sections and safety metal end sections are used to provide a safety slope over the structure opening. Safety metal end sections are detailed on Standard Drawings **E 715-SMES – 01** through **E 715 SMES – 12**, and grated box end sections on Standard Drawings **E 715-GBTO – 01** through **E 715-GBTO – 08** and **E 715-GBTT – 01** through **E 715-GBTT-06**. There are two basic types of grated box end sections: Type I and Type II.

GBES Type I

Type I grated end sections (Figure 2-6) are used on crosspipes under the roadway or other structures perpendicular to the direction of traffic. These units are constructed to the same slope as the embankment they fit into and have a tubular type grating which supports vehicles traveling across them.

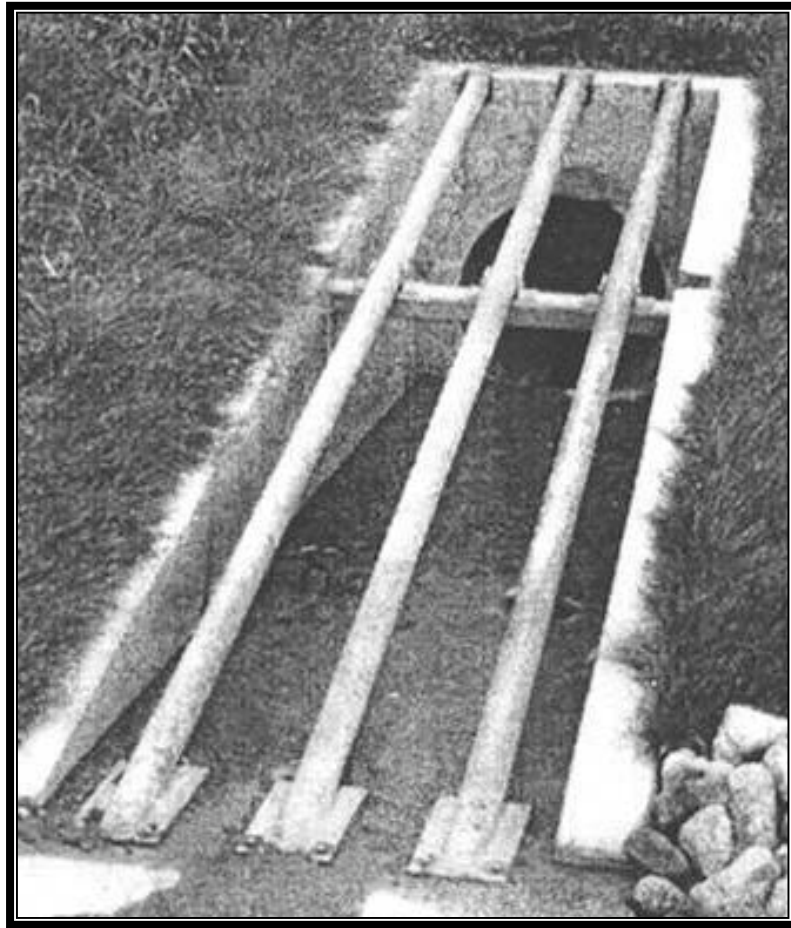


Figure 2-6. GBES Type I

GBES Type II

Type II grated box end sections (Figure 2-7) are used where the end of a structure would be facing incoming traffic. They are built to flatter slopes and have a crossbar grating for vehicle support.

Both Type I and Type II units may be either precast or constructed in place. In either case, the units are set on a bed of No. 8 aggregate and the structure is partially backfilled with No. 8 aggregate. This procedure allows ground water to filter in through weep pipes in the sides of the units. Precast units have a toewall that is poured with class A concrete after the unit is set. Constructed in place units are poured with class A concrete and reinforcing steel as designated in the Standard Sheets.



Figure 2-7. GBES Type II

Concrete Headwalls

Headwalls may be precast or cast-in-place. Working drawings that include design calculations shall be submitted in accordance with 105.02. Reinforcement in headwalls shall be epoxy coated and have a minimum of 2 inches of concrete cover. Plans should indicate weep holes, loading conditions, connections to guardrail or wingwalls, reinforcement locations and dimensions.



Figure 2-8. Concrete Headwall

3 Measurement of Pipe Items

Pipe Measurement

Tees, Stub-Tees, and Wyes

Elbows

Other Connections

Anchors

Pipe End Sections and Safety Metal Sections

Grated Box End Sections

CHAPTER THREE:

MEASUREMENT OF PIPE ITEMS

PIPE MEASUREMENT

Pipes are paid for by the linear measurement of the type, shape and size complete in place as specified in Section 715.13. For pipes connecting to inlets, manholes and catchbasins, the pipe is measured from outside of structure to outside of structure.

TEES, STUB-TEES, AND WYES

Tee, Stub-Tee, and Wye connections are measured along the centerline of the barrel. For making the connection, an additional 5 ft of the smaller pipe size is paid.

ELBOWS

Elbow connections are measured along the centerline of the elbow. An additional payment of 2 ft is allowed for each elbow connection.

OTHER CONNECTIONS

Other connections, such as size reducers, are measured for length and paid as the larger diameter pipe size specified.

ANCHORS

Pipe anchors are paid as each for the size and can be cast in place or precast. The reinforcing steel and/or straps are to be included in other costs.

PIPE END SECTIONS and SAFETY METAL SECTIONS

Pipe end sections, metal or precast concrete, and safety metal end sections are paid for each according to the diameter of the pipe the sections connect to. This is because 15 in. metal end sections are required to fit a 12 in. concrete pipe.

GRATED BOX END SECTIONS

Grated box end sections are paid for each, by the size, slope, and type specified.

MISCELLANEOUS PIPE

Roadway Drain Casting Extension Pipes are paid for at the contract unit price per each drain extension. Bridge Deck Drainage System shall be Cast Iron Soil pipe in accordance with 908.10 or reinforced thermosetting resin pipe in accordance with 907.28.

4 Manholes, Inlets, and Catch Basins

Structure

Methods of Construction

Material Requirements

Concrete

Brick or Block

Structures in Pavement Area

Hoods for Catch Basins

Mortar Mixture

Precast Structure Openings

Structure Joints

Adjustments

Grade Adjustment to Existing Structures

Adjusting Existing Structures

Replacing Castings

Reconstructed Structures

Castings in Pavement Area

Adjustment on Resurface Contracts

Payment of Manhole, Inlets, and Catch Basins

Basis of Use

Miscellaneous Requirements

CHAPTER FOUR:

MANHOLES, INLETS, AND CATCH BASINS



There are numerous types of manholes, inlets and catch basins. Standard Drawings **E 720-CBST-01 thru 09**, **E 720-CBCA-01**, **E 720-ICCA-01**, **E 720-INST-01**, **E 720-INCA-01 thru 10**, **E 720-MHCA-01 thru 03**, **E 720-EDCA-01** and **E 720-MHST-01 thru 10** contain diagrams for each type of structure. Construction details shall be in accordance with Section 720. Precast reinforced concrete structure sections shall be from a source listed on the QPL of Certified Precast Concrete Producers. Materials shall be as per 907.04. Castings are required to be in accordance with Section 910.05.

STRUCTURE

The letter prefix listed in the Standard Drawings represents the structure type and the number suffix is for the casting type. Thus, an E-7 inlet would be type E box using a type 7 casting.

METHODS OF CONSTRUCTION

Several types of construction methods are designated for manholes, inlets, or catch basins. Some units may be constructed from brick, block, concrete class A, or precast, when allowed. The materials that are used for each type of structure are noted on the applicable Standard Drawing.

When constructing manholes, inlets, or catch basins in the field, the excavation for the floor slab is required to be on firm, stable soil. If rock is encountered, the rock is required to be removed 6 in. below the bottom elevation and backfilled with approved material.

When precast units are used, bases are required to be set on a minimum of 4 in. of compacted B borrow.

MATERIAL REQUIREMENTS

CONCRETE

Concrete construction is required to be in accordance with Section **702** and reinforcing steel in accordance of Section **910.01**.

BRICK OR BLOCK

Brick or other masonry units are required to be laid with joints not exceeding 3/8 in. If brick is used, at least every 7th course is required to be laid as a header course (Figure 4-2).

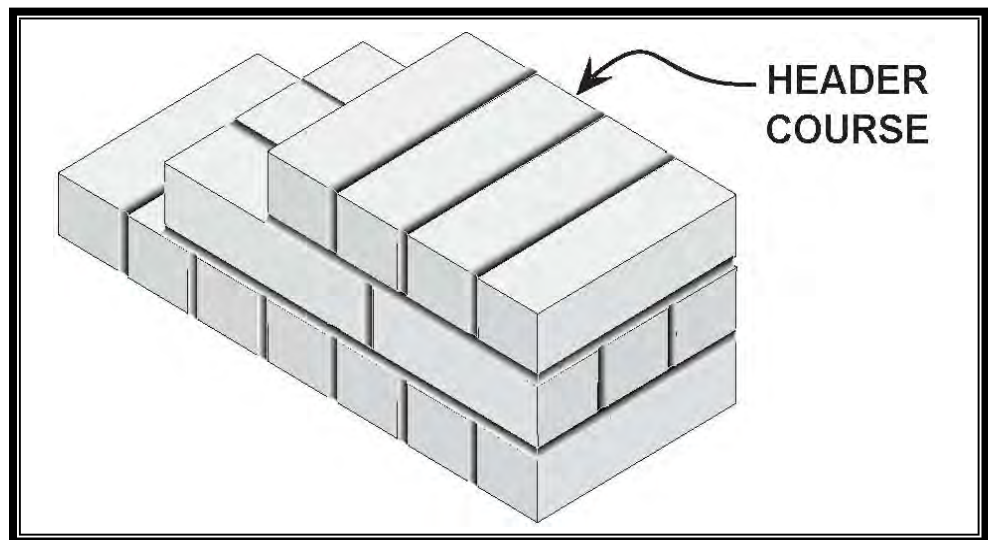


Figure 4-2. Brick Manhole, Inlet, or Catch Basin

In the header course, the bricks are turned so that the mortar joint does not run continuously from the top to the bottom of the structure.

Brick or block structures are required to have a 1/2 in. mortar plaster coat on the inside and outside of the structure, as designated.

STRUCTURES IN PAVEMENT AREA

When manhole castings are surrounded by concrete pavement, the casting is required to be the same thickness as the concrete pavement. Where castings are adjacent to or surrounded by concrete pavement, they are separated from the concrete pavement by using a 3/8 in. minimum thickness preformed joint filler.

HOODS FOR CATCH BASINS

Cast iron hoods for catch basins are to be installed in the walls of the structure as shown on the plans or in the Standards. These are to be placed so that a 6 in. seal is formed. Joints between castings and the structure are required to be made gas tight by use of cement mortar.

MORTAR MIXTURE

Mortar for laying brick or block is required to be 1 part masonry cement and 2 parts mortar sand. The mortar for plastering a brick or block structure may be the same or may be made using 1 part Portland cement, 1 part hydrated lime and 2 parts mortar sand. The lime should not exceed 10 % of the cement.

PRECAST STRUCTURE OPENINGS

When using precast structure components, the opening for the pipe may be either preformed or field cut. The gap between the structure and the pipe is required to be filled with Class A concrete. If openings are cast or cut in the wrong locations, they are required to be filled satisfactorily and the new holes placed in the required locations. The cost to cut or form holes and seal the pipe with a concrete collar is included in the structure cost.

STRUCTURE JOINTS

Horizontal joints may be used in the construction of precast structures. The Contractor or Manufacturer is required to submit drawings showing the location of the joints, type of joints, and types of sealers to be used for approval prior to the construction of these units. No joint may be closer than 3 in. above standing water for those catchbasins requiring hoods.

ADJUSTMENTS

There is no cost adjustment for precast structures that are required to be located in a different location or that require height adjustment to meet the necessary grade. These costs are included in the structure costs.

GRADE ADJUSTMENT TO EXISTING STRUCTURES

ADJUSTING EXISTING STRUCTURES

When grade adjustments for existing structures is required, the casting frame, covers, or gratings are required to be removed and the walls of the structure reconstructed as required to meet the necessary elevation. If an existing casting is unfit for re-use, the casting is replaced with the type specified. If an existing casting is in good condition and is of the type required, the elevation may be adjusted by the use of risers or adjusting rings.

REPLACING CASTINGS

Castings are replaced with the type specified and adjusted to the required grade. This grade adjustment includes up to 12 in. of masonry reconstruction in average height, cleaning of the existing structure, and keeping the structure clean until the final acceptance of the work.

RECONSTRUCTED STRUCTURES

If masonry reconstruction exceeds 12 in., that portion above 12 in. is required to be paid as a reconstructed structure of the type of inlet, manhole, or catch basin specified.

CASTINGS IN PAVEMENT AREA

When castings adjusted to grade are in concrete pavement or adjacent to concrete pavement, they are separated from the concrete by at least 3/8 in. preformed joint filler. The cost of the joint filler is to be included in the cost of other items.

ADJUSTMENT ON RESURFACE CONTRACTS

On resurface contracts, unless otherwise allowed, castings are required to be adjusted prior to placing the surface course.

MANHOLES, INLETS, AND CATCH BASINS

Basis of Payment

Payment is made for the placed quantity of manholes, inlets, or catch basins by the specified type each. Castings are paid as each, for the type specified. Castings furnished and adjusted to grade (not exceeding 12 in. or masonry work) are paid as each for the type specified. The portion of masonry work necessary above a 12 in. average height is paid for by the linear foot and the type of structure specified.

MISCELLANEOUS REQUIREMENTS

The cost of excavation, backfill, reinforcing bars, structure backfill, concrete collar required for pipe connection to structures, removal, disposal and replacement of pavement, or surface material, casting removal, installation of concrete cap, HMA wedge, damage repair to pavement and shoulders, and necessary incidentals shall be included in the cost of the pay items.

As per GIFE 4.20 RECORD OF STRUCTURES report structure modifications and new construction to either the District Bridge Engineer or Culvert Asset Engineer.



Figure 4-3 Manhole with Concrete Collar Connections

Joining Pipe

Pipe shall be joined by specified methods per 715.06. Pipe connecting to a manhole, inlet or catchbasin will be connected by means of a concrete collar so as to allow for a gas tight joint to prevent any leaking. Plastic pipe should be connected to structures as recommended by the manufacturer but shall be a soil tight connection. Leaking that occurs at a structure can quickly lead to multiple issues on mainline pavement including subgrade failure and pavement sinkholes, along with pipe and structure damage.

5 Structure Backfill and Inspection

Backfill Limits

Basis of Use

Backfill Methods

Trench Details

Rock

Bedding Details

Backfill Placement

Method 1 Backfill

Method 2 Backfill

Other Backfill

Backfilling Outside Specified Limits

Cover Limits

Ramps over Structure for Protection

Post-Installation Inspection

Limitations

Payment for Backfill

Structure Backfill

Flowable Backfill

Example Problem

CHAPTER FIVE:

STRUCTURE BACKFILL AND INSPECTION

BACKFILL LIMITS

The trench for the pipe is required to be backfilled as indicated on the plans or Standard Sheets with structural backfill or coarse aggregate (Section **211.02**) or flowable backfill (Section **213.02**). When flowable backfill is used, the Contractor is required to submit a mix design and arrange for a trial batch demonstration.

BASIS OF USE

The basis of use for structure backfill or coarse aggregate is a Certified Aggregate Producer Program (CAPP) D Number. The Contractor has the option of using a local site and having a CAPP Certified Aggregate Technician or a consultant on the Department's list of approved Geotechnical Consultants for gradation control. The Frequency Manual is reviewed to verify the testing requirements. The basis of use for flowable mortar is the flow test in accordance with **ASTM D 6103**, the lightweight dynamic cone penetrometer test in accordance with **ITM 216**, and the dry unit weight test in accordance with **ITM 218**.

To conduct the flow test, a 3 in. diameter by a 6 in. cylinder is placed on a smooth level surface and filled to the top with the flowable mortar. The cylinder is quickly pulled straight up and the mortar spread measured. The diameter of the mortar spread is required to be at least 8 in. The lightweight dynamic cone penetrometer (DCP) test requires determination of the blow count penetration resistance of flowable backfill, after a three day cure, to assess the strength of the material. Removal flowable backfill shall have a penetration resistance blow count of not less than 12 nor greater than 30.

The dry unit weight test is used to calculate the removability modulus (RM) of the flowable backfill. If the RM is calculated at 1.0 or less, the flowable backfill is classified as removable.

BACKFILL METHODS

There are different methods of backfill required, depending on where the pipe structure is located and what the purpose of the structure is. These are indicated on Standard Drawings **E 715-BKFL -01** through **E 715- BKFL -10**.

TRENCH DETAILS

The basic trench details are indicated on Standard Drawings **E 715-BKFL-01** through **E 715-BKFL-10**.

ROCK

If rock is encountered during excavation for the pipe, the rock is required to be removed 8 in. below the bottom of the pipe. B borrow is used as backfill to bring the pipe to the proper flowline.

BEDDING DETAILS

All of the details use structure backfill or flowable mortar bedding for pipe (where pipe is bedded in a soil cradle cut). On Standard Drawings **E 715-BKFL-01 thru 10** the proper limits and dimensions for backfilling with structure or flowable backfill are indicated.

BACKFILL PLACEMENT



Figure 5-1. Flowable Backfill for Box Structure

Per 715.09, if a pipe is to be backfilled using one of the flowable backfill options, design calculations shall be submitted in accordance with 105.02, either proving the pipe will not float or detailing the methods that will be taken to prevent the pipe from floating during installation of the flowable backfill. Structure backfill material is required to be placed in no greater than 12 in. loose lifts and compacted with mechanical compactors to the required density. When compacting structure backfill, the material is

required to be within the allowable range of moisture content to obtain the required density. Types 1 through 5 structural backfill are covered in Section **211.03** and compaction requirements are covered in 211.04.

Flowable backfill is required to be uniformly placed up to the fill line as indicated on the plans or Standards. Before flowable backfill is placed in a trench, all standing water is required to be removed. If removal of water is not possible, structure backfill is used up to an elevation of 2 ft above the ground water.

METHOD 1 BACKFILL

When a pipe or other structure is placed under the mainline pavement or under public road approaches or is within 5 ft or less of the pavement, sidewalk, curbs or gutters, Method 1 Backfill is used. Method 1 requires that flowable backfill or structure backfill be used as backfill for the width of the pavement plus 5 ft on each side of the pavement. Method 1 is also used for a distance required to maintain a 2:1 slope from the above width down to the bottom of the pipe structure. Method 1 Backfill for fill sections is indicated on Standard Drawings **E 715-BKFL-01** and **E 715-BKFL-02**. Existing trench cut sections is indicated in Standard Drawings **E 715-BKFL-03** and **E 715-BKFL-05**. The proper elevation of backfill material is always maintained as indicated in these Standard Drawings. The remaining area may be backfilled with suitable materials in layers of not more than 6 in. when inside the slope stake area.

METHOD 2 BACKFILL

When a pipe or other structure is placed under commercial or private drive approaches, Method 2 Backfill is used. Method 2 requires that backfill be placed at a height as indicated on the Standard Drawing, in addition to heights shown on the **715-PHCL** series. The length of the backfill material is the same as Method 1 Backfill. Method 2 Backfill for a cut and a fill sections are indicated on Standard Drawings **E 715-BKFL-06** and **E 715-BKFL-07**. The remaining area may be backfilled with suitable materials in layers of not more than 6 in. when inside the slope stake area.

METHOD 3 BACKFILL

When a pipe or other structure is placed under the median in a trench on a highway divided by an unpaved strip that has side slopes and back slopes, Method 3 Backfill is used. Method 3 requires backfill for 2 directions of cross sectional pavement in addition to backfill placed in the median. Standard Drawing 715-BKFL-08 indicates requirements of the trench median installation.

OTHER BACKFILL

Where other than special backfill material is required, the material is required to be easily compacted and free of large stones for the portions around and 6 in. above the pipe (Figure 5-2).



Figure 5-2. Structural Backfill

BACKFILLING OUTSIDE SPECIFIED LIMITS

If the structure is outside the aforementioned areas, the pipe may be backfilled with suitable material.

POST-INSTALLATION INSPECTION

After a period of no less than 30 days following backfilling, the structure will be visually or video inspected (Figure 5-4). If the structure cannot be visually inspected, video inspection shall be performed in accordance with 715.09 using equipment described in 718.07. The Contractor shall provide project personnel with the inspection video prior to acceptance of the pipe. If mandrel testing is required, the video shall be provided prior to mandrel testing. Mandrel testing is also covered by 715.09 and is described elsewhere in this document for materials that require mandrel testing.

PIPES REQUIRING MANDREL TESTING	
Pipe Material	Standard Specifications
Corrugated Polyethylene Pipe*	907.17(b)
Corrugated Polypropylene Pipe	907.19
Profile Wall Polyethylene Pipe	907.20
Smooth Wall Polyethylene Pipe	907.21
Profile Wall PVC Pipe	907.22
Smooth Wall PVC Pipe	907.23
* When used as underdrain pipe, mandrel testing will not be required.	

Figure 5-3



Figure 5-4. Van with Video Inspection Equipment

COVER LIMITS

The proper cover is required to always be maintained for heavy equipment to cross pipe structures during construction. The cover requirements are:

- Up to and including 18 in. diameter (Bc) or equal – 1ft 6 in. cover
- Greater than 18 in. diameter (Bc) up to and including 54 in. diameter (Bc) – 3 ft cover
- Over 54 in. diameter (Bc) or equal – 4 ft cover

In addition to these cover requirements, INDOT Standard Drawing series 715-PHCL should be reviewed for appropriate height of cover depths with regard to specific pipe types.

RAMPS OVER STRUCTURE FOR PROTECTION

If the minimum amount of cover is not available, the Contractor is required to ramp over with soil to provide the cover needed to prevent structure damage.

Flowable Backfill

Per 213.07, flowable backfill is not to be placed on frozen ground and is required to be protected from freezing for 72 hours. Flowable backfill may not be loaded or disturbed by construction until a lightweight dynamic cone penetration test produced a minimum blow count after curing for 3 days per 213.04 (b). The minimum blow count shall be as follows in Accordance with ITM 216 & 213.07.

- Construction Activities with Vibratory Compaction after Backfill.....12
- Construction Activities without Vibratory Compaction after Backfill.....7

PAYMENT FOR BACKFILL

STRUCTURE BACKFILL

When the proposal contains an item for structure backfill, the material is paid for by the cubic yard as computed from the neat line limits shown on the plans. Standard Drawings E 715-BKFL & the method of backfill should be consulted. The backfill calculator available on INDOT's website at www.in.gov/dot/div/contracts/standards may be used to determine the standard planned amounts and the standard neat line amounts for all backfill methods and pipe types. If neat lines are not available, payment will be based on approved truck bed measurements.

FLOWABLE BACKFILL

When the contract contains an item for flowable backfill or Structural Backfill Type 1 (flowable option), 2 (flowable option), 4 or 5, this material is paid for by the cubic yard as computed from the neat line limits shown on the plans. If no neat lines are shown, the cubic yard will be determined based on the batched ticketed amount as delivered to the job.

If one of the four mix designs in 213.03 (a) is used, a trial batch will not be required, otherwise a trial batch shall be produced as per 213.05. Flowable backfill mix shall be in accordance with 213.04. The flowable backfill shall be brought up uniformly to the fill line shown on the plans or as directed and as to prevent both float and unbalanced loading on the Structure.

EXAMPLE PROBLEMS

1. 1. 150 feet of 36" Thermoplastic Type 1 Pipe is placed as a culvert cross pipe.
Plans show that mainline width is 60 feet and shoulders are 12 feet each side.
Plans show that the height of cover over the structure is 30 inches.
Plans show the total Structure Backfill for this structure to be 100 cubic yards.

Solution: The Pipe Inspector should periodically check the height of cover over the pipe and the width of the trench. See Standard Drawing 715-BKFL-01. Average height measurements indicate 30".

Open the backfill Calculator at: www.in.gov/dot/div/contracts/standards

- Select Start Here --> Fill out Project Information --> Click INPUT --> Enter STRUCTURE DATA (USER INPUT DATA) --> Enter BACKFILL/TRENCH DATA (USER INPUT DATA)
- Outside Diameter of Pipe & Wall /Corrugation Thickness should be checked on the Manufacturers website --> 36 in
- Enter Shape – **“Circular”**
- Enter Structure Backfill Type – (Hover cursor over Title Cell for information) **“Type 2”**
- Enter Interior Span & Rise – **“36 inches”**
- Enter Wall/Corrugation Thickness – According to Manufactures Website **3 inches**

- Enter Length – “**150 feet**”
- Enter Backfill Method – “**Method 1 – New Roadway, Trench**”
- Enter Rock Foundation – “**N**”
- Enter Average Pipe Cover – $36''/12 = 3.0 \text{ feet}$
- Enter Encasement Length – Leave this “**BLANK**”. Borrow will be Calculated based off of ticket amounts and converting as shown in 203.27 (b).
- Enter Structure Backfill Length – Must be calculated:
 - o $2 \times (\text{Pipe Diameter} + \text{Wall Thickness} + \text{Wall Thickness} - .1 \times \text{Pipe Diameter} + \text{Average Pipe Cover})$
 $= 2 \times (36 \text{ inches} + 3 \text{ inches} + 3 \text{ inches} - .1 \times 36 \text{ inches} + 30 \text{ inches})$
 $= 2 \times (36 \text{ inches} + 6 \text{ inches} - 3.6 \text{ inches} + 30 \text{ inches}) = 2 \times 68.4 = 136.8 \text{ inches}$
 - o $\text{Paved width} + 5.0' + 5.0' + 136.8 \text{ inches} / 12 + 136.8 \text{ inches} / 12 = (60' + 12' + 12') + 5' + 5' + 11.4' + 11.4' = \underline{\underline{116.8'}}$

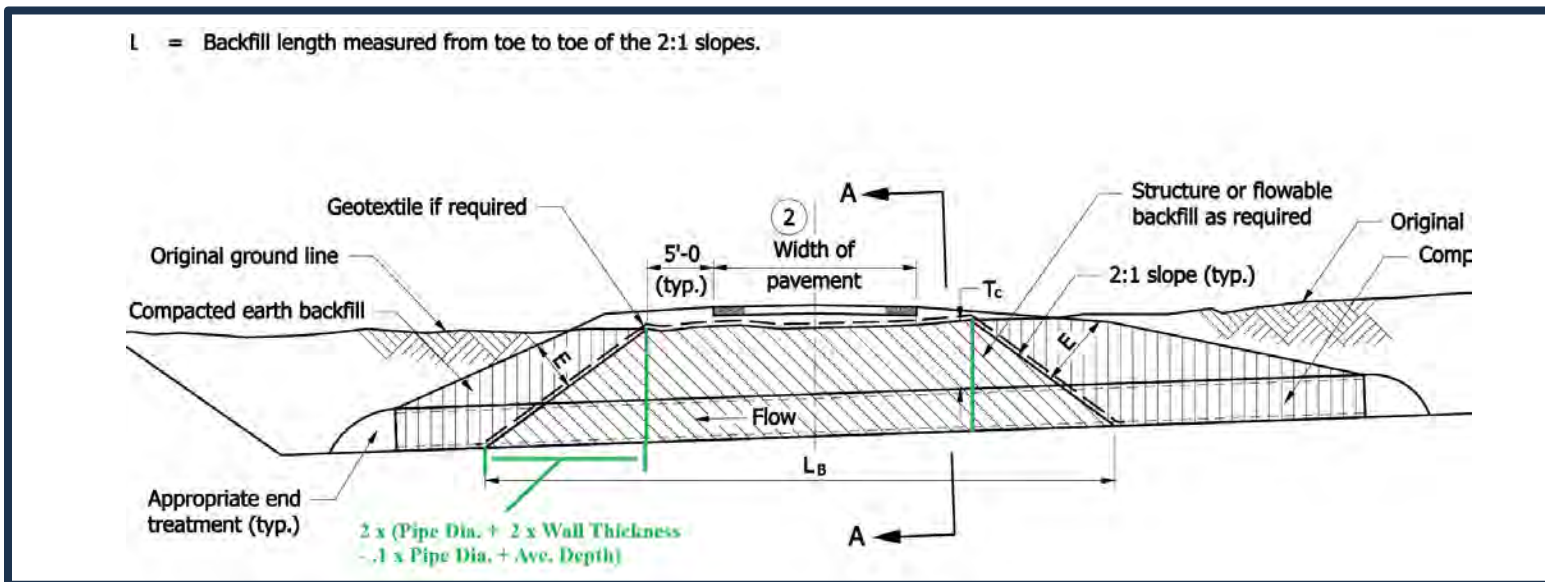


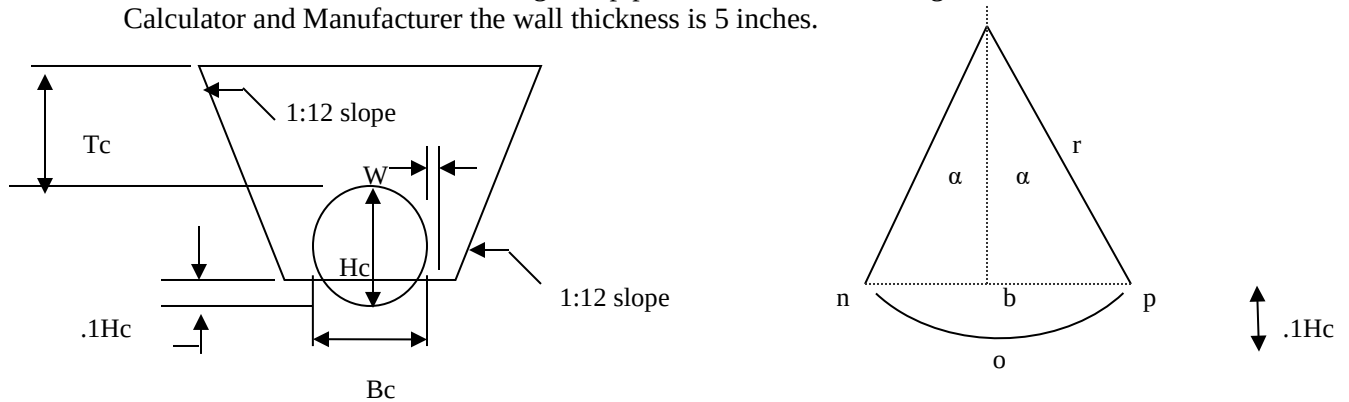
Figure 5-5 Determining Structure Backfill Length

STRUCTURE DATA (USER INPUT DATA)							BACKFILL / TRENCH DATA (USER INPUT DATA)					Standard Drawing (Click Here for Link)	REAL-TIME OUTPUT		
Structure No.	Shape (Select)	Structure Type (1 or 2)	Interior Span (in.)	Interior Rise (in.)	Corr. Thickness (in.)	Length (ft.)	Backfill Method (Select)	Rock Foundation (Y or N)	Average Pipe Cover (ft.)	Encasement Length (ft.)	Structure Backfill Length (ft.)		Structure Backfill (CYS)	Comp. Earth Fill (CYS)	Rock Fdn. Backfill (CYS)
1	Circular	2	36	36	3	150	Method 1 - New Roadway, Trench	N	3		116.8	E 715-BKFL-01	113.9		

Figure 5-6 Structure Backfill Calculator

- Total Calculated Structure Backfill is **113.9 cyds.**
- Pay based on the Calculated amount of **113.9 cyds.**

2. 200 feet of 48 in Reinforced Concrete Pipe is placed from one manhole to another manhole in mainline pavement. 20 sticks of pipe are placed and the measured length from face of structure to face of structure is 195 feet. Height of pipe is 36 inches. According to the Structure Backfill Calculator and Manufacturer the wall thickness is 5 inches.



Depth checks show the average depth to be 36 inches.

According to INDOT Standard Drawing 715-BKFL-04 & 715-BKFL-05 the following information is given:

Using an INDOT's Structure Backfill Calculator, calculate the payment amount.

STRUCTURE DATA (USER INPUT DATA)							BACKFILL / TRENCH DATA (USER INPUT DATA)					Standard Drawing (Click Here for Link)	REAL-TIME OUTPUT		
Structure No.	Shape (Select)	Structure Type (1 or 2)	Interior Span (in.)	Interior Rise (in.)	Wall / Corr. Thickness (in.)	Length (ft.)	Backfill Method (Select)	Rock Foundation (Y or N)	Average Pipe Cover (ft.)	Encasement Length (ft.)	Structure Backfill Length (ft.)		Structure Backfill (CYS)	Comp. Earth Fill (CYS)	Rock Fdn. Backfill (CYS)
1	Circular	2	48	48	5	195	Method 1 - Existing Roadway, Trench	N	3		195		715-BKFL-03 to 0	341.9	

Figure 5-7. Structure Backfill Calculator

Payment should be = **341.9 cyds.**

6 Relining Existing Pipe Structures

Solid Wall HDPE Liner Pipe

Markings

Profile Wall HDPE Liner Pipe

Markings

Profile Wall PVC Liner

Cured In Place Pipe Liner

Frequency Manual

Installation

Joints

Grout

Equipment

Right of Entries

Construction Requirements

Post-Installation Inspection

Jacked Pipe

Construction Requirements

Jacking

Boring

Jacking Steel Pipe

Jacking Concrete Pipe

CHAPTER SIX:

RELINING EXISTING PIPE STRUCTURES

A method of reconditioning existing structures, by which an existing structure is relined with a liner is currently being used. Using this method saves costly disruption to traffic, especially in areas where a structure has a high fill over the pipe.

Pipe liners are used for relining existing in-place concrete, vitrified clay, or metal culvert pipe. The annular space between the liner and the existing culvert is filled with cellular grout. The Contractor is required to furnish and install the liner and grout in accordance with Sections **105.03** and **725**.

SOLID WALL HDPE LINER PIPE

The materials used to manufacture solid wall HDPE liner are required to be high density high molecular weight polyethylene pipe material meeting the requirements of **ASTM F 714**. Solid wall HDPE liner pipe is a black plastic material. The black appearance is due to the specification requirement that carbon black be used to provide UV resistance. The liner pipe is generally smooth on both interior and exterior. Standard laying lengths are required to be a minimum of 19 ft, but not exceed 40 ft or as specified by the PE/PS.

The liner is also required to have a Standard Dimension Ratio (SDR) equal to 32.5. SDR is defined as the ratio of the liner outside diameter to the minimum thickness of the wall of the liner and may be expressed mathematically as:

$$\text{SDR} = \frac{D}{T}$$

where:

D = liner outside diameter in inches

T = minimum liner wall thickness in inches

The smaller the dimension, the thicker the wall and generally, the stronger the pipe. Section **907.25(a)** requires a minimum dimension ratio (DR) of 30.0 in accordance with **ASTM F 412** to prevent a wall thickness that reduces the hydraulic capacity.

A 12 in. section of the liner is required to show no evidence of splitting, cracking, or breaking when compressed between parallel plates to 40 percent of its outside diameter within 2 to 5 minutes. The liner is required to have sufficient rigidity to withstand being placed by either pulling or pushing and exhibit a minimum amount of distortion.

Solid wall HDPE liner pipe is accepted from the Approved List of Thermoplastic Pipe and Pipe Liner Sources or by having a **Type A Certification**. The procedure for being placed on the Approved List is included in **ITM 806, Procedure Q**.

MARKINGS

The print line on Solid Wall HDPE liner pipe should appear every 5 ft or less. The markings include the manufacturer, size, dimension ratio, specification designation, plant code and date of manufacture (Figure 6-1).

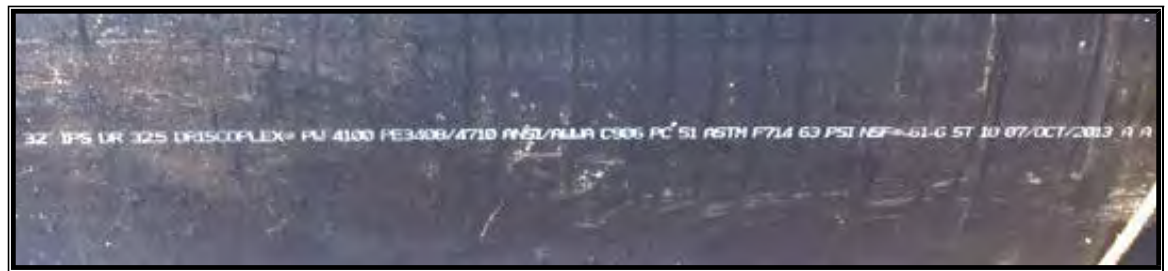


Figure 6-1. Markings on Solid Wall HDPE liner pipe

PROFILE WALL HDPE LINER PIPE

Profile wall HDPE liner pipe is required to be in accordance with **ASTM F 894**. The minimum liner ring stiffness constant, RSC, shall be a value of 160 for circular installations and 250 for deformed installations. Profile wall HDPE liner pipe is accepted from the Approved List of Thermoplastic Pipe and Pipe Liner Sources or by having a **Type A Certification**. The procedure for being placed on the Approved List is included in **ITM 806, Procedure A**.

MARKINGS

The print line on Profile Wall HDPE liner pipe should appear every 10 ft or less. The markings include the manufacturer, size, dimension ratio, specification designation, plant code and date of manufacture.

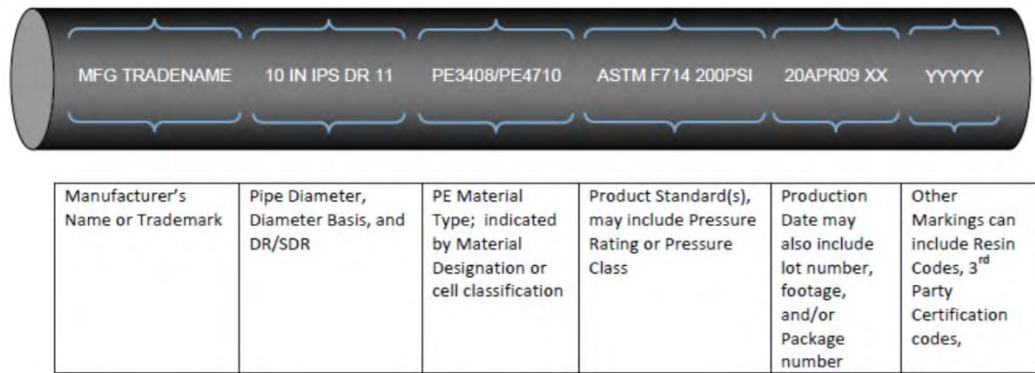


Figure 6-2. Thermoplastic Pipe & Liner Markings

PROFILE WALL PVC LINER

Profile wall PVC liner pipe is required to be in accordance with **ASTM F 949**. Profile wall PVC liner pipe is accepted from the Approved List of Thermoplastic Pipe and Pipe Liner Sources or by having a Type A Certification. The procedure for being placed on the Approved List is included in **ITM 806, Procedure A**.

FREQUENCY MANUAL

Acceptance information for pipe liners is included under Reference 63, Sub Reference 09 of 12 of the Frequency Manual.

INSTALLATION

Pipe liner installation is required to be in accordance with Section **725** including joint seals in accordance Section **907.27**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with appropriate aggregate material coming from CAPP sources.

JOINTS

There are several types of joints typically used with pipe liners. These joints include butt fusion, extrusion welded, or other joints as recommended by the liner pipe manufacturer. The joint is required to have sufficient mechanical strength to allow the liner to be installed through the existing pipe without affecting the joint's integrity. Jointing is required to provide water tight integrity for all joints and not interrupt the flow characteristics of the pipe. The Contractor shall propose and describe in the QCP a destructive test such as but not limited to a bend strap test, to demonstrate that an operator can produce an extrusion welded joint that will not fail as per 725.06.



Figure 6-3. Jointing a Liner

Certification

Welding, butt fusing, or joining shall be performed by an operator trained and certified by either the manufacturer of the liner pipe or the manufacturer of the joining equipment.

Grooved Press-on

Typical grooved press-on joints feature male and female joint ends. Opposing ends of the liner pipe have grooves cut on the interior and exterior of the pipe, respectively. The ends of the liner pipe may also be beveled to allow the edges to slip past one another. Once joined, the liner pipe joint is virtually smooth both inside and out.

Butt Fusion

Liner pipe sections that are butt fused undergo a three-step joining process. The meeting ends of the sections are shaved or planed to ensure perfectly smooth and perpendicular surfaces. The ends are then simultaneously heated to soften the plastic so that the ends may be re-bonded. The sections are then pressed together while the thermoplastic cools, creating a permanent joint between the sections. The resulting interface may project a slight double-bead on both the interior and exterior of the liner pipe.

Extrusion Weld

An extrusion welded joint on solid wall HDPE & Profile Wall liner pipe incorporates a bead of plastic material to join two sections of liner pipe. Polyethylene material is extruded at the interface of the two sections to bond them together. The welding process results in an external weld bead at the joint.

Cellular Concrete Grout

The cellular concrete grout shall be designed in accordance with ASTM C869. Section **725.07** includes the procedures for placement and testing of cellular grout. The equipment used to produce the grout and all equipment used in the mixing, pumping and placing is certified as to suitability by the Supplier of the foam concentrate.

A Type A Certification in accordance with 916 shall be provided for the cellular concrete grout.

The Contractor supplying and placing the grout is certified by the foam concentrate Supplier and is required to be capable of developing a mix design, batching, handling, pumping and placing grout under the contract conditions.

The materials used to manufacture the cellular grout are required to be in accordance with the following:

Fine Aggregate	904.02
Fly Ash	901.02
Foam Concentrate	ASTM C 796
Water	913.01

Admixtures, retarders, and plasticizers used are required to be in accordance with the foam concentrate Supplier's specifications. Portland cement is required to be in accordance with Section **901.01 (b)**, except Type II cement is not allowed.

The grout is made using the preformed foam process using generating equipment calibrated by the manufacturer to produce a precise and predictable volume of foam. The foam concentrate is certified by the manufacturer to have specific liquid/foam expansion ratio at a constant dilution ratio with water.

The specific job mix is submitted by the foam concentrate certified Contractor to the PE/PS for approval prior to use on the contract. The mix is required to have a minimum 28-day compressive strength of 150 psi or be approved based on prior acceptance and suitable performance on INDOT contracts.

Grout mixed off site is delivered to the job site in a truck mixer in accordance with Section **702.09**, filled to half of the mixer. The foam concentrate is then added to the cement mix in the truck and mixed to a uniform consistency.

Grout mixed on site is done in a deck mate or a similar device. Small batches of approximately 1 yd³ are mixed and pumped in a continuous operation.

For each day worked or for each 100 yd³ placed, four test cylinders measuring 3 in. by 6 in. are cast. The cylinders are prepared, cured, and transported in accordance with **ITM 522**. The cylinders are also tested in accordance with **ITM 522**, except the test specimens are broken within the permissible tolerance of 150 psi at 28 days after an initial 2 – 5 day 70 deg +/- 10 deg cure period and moist enclosed water bath thereafter.

The cylinders are obtained from the point of placement.

The equipment used to produce the grout and all equipment used in the mixing, pumping and placing is certified for suitability by the Supplier of the foam concentrate.

EQUIPMENT

As shown and approved in the QCP, all equipment necessary for the satisfactory performance of realigning existing pipes is required to be approved by the PEMS. The equipment includes all machinery necessary for the installation of the liner (Figures 6-4 & 6-5), and the reworking of the temporary easements.



Figure 6-4. Pulling Pipe Liner

RIGHT OF ENTRIES

All right of entries necessary for the work are required to be acquired by the Contractor. All damage within these areas is repaired to the original condition and bare areas having sod cover are required to be repaired. The Contractor is required to install and maintain temporary fence as directed by the PEMS.



Figure 6-5. Pushing Pipe Liner over Water

CONSTRUCTION REQUIREMENTS

The Contractor is required to re-establish the flow line of any eroded inverts with grout meeting the requirements as set out in the Specifications. Pre-mixed grout may be used subject to approval of the PEMS. The Contractor is required to maintain a positive flowline in the liner. Any obvious cavities under the existing pipe are filled with grout.

After the liner pipe installation is complete and the liner pipe has cooled to the temperature of the existing pipe, the liner pipe shall be cut so that each end is 8 inches outside the end of the existing pipe.

The cellular concrete grout within the annular space between the existing Pipe and the liner pipe shall be contained by the bulkheads. The bulkheads shall be constructed at each end of the structure. Each bulkhead shall be constructed to withstand the pressure of the grouting operation. The bulkhead shall be free from leaks and the exterior surface shall be give a smooth trowel finish. The bulkhead shall extend from the end of the existing pipe inward a minimum depth of 18 in. Block and mortar bulkheads are placed at both ends of the culvert. A 2 in. vent hole at the crown and a 1 in. hole at the invert are placed in the downstream bulkhead. An access hole, sized to facilitate the method of grout input, and a 2 in. air vent are placed at the crown in the upstream bulkhead.

The grout is placed from the upstream end of the culvert where practical (Figure 6-6). The vent holes in the downstream bulkhead are plugged as soon as grout begins to flow out each hole. The 2 in. air vent in the upstream bulkhead is kept clear until grout begins to flow out of the vent.



Figure 6-6. Grouting Pipe Liner

The grout is placed by either gravity flow or by low pressure pumping to completely fill all voids within the annular space without causing deformation of the liner. The grout extends for the full length of the culvert.

Grout placed by gravity flow is limited to a maximum length of flow of 10 ft for each foot of available head per access hole. Additional access holes, where required, are drilled from the top and sleeved with 6 in. PVC piping.

The injection operation shall provide sufficient cellular concrete grout to fill all voids between the existing pipe and liner pipe over the entire structure length, but done in a way that will not distort the liner.

Liner storage areas are required to be approved by the PEMS. All drainage structures and ditches are required to remain open at all times, and traffic control is required to be in accordance with the MUTCD or as directed.

All liner sizes are required to be approved by the PEMS prior to installation.

All incidental work, such as brush removal, flowline adjustments, etc., is done by the Contractor. Where required, and practical, a bull nose device is pulled through the existing culvert to facilitate the liner installation. The bull nose device is of appropriate diameter to permit the installation of the intended liner size. The pipe is completely cleared of all foreign material just prior to the installation of the liner at no additional cost to the State. In addition, any restoration of right of entry areas, acquiring all necessary new permits or amendments are at no added cost to the State.

POST-INSTALLATION INSPECTION

A visual inspection is required for acceptance of all liner pipe joined by methods other than by welding or fusing joints. All joints that do not pass visual inspection shall be removed, shall have a new joint fabricated, and will be re-inspected.

TRENCHLESS PIPE

Jacking steel or reinforced concrete pipe consists of pushing the pipe through or under an embankment.

Definitions of additional terminology for trenchless pipe can be found in 716.01.

CONSTRUCTION REQUIREMENTS

The Contractor shall submit a QCP in accordance with ITM 803, detailing a description of the trenchless pipe install, along with the Contractors plan to construct, test and manage the process.

An approach trench is dug at the forward end of the proposed pipe to a depth sufficient to form a vertical face at least 1 ft higher than the top of the pipe and large enough to provide ample working room. The size and height of this vertical face may vary; however, the roadbed and shoulders are required to always be adequately protected. After the pipe is installed, the excavated area not occupied by the pipe is backfilled with suitable material and thoroughly compacted into place.

Sheeting and bracing is provided if the nature and conditions of the soil or height of exposed face is such as to endanger either the traveling public or the integrity of the road surface.

When the use of explosives is necessary for the prosecution of the work, their use is required to be in accordance with Section **107.13**.

When ground water is known or anticipated, a dewatering system of sufficient capacity to handle the flow is maintained at the site until the dewatering system operation may be safely halted. The dewatering system is required to be equipped with screens or filter media sufficient to prevent the displacement of fines.

Jacked pipe is constructed so as to prevent leakage of any substance from the pipe throughout the length of the pipe. Installation by open-trench methods is permitted only at locations indicated and is required to be in accordance with the applicable specifications for that type of installation.

JACKING

Excavation is undertaken within a steel cutting edge or shield attached to the front section of pipe to form and to cut the required opening for the

pipe. Excavation is not carried ahead of the pipe far enough to cause a loss of soil. When jacking in loose, granular, or running soils, the shield is required to have a means for inserting steel baffle plates and shelves for the purpose of preventing voids.

The thrust wall is required to be adequate for installation of the jacked pipe and be constructed normal to the proposed line of thrust.

A suitable lubricant, such as bentonite, may be applied to the outside surface of the jacked pipe to reduce frictional forces. This material is applied by the use of pressure equipment which pumps the lubricant to the outside of the shield on the lead pipe. The lubricant may be pumped outside the surfaces of the pipe through the grout holes.

The thrust load of the jacking equipment is imparted to the pipe through a suitable thrust ring which is sufficiently rigid to ensure distribution of the load without creating point loading.

When necessary to prevent loss of soil at the heading, the face of the excavation is required to have an adequate bulkhead when the work is shut down at the end of the working day.

Bracing, backdrops and jacks are required to be sufficient so that jacking may progress without stoppage, except for adding lengths of pipe, until the pipe reaches the leading edge of the pavement as shown on the plans.

BORING

Boring consists of pushing a pipe into the fill with a boring auger rotating within the pipe to remove the spoil. Advancement of the cutting head ahead of the pipe is not allowed, except for that distance to permit the cutting head teeth to cut clearance for the pipe. If granular, loose, or unstable soil is encountered during the boring operation, the cutting head is retracted into the casing a distance that assures no voiding is taking place. The excavation by the cutting head is required to not exceed the outside diameter of the pipe by more than 1/2 in. The face of the cutting head is arranged to provide reasonable obstruction to the free flow of soft or porous material.

The use of water or liquids to soften or wash the face of the cutting head is not permitted. Water may be used in sticky clays to facilitate spoil removal provided the water is introduced behind the cutting head. Lubricating agents, such as bentonite, may be used to lubricate the casing and reduce friction between the casing and embankment.

If an obstruction is encountered during installation which stops the forward progress of the pipe, operations are required to cease. The pipe is abandoned in place and filled completely with grout or other approved

materials. The abandoned work is paid for in the amount of at least 75% of the contract unit price as specified in the schedule of pay items.

Bored or jacked installations have a bored hole essentially the same as the outside diameter of the pipe. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe by more than approximately 1 in., grouting or other approved methods are required to be used to fill such voids with no additional payment.

JACKING STEEL PIPE

For jacking steel pipe, the joints are welded in accordance with Section **711.32** and required to be watertight. The minimum wall thickness of the pipe shall be in accordance with the table shown in 716.02.

JACKING CONCRETE PIPE

Concrete pipe installed by pipe jacking shall be designed with sufficient concrete strength and steel reinforcement to resist jacking forces and shall have tongue and groove joints. All pipes are required to have steel reinforcement concentric with the pipe wall, and, where required, additional reinforcement at the ends of the pipe. The pipe is required to be in accordance with **ASTM C 76M**.

To avoid concentrated loads at the joints from pipe to pipe, strips of plywood, asphalt roofing paper, or other similar resilient materials are inserted around the circumference in the joints as each pipe is placed head of the thrust ring. Resilient material is also used between the pipe end and the thrust ring.

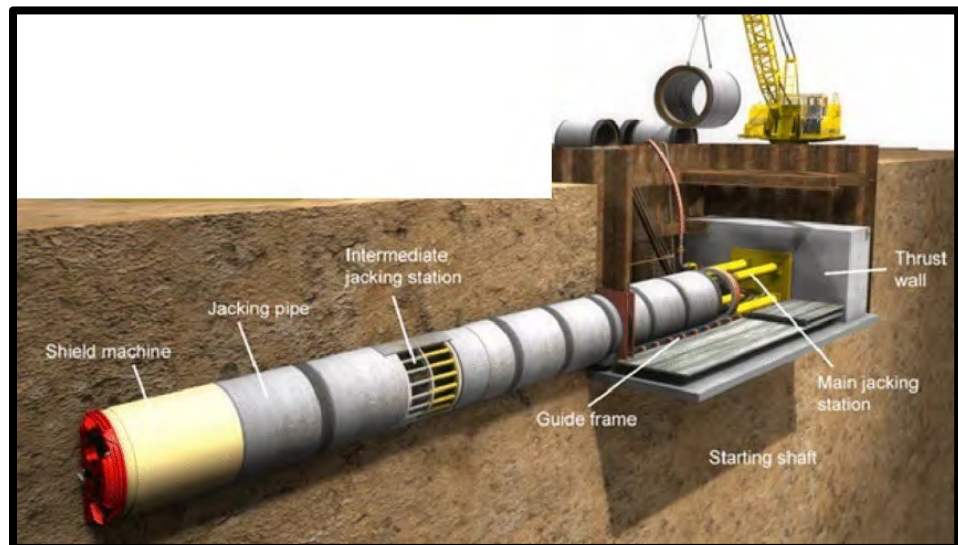


Figure 6-7 Jacking Concrete Pipe

CURED-IN-PLACE PIPE LINER, CIPP



Figure 6-8. Cured In Place Pipe Liner

Construction shall consist of the fabrication, installation, and curing of a tight-fitting, resin-impregnated fabric called Cured in Place Pipe Liner, CIPP. CIPP shall be in accordance with ASTM D5813. The Installer/Manufacturer shall determine the type of CIPP to be used depending on the conditions that the liner is placed. Under normal conditions the CIPP shall be designed in accordance with ASTM F1216

A Type A certification in accordance with 916 and a test report of the sample taken showing results from tests taken per ASTM D5813, section 7.3. A preapproved independent laboratory shall sample each CIPP install after field curing has taken place. These results should be provided to the State within seven days.

Design calculations shall be submitted in accordance with 105.02 and should detail the liner thickness, required curing pressure, the proposed waterway opening, minimum required temperatures, and minimum time to cool down.

The Contractor shall monitor and record temperatures during initial cure, post cure and cool down. A copy of these temperatures shall be provided to the Engineer.

The Liner shall be one continuous run of material and will be leak free. Any damage or leaking to the inner or outer film shall be repaired immediately. Any

cofferdams in place shall remain in place until all potential wastewater is secured. The final product shall be inspected and videotaped for workmanship in accordance with ASTM D5813. Defects will be repaired or the CIPP shall be replaced so it meets appropriate specifications. The videotape will become the property of the State. The cured CIPP shall be cut within 6 inches of the ends of the existing structure. Existing connections to underdrains or other intersecting structures shall be perpetuated through the CIPP. The CIPP will be measured by the linear foot, complete in place.

7 Calculating Pipe Lengths

Example Problems

Pipe lengths are calculated based on the type of pipe being placed, the application of the pipe and what method of installation is being utilized.

As a Pipe Inspector, you should become familiar with the various types of pipes and techniques required for measuring these structures. The types of pipes placed on INDOT jobs are as follows:

1. Liner Pipe & Trenchless Pipe (Jacked Pipe)
2. Culvert Pipe & Reinforced Concrete Small Structures
3. Stormwater Pipe
4. Underdrain Pipe

Liner Pipe and Trenchless Pipe (Jacked Pipe)

Liner Pipe is exclusively installed to rehabilitate an existing pipe. The reason for using a pipe liner is normally due to the disadvantages associated with open cutting and installing new. These disadvantages are lane restrictions in high traffic areas, deep fill cuts, limited right of way, and the cost to replace subgrade, subbase and pavement. Trenchless Pipe is also used in areas where it is not practical to open cut and install new pipes for the same reasons as Liner Pipe. In these locations, obtaining accurate pipe measurements can be very difficult. Unfortunately, the Pipe Inspector can't always wheel off a distance due to traffic, grade of slope or other various obstructions. The following method is recommended when determining the length of Liner Pipe or Trenchless Pipe installed:

1. Review the plans to determine what the planned amount is.
2. Review the As-Built Plans to determine what the existing Pipe Length is.
3. If Construction Engineering is an Item on the job, request that the Surveyors obtain needed off-sets from centerline or right of way to allow a measured length to both ends of the pipe.
4. Is a Total Station or Bad Elf geospatial device available? If so, the length can be determined by setting either of the devices on both ends of the structure.
5. Request to meet with the Contractor and compare Planned amount, As-Built amount, Construction Engineering off-set amount or Geospatial device amount with what amount the Contractor has measured. Determine the amount to be paid.

6. Report this amount to the Bridge Engineer or Culvert Asset Engineer as stated in the GIFE Manual 4.20.
7. It is also recommended that the existing pipe diameter be checked alongside the Contractor prior to any construction activities in order to verify the correct size liner is being installed.

Culvert Pipe & Reinforced Concrete Small Structures:

The installation of new culvert pipe & reinforced concrete small structures typically involves disruption of traffic and open cutting of a fill area to place the new structure in existing or new facilities. It is recommended that any necessary measurements be completed while traffic is restricted and prior to placement of any significant backfill.

1. Review the plans to determine what the planned amount is.
2. If Construction Engineering is an Item on the job, request that the Surveyors obtain needed off-sets from Centerline or right of way to allow a measured length to both ends.
3. Wheel off a distance of the placed length, while traffic is restricted and after the initial coverage over the pipe has occurred, but before any significant backfill is placed. Record this measurement.
4. Once Traffic is switched, measure the pipe that is installed repeating step 3.
5. Periodically verify that the appropriate Structure Backfill depth is placed on the structure prior to the remaining fill being installed.
6. Request to meet with the Contractor and compare Planned amount, Construction Engineering off-set amount, Total Wheeled amount with the amount determined by the Contractor. Determine the amount to be paid.
7. Structural Backfill should be paid according to the neat lines unless a discrepancy is discovered (as shown in Chapter 5).
8. Report this amount to the Bridge Engineer or Culvert Asset Engineer as stated in the GIFE Manual 4.20.

Stormwater Pipe:

Installation of stormwater pipe usually involves lane closures and open trench cuts that run from drainage structure (manhole, inlet or catch basin) to another structure (manhole, inlet or catch basin). It is recommended that any necessary measurements be completed while traffic is restricted and after the trench is backfilled to prevent from having to take measurements while in the trench or under traffic.

1. Review the plans to determine what the planned amount is.
2. Count the number of measured sticks of pipe that are set in the trench per day. Record this number with appropriate locations.

3. Periodically measure the depth of the trench and amount of Structural Backfill being placed on top of the pipe to determine depth of backfill. Compare this to the plans for verification.
4. Once the trench is backfilled, measure from the face of the drainage structure to the face of the next drainage structure.
5. Be sure to count the number of elbows or tees used in the stormwater pipe install.
6. Record the measured amount, along with the number of elbows and tees, with their appropriate locations.
7. Structural Backfill should be paid according to the neat lines unless a discrepancy is discovered (as shown in Chapter 5).
8. Request to meet with the Contractor and compare Planned amount, Counted Pipe Sticks, Measured amount with the Contractors amount. Determine the amount to be paid.
9. Report this amount to the Bridge Engineer or Culvert Asset Engineer as stated in the GIFE Manual 4.20.

Underdrain Pipe:

Underdrain pipe is normally placed in the shoulder area of a Pavement's cross-section on new Construction to allow surface drainage to filter through the pavement and outlet to the ditch line. The trench for underdrain is constructed using a Trenching Machine or small backhoe that cuts the constructed subgrade. Underdrain pipe, with tees and elbows is placed in the trench after geotextiles are installed. The Trench is then filled with Aggregate for Underdrain No. 8. Underdrain is installed while traffic is restricted.

1. Review the plans to determine what the planned amounts are for Pipe, Geotextiles and No. 8 stone.
2. Measure the length of Trench Pipe installed next to the cut out trench. Record the length and locations per day.
3. Be sure to count the number of elbows and tees used along with their location.
4. Measure the length of outlet pipes and record the locations daily.
5. Periodically measure the depth of the trench and compare this to the planned depth. Amount of aggregate for underdrain should be paid to neat line limits unless a discrepancy is discovered (as shown in Chapter 5).
6. Request to meet with the Contractor and compare Planned amount and Measured amount with the Contractors amount. Determine the amount to be paid.
7. Any calculations needed for Aggregate for Underdrain or Geotextiles should be per 718- UNDR-02.
8. Report these amounts to the Bridge Engineer or Culvert Asset Engineer as stated in the GIFE Manual 4.20.

Example 1 (Liner Pipe & Trenchless Pipe):

Data determined in the Field:

- Planned Amount of a 72 inch Liner Pipe is 365' long.
- As-builts show the existing pipe to be 360' long
- Construction Engineering was able to provide Centerline off-sets to Right of Way of 200' Left at Station 565+30 and 220' right at Station 564+70
- The Pipe Inspector measured 30' to offset right from liner end
- The Pipe Inspector measured 30' to offset left from liner end
- The Contractor says that they placed the planned amount

What amount should be paid and what amount should be reported to Asset Management?

SOLUTION:

Calculation from centerline to end of

Liner right: $220' - 30' = 190'$

Calculation from centerline to end of

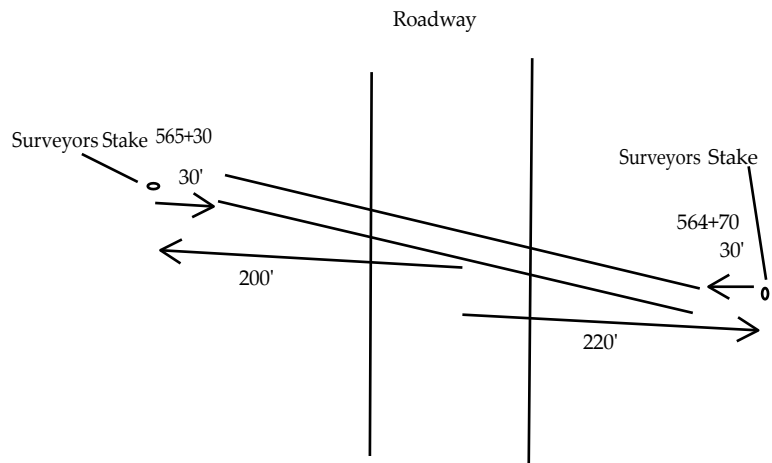
Liner left: $200' - 30' = 170'$

Linear Measurement = $190' + 170' = 360'$

Station 565+30 - Station 564+70 = 60'

Skewed Pipe Liner Length = Square Root of $(60^2 + 360^2) = 365'$

Report to the Culvert Engineer that 365' of Newly placed 72" Pipe Liner was placed at 565+30 Left & 564+70 Right. Pay 365'



Example 2 (Culvert Pipe & Reinforced Concrete Structure):

Data Determined in the Field:

- A New 96" Culvert Pipe is planned to be installed at a Length of 290' in a new Roadway Embankment
- While half the road was closed, it was determined that 130' of Culvert pipe was placed right
- While the other half of the road was closed, it was determined that 160' of Culvert was placed left
- Periodic measured depths of Structure Backfill showed that 48" of Backfill was placed on top of the Structure.
- Construction Engineering placed 150' off-set to Right of Way right and 200' left. Both at Station 345+20 with no Skew
- The Pipe Inspector measured 20' from off-set right and 40' from off-set left to the ends of the pipe
- The Contractor says they placed the Pipe to Plan

How much Pipe should be paid and reported to Asset Management?

SOLUTION:

$130' \text{ right} + 160' \text{ left} = 290'$

Verify - $150' - 20' = 130'$

Verify - $200' - 40' = 160'$

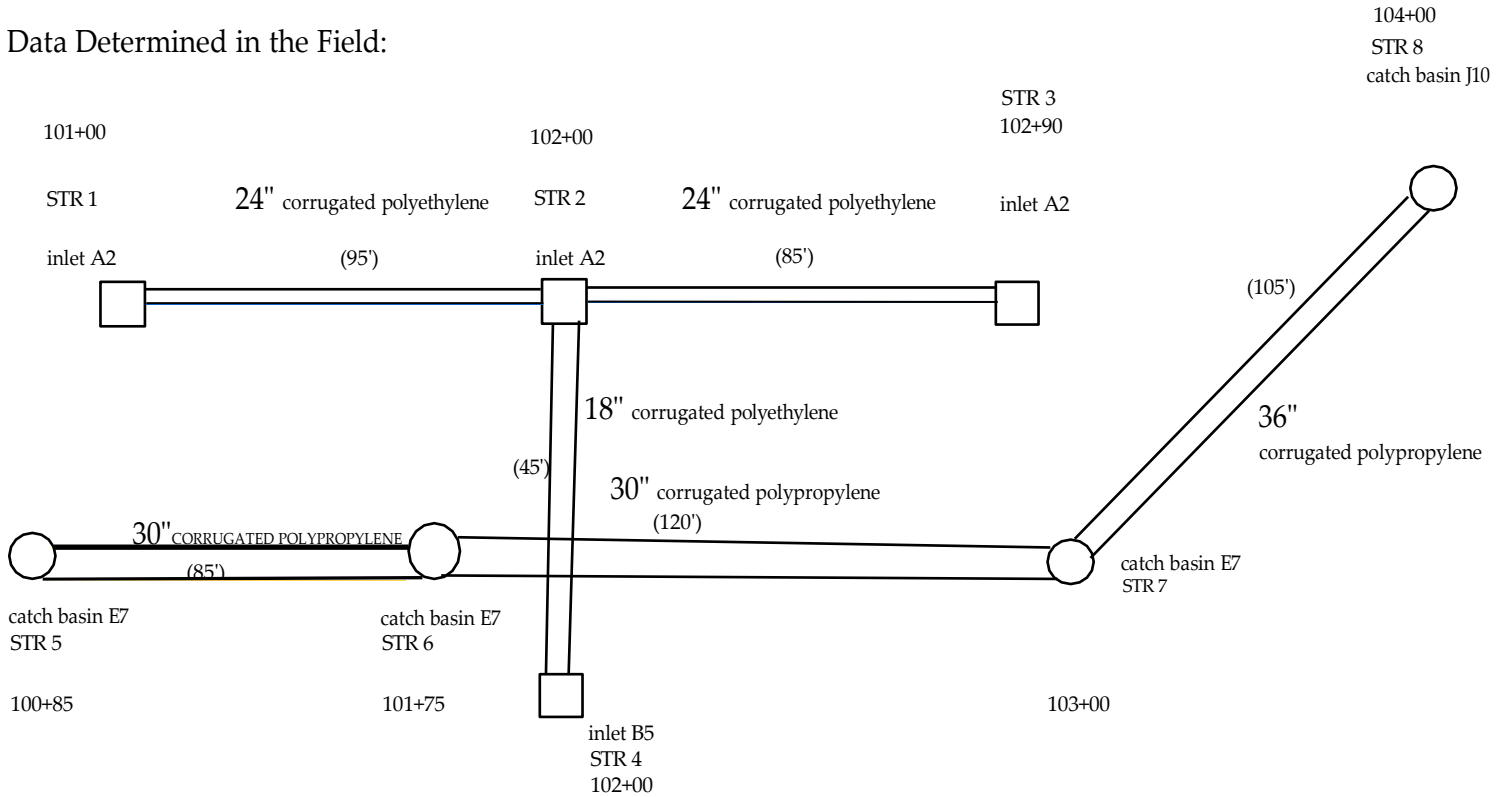
$130' + 160' = 290'$

Pay and Report 290'

48 inches of Structure Backfill is required on top of the Structure per 715-BKFL-02. 48" was placed on top. Calculate to Structure Backfill as shown in Chapter 5.

Example 3 (Stormwater Pipe):

Data Determined in the Field:



Determine how much payment is required for each pay item:

- 24" corrugated polyethylene: 10 sticks of pipe, Supplier "ABC Pipe Co"
- 18" corrugated polyethylene: 3 sticks of pipe, Supplier "ABC Pipe Co"
- inlet A2: Supplier "XYZ Concrete Products"
- inlet B5: Supplier "XYZ Concrete Products"
- 30" corrugated polypropylene: 11 sticks of pipe, Supplier "ABC Pipe Co"
- 36" corrugated polypropylene: 6 sticks of pipe, Supplier "ABC Pipe Co"
- catch basin E7: Supplier "XYZ Concrete Products"
- catch basin j10: Supplier "XYZ Concrete Products"

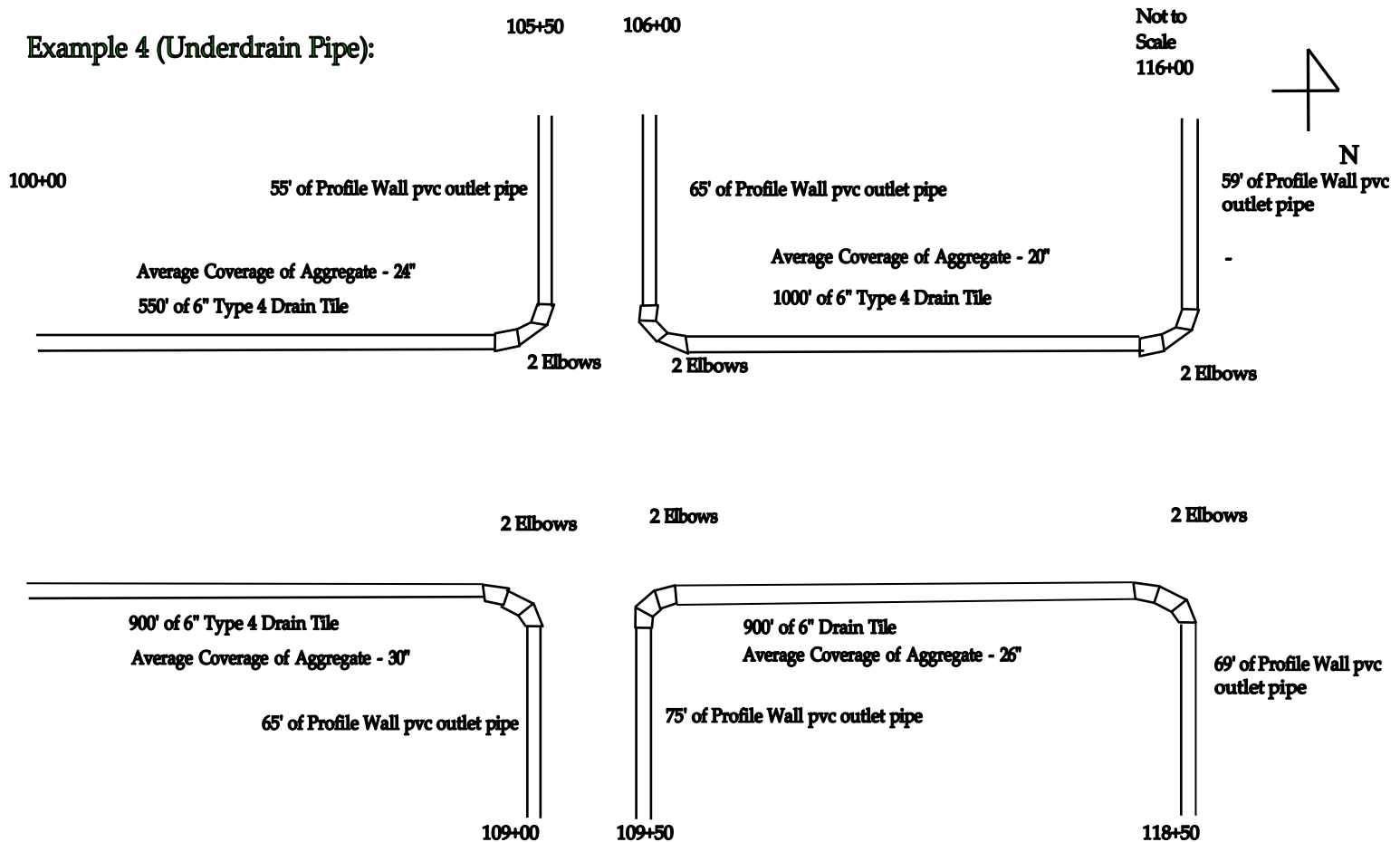
Answers:

- 24" corrugated polyethylene: $95' + 85' = 180'$, check for required Certification & QPL requirements
- 18" corrugated polyethylene: 45', check for required Certification & QPL requirements
- inlet A2: 3 each, check for required Certification & QPL requirements
- inlet B5: 1 each, check for required Certification & QPL requirements
- 30" corrugated polypropylene: $85' + 120' = 205'$, check for required Certification & QPL requirements
- 36" corrugated polypropylene: 105', check for required Certification & QPL requirements
- catch basin E7: 3 each, check for required Certification & QPL requirements
- catch basin j10: 1 each, check for required Certification & QPL requirements

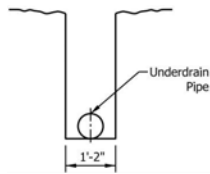
What to Report to the Culvert Asset Engineer:

STR 1: 100+00 (or Ref. Post) inlet A2 - 1 each, 95' of 24" corrugated polyethylene
 STR 2: 102+00 (or Ref. Post) inlet A2 - 1 each, 85' of 24" corrugated polyethylene
 STR 3: 102+90 (or Ref. Post) inlet A2 - 1 each
 STR 4: 102+00 (or Ref. Post) inlet B5 - 1 each, 45' of 18" corrugated polyethylene
 STR 5: 100+85 (or Ref. Post) catch basin E7 - 1 each, 85' of 30" corrugated polypropylene
 STR 6: 101+75 (or Ref. Post) catch basin E7 - 1 each, 120' of 30" corrugated polypropylene
 STR 7: 103+00 (or Ref. Post) catch basin E7 - 1 each, 105' of 36" corrugated polypropylene
 STR 8: 104+00 (or Ref. Post) catch basin J10 - 1 each

Example 4 (Underdrain Pipe):



Determine Payment amounts and what to Report to the Culvert Asset Engineer:



Trench cut to the required 1'-2"

What to Report to the Culvert Asset Engineer:

100+00 to 105+50 Lt (or Ref Post) - 550' Type 4 Drain Tile
106+00 to 116+00 Lt (or Ref Post) - 1000' Type 4 Drain Tile
100+00 to 109+00 Rt (or Ref Post) - 900' Type 4 Drain Tile
109+50 to 118+50 Rt (or Ref Post) - 900' Type 4 Drain Tile
105+50 Lt (or Ref Post) - 55' of Profile Wall PVC Outlet Pipe
106+00 Lt (or Ref Post) - 65' of Profile Wall PVC Outlet Pipe
116+00 Lt (or Ref Post) - 59' of Profile Wall PVC Outlet Pipe
109+00 Rt (or Ref Post) - 65' of Profile Wall PVC Outlet Pipe
109+50 Rt (or Ref Post) - 75' of Profile Wall PVC Outlet Pipe
118+50 Rt (or Ref Post) - 69' of Profile Wall PVC Outlet Pipe

- Type 4 Drain Tile, Supplier "ABC Pipe Co"
- Profile Wall PVC Outlet Pipe, Supplier "ABC Pipe Co"
- Geotextiles for Underdrain, Supplier "Erosion Co"
- Aggregate for Underdrain, Supplier "XZ Gravel"

Answers:

- **Type 4 Drain Tile** - 550' + 1000' + 900' + 900' = 3,350'
- Add Elbows: 12 Elbows x 2' = 24'
- 3350' + 24' = 3374', check for appropriate Certifications & Qualified List requirements

Profile Wall PVC Outlet Pipe - 55' + 65' + 59' + 65' + 75' + 69' = 388', check for appropriate Certifications & Qualified List requirements

- Geotextiles:

Width of 550' Section - $24/12 + 24/12 + 6/12 + 6/12 + 1.17 + 1.17 = 7.34'$
Width of 1000' Section - $20/12 + 20/12 + 6/12 + 6/12 + 1.17 + 1.17 = 6.67'$
Width of 900' Section - $30/12 + 30/12 + 6/12 + 6/12 + 1.17 + 1.17 = 8.34'$
Width of 900' section - $26/12 + 26/12 + 6/12 + 6/12 + 1.17 + 1.17 = 7.67'$
 $(550' \times 7.34) + (1000' \times 6.67) + (900' \times 8.34) + (900' \times 7.67) = \underline{25,116 \text{ sq ft}}$

Aggregate for Underdrain:

Depth of 550' Section - $24/12 + 6/12 = 2.5'$
Depth of 1000' Section - $20/12 + 6/12 = 2.17'$
Depth of 900' Section - $30/12 + 6/12 = 3'$
Depth of 900' Section - $26/12 + 6/12 = 2.67'$
 $[550' + 2'(\text{no. of elbows})] \times 2.5 \times 1.17 = 1620.45$ divide by 27 = 60.02 cyds
 $[1000' + 2'(\text{no. of elbows})] \times 2.17 \times 1.17 = 2559.21$ divide by 27 = 94.79 cyds
 $[900' + 2'(\text{no. of elbows})] \times 3 \times 1.17 = 3173.04$ divide by 27 = 117.52 cyds
 $[900' + 2'(\text{no. of elbows})] \times 2.67 \times 1.17 = 2836.50$ divide by 27 = 105.06 cyds
Subtract Total Volume of the Pipe $(550' + 4' + 1000' + 8' + 900' + 4' + 900' + 8') \times (6/12)^2 \times \pi/4 = 662.15$ divide by 27 = (-)24.52 cyds
Total = 60.02 + 94.79 + 117.52 + 105.06 - 24.52 = **Total = 352.87 cyds**

8 Concrete Pipe

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CHAPTER EIGHT:

Concrete Pipe



All precast concrete pipe is required to be produced by a Certified Precast Concrete Producer.

MATERIALS

NON-REINFORCED CONCRETE PIPE

Non-reinforced concrete pipe is covered by Section **907.01**, which references **AASHTO M 86**.

REINFORCED CONCRETE PIPE

Circular Reinforced Concrete Pipe (RCP) is covered by Section **907.02**, which references **AASHTO M 170**. Deformed or elliptical RCP is covered by Section **907.03**, which references **AASHTO M 207**.

ACCEPTANCE

FREQUENCY MANUAL

Acceptance and information for concrete pipe is found under Reference 57, Sub Reference 01 of 02 & 02 of 02 of the Frequency Manual.

IDENTIFICATION

Concrete Pipe is precast and bears a stencil in accordance with **ITM 813**, which includes the certification agency, the date of manufacture, any applicable Standard Specification required marking, and the INDOT ID number for the source. For the American Concrete Pipe Association (ACPA), product marking is the “QCast” emblem (Figure 8-1) or the words “ACPA Certified Product”. For National Precast Concrete Association (NPCA), product marking is the words “NPCA Certified Product” (Figure 8-2). For Precast/Prestressed Concrete Institute (PCI), product marking is the words “PCI Certified Product”.



Figure 8-1. QCast Emblem



Figure 8-2. NPCA Certified Plant

APPROVED SOURCES

Sources of both reinforced and unreinforced concrete pipe are found on the Certified Precast Producers List. Sources are approved in accordance with **ITM 813**. Materials shall be visually inspected for workmanship. If cracks are observed with the naked eye, a crack comparator or similar device shall be used to determine the severity and extent of cracking in order to establish suitability.

CERTIFIED PRECAST CONCRETE PRODUCER

ITM 813 requires a Precast Producer to be certified by the ACPA, the NPCA, or the PCI B1A & Group C1 or C1A, certification programs prior to becoming an INDOT Certified Precast Concrete Producer. The program requires the Producer to take responsibility for the production of quality precast products in accordance with contract requirements, and INDOT monitors the Producer's quality control procedures.

PRE-INSPECTION

The precast manufacturer is required to use INDOT approved materials in the construction of the concrete pipe intended for INDOT contracts. These materials include:

- 1) Fine and coarse aggregates
- 2) Cement and pozzolans
- 3) Portland Cement Concrete (PCC) admixtures

The aggregate sources are not required to be Certified Aggregate Producers as stated in Section 904.01; however, the aggregate source is required to maintain current quality approval for all aggregate materials used in the concrete pipe.

The cement, pozzolans, and PCC admixtures are required to be from the INDOT List of Approved Materials.

Annually, the reinforcing steel and/or wire fabric is sampled and approved. Copies of the reinforcing steel manufacturer certification are kept on file and are required to be available for review for 5 years.

The three-edge-bearing machine is required to meet the requirements of **AASHTO T 280**. The machine is certified every 12 months, but not to exceed 18 months.

INSPECTION

The Construction Technician is required to visually inspect the item received on the contract for any quality deficiencies that may be apparent. The basis of use for the item is the approval number. **ITM 813** allows INDOT to conduct an audit of each Certified Precast Producer.

Materials

During an audit, the Technician should report to the source office and obtain a list of materials that were used in the precast products. The material list contains the INDOT contract, Purchase Order, or material to be added to stock, kinds, diameters, classes, etc. This information is necessary to determine the requirements for physical testing.

The Technician locates the material to be inspected and verifies that the precast item has the markings required by **ITM 813**.

Internal Diameter

Both ends of the pipe are checked for the internal diameter with a tape measure (Figure 8-3). A measurement is made on both ends of the pipe consisting of two measurements at 90 degrees to each other which are averaged.

Wall Thickness

Both ends of the pipe are measured for wall thickness with calipers or micrometers. Four measurements are taken at 90 degree opposing points (Figure 8-3).

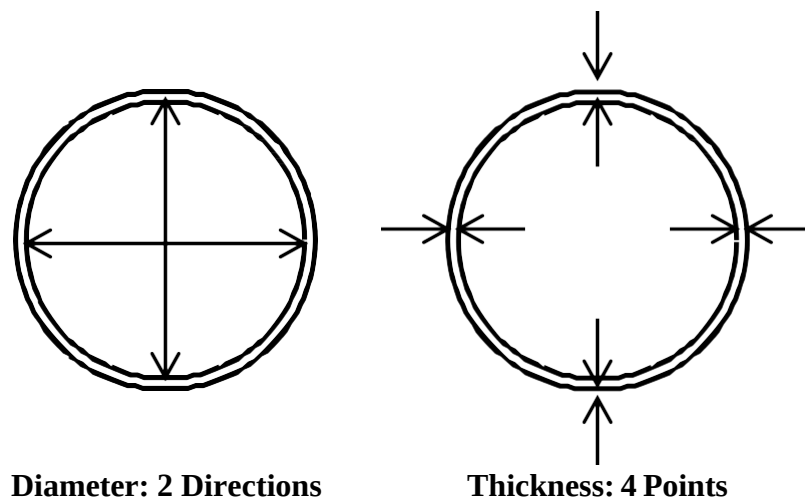


Figure 8-3. Pipe Diameter and Wall Thickness

Straightness

Straightness for non-reinforced concrete pipe is measured by placing a straightedge on the concave side of the pipe for the full length of the barrel, being sure not to include spigot joint material or socket, and measuring the maximum distance between the straightedge and the concave side of the pipe.

Laying Length

A length measurement of the pipe is taken at the top and bottom of the specimen.

Other Visual Checks

The Technician also checks the workmanship and finish of the material. Concrete pipe is required to have no cracks that extend through the wall in excess of 1/2 in. length.

Outside irregularities are not considered for rejection unless the irregularity affects strength.

Special shapes such as wyes, tees, bends, and adapters are checked for workmanship. Dimensional tolerance is required to be the same as for straight pipe and conform to specifications. The special shape is required to be securely and completely fastened to the barrel of the pipe. Socket and ball sections are required to permit proper fit and seating capabilities.

REJECTION

The list of items that are cause for rejection of precast pipe prior to installation are included in the appropriate AASHTO or ASTM Standard as follows:

Non-Reinforced Concrete Pipe

Non-reinforced concrete pipe is covered by Section **907.01**, which references **AASHTO M 86**. The reasons for rejection prior to installation include:

1. Fractures or cracks passing through the wall or joints. However, a single crack not exceeding 2 in. in length at either end of a pipe or a single fracture or spall in the joints not exceeding 3 in. around the circumference of the pipe nor 2 in. in length into joint shall not be considered cause for rejection unless these defects exist in more than 5 percent of the entire shipment or delivery.
2. The planes of the ends of the pipe are not perpendicular to the longitudinal axis. The length of two opposite sides of any section of pipe shall vary not more than 1/4 in. or 2 percent of the designated diameter, whichever is larger.
3. Defects that indicate mixing and molding is not in accordance with the manufacturing requirements.

4. Cracks sufficient to impair the strength, durability, or serviceability of the pipe.

Reinforced Concrete Pipe

Circular Reinforced Concrete Pipe is covered by Section **907.02**, which references **AASHTO M 170**. The reasons for rejection prior to installation include:

1. Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
2. Defects that indicate mixing and molding is not in accordance with the manufacturing requirements or surface defects indicating honey-combed or open texture that would adversely affect the function of the pipe.
3. The ends of the pipe are not normal to the walls and centerline of the pipe as follows:

Length of Two Opposite Sides -- Variations in the laying length of two opposite sides of the pipe shall not be more than 1/4 in. for all sizes through 24 in. internal diameter. For all sizes larger, the variation shall not be more than 1/8 in./ft. with a maximum of 5/8 in. in any length of pipe through 84 in. internal diameter, and a maximum of 3/4 in. for 90 in. internal diameter or larger, except where beveled-end pipe for laying on curves is specified.

Length of Pipe: -- The underrun in length of a section of pipe shall not be more than 1/8 in./ft with a maximum of 1/2 in. in any length of pipe. Regardless of the underrun or overrun in any section of the pipe, the end cover requirements of the specification shall apply.

4. Damaged or cracked ends where such damage would prevent making a satisfactory joint.
5. Any continuous crack having a surface width of 0.01 in. or more and extending for a length of 12 in. or more, regardless of position in the wall of the pipe.

Reinforced Concrete Horizontal Elliptical Pipe

Concrete Horizontal Elliptical Pipe is covered by Section **907.03**, which references **AASHTO M 207**. The reasons for rejection prior to installation include:

1. Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
2. Defects that indicate mixing and molding is not in accordance with the manufacturing requirements or surface defects indicating honey-combed or open texture that would adversely affect the function of the pipe.
3. The ends of the pipe are not normal to the walls and centerline of the pipe as follows:

Length of Two Opposite Sides -- Variations in the laying length of two opposite sides of the pipe shall not be more than 1/4 in. for all sizes through 24 in. internal diameter. For all sizes larger, the variation shall not be more than 1/8 in./ft. of internal equivalent diameter with a maximum of 5/8 in. in any length of pipe through 84 in. internal equivalent diameter, and a maximum of 3/4 in. for 90 in. internal equivalent diameter or larger, except where beveled-end pipe for laying on curves is specified.

Length of Pipe: -- The underrun in length of a section of pipe shall not be more than 1/8 in./ft with a maximum of 1/2 in. in any length of pipe.

4. Damaged or cracked ends where such damage would prevent making a satisfactory joint.
5. Any continuous crack having a surface width of 0.01 in. or more and extending for a length of 12 in. or more, regardless of position in the wall of the pipe for pipe not installed or under load.

Repairs for workmanship and finish may be made for occasional imperfections in manufacture or accidental damage during handling. The Technician is required to determine that the repairs are sound, properly finished, cured, and the repaired pipe conforms to the requirements of the specifications. The Technician should examine the pipe before and after the repairs are made.

The PE/PS has the right to reject any item upon arrival to the contract in accordance with Section 106.01(a), regardless of pre-approval. The INDOT Inspectors Manual for Precast Pipe and Structures should be consulted prior to rejection of any precast pipe product.

Pipes meeting the above-noted requirements are subject to the physical test requirements for strength and absorption.

PHYSICAL TESTING

Compressive Strength

Compressive strength of pipe is determined by testing pieces of pipe in a three-edge bearing machine in accordance with **AASHTO T 280** or by breaking concrete cylinders in accordance with **ASTM C 31**. Compressive strength determined by the three-edge bearing machine is expressed in pounds force per lineal foot (lb/ft) for all non-reinforced concrete pipe. Compressive strength determined by the three-edge bearing machine for reinforced concrete pipe is expressed as the D- load.

D-load is defined in **AASHTO M 262** as the supporting strength of a pipe loaded under three-edge bearing test conditions expressed in pounds per linear foot of inside diameter or horizontal span.

Minimum compressive strength requirements for non-reinforced concrete pipe are found in **AASHTO M 86**; for reinforced concrete pipe in **AASHTO M 170**; and for reinforced concrete horizontal elliptical pipe in **AASHTO M 207**.

There are three methods for compressive strength acceptance: Method A, B, or C. The method used depends on the type and size of the pipe and whether or not the pipe is destroyed.

Method A is used for all non-reinforced concrete pipe and reinforced concrete pipe 24 in. or less in diameter. This method uses a three edge bearing machine. The ultimate load is reached when the pipe sustains no greater load. Reinforced concrete pipe is tested to a load to produce 0.01 in. crack and ultimate strength. Non-reinforced concrete is tested to ultimate strength.

The 0.01 in. crack load is the maximum load applied to a reinforced concrete pipe before a crack having a width that permits the point of the measuring gauge to penetrate 1/16 in., without forcing at close intervals throughout the specified distance of 1 ft. The width of the crack is measured by means of a gauge made from a leaf 0.01 in. in thickness and ground to a point 1/16 in. (Figure 8-4).

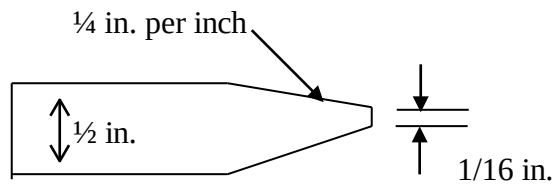


Figure 8-4. Gauge Leaf

Method B is used for reinforced pipe larger than 24 in. in diameter. The pipe is tested on a three edge-bearing machine to the required strength plus 10% overload.

Method C is used for reinforced concrete pipe larger than 72 in. in diameter. Compressive strength cylinders are used for test purposes. Test cylinders 6 in. x 12 in. are made, cured, and stored in the same manner as the pipe represented. Testing of the cylinders is done in accordance with **ASTM C 39**.

For certain size pipe, Method B or C may be used. Elliptical pipe has alternate methods of choice because of physical loading problems into the three edge-bearing machine.

Absorption

The absorption test is conducted on various types of samples depending on the type of compressive strength test conducted and the type of material.

Concrete pipe using Method A for compressive strength requires a sample with approximately 25 in² of surface area and the full depth of the pipe from the destroyed pipe. Pipe that is flaked or fractured is not used. Reinforcing steel is not cut using heat.

For the pipe tested by Method B and Method C, a core is obtained that has a minimum surface area of 9 in² and a thickness equal to the full depth of the pipe. The sample may not be flaked or fractured and the reinforcing steel may not be cut using heat.

Two cores for absorption are required from wet cast units. Some pipe manufacturers dry cast the pipe and therefore absorption requirements do not apply. For dry cast products, acceptance is by strength only.

The Technician submits the samples to the District Lab for testing.

Reinforcement Steel

Placement of reinforcement steel is checked only when Method A is used. Methods B and C do not destroy the pipe. **AASHTO M 170** and **M 207** define the reinforcing steel placement requirements for reinforced concrete pipe. The placement, clearance, splices, and size of reinforcement steel are items that are checked.

INSTALLATION

Pipe installation shall be in accordance with Sections **715.05** and **715.06** including joint sealant/mortar in accordance Section **907.11** through **907.13**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with appropriate material from CAPP sources. As per GIFE 4.20 report structure modification and new construction to either the District Bridge Engineer or Culvert Asset Engineer.

POST-INSTALLATION INSPECTION

Pipe shall be inspected in accordance with Section **715.09** with visual or video inspection performed as required therein.

9 Polyethylene Pipe

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CHAPTER NINE:

Polyethylene Pipe



MATERIALS

There are two specifications for corrugated polyethylene pipe. Smaller diameters (less than 12 in.) are designated as "tubing" in the specifications and elsewhere on INDOT documentation. Corrugated polyethylene tubing is covered in Section **907.17 a)**, which references **AASHTO M 252**. Larger diameters (12 in. and greater) are simply designated "pipe" and covered by Section **907.17 b)**, which references **AASHTO M 294**.

An additional specification found in Section **907.21** covers smooth wall polyethylene pipe in accordance with **ASTM F 714**. However, smooth wall polyethylene pipe is almost never used in direct-bury applications for INDOT storm sewers. Smooth wall Polyethylene pipe is accepted by a Type D Certification.

907.20 covers Profile Wall Polyethylene pipe. The Profile Wall pipe shall be closed profile or ribbed open profile in accordance with ASTM F894.

ACCEPTANCE

FREQUENCY MANUAL

Acceptance information for corrugated polyethylene tubing and pipe is found under Reference 63, Sub References 01 and 02 of 07 in the Frequency Manual.

TYPES

Polyethylene Pipe is a black plastic material. The black appearance is due to the specification requirement that carbon black be used to provide UV resistance. The pipe may also have one or more colored stripes to help identify the manufacturer. Various configurations exist depending on the application and strength needed of the pipe.

Tubing

The specification term “tubing” refers to material in accordance with **AASHTO M 252**. This specification covers material of diameters nominally less than 12 in.

Pipe

The specification term "pipe" when referenced with Poly material indicates material in accordance with **AASHTO M 294**. However, outside of the specifications, pipe may also be used to describe "tubing" as defined above. The specifications differentiate the material based on the diameter. Material covered by **AASHTO M 294** has a nominal diameter of 12 in. or more.

Type C

Pipe or tubing designated as Type C is corrugated and has only a single wall. Thus, industry may refer to Type C pipe or tubing as "single wall".

Type S

Pipe or tubing designated as Type S has a single smooth interior wall as well as a corrugated exterior wall. Because of the corrugated wall and inner liner wall, Industry may refer to Type S pipe or tubing as "dual wall".

Type D

Type D pipe has a dual smooth liner, both interior and exterior with corrugations between the two smooth liners. Industry typically refers to this product as "triple wall" pipe and the main use for this pipe is in sanitary sewer applications.

Perforated Pipe

When either Type C or Type S pipe is also perforated, a “P” is added to the type designation. Thus, perforated Type C becomes Type CP and perforated Type S becomes Type SP.

MARKINGS

The printline on polyethylene corrugated pipe or tubing should appear every 10 ft or less and include the manufacturer, size, specification designation, plant code, and date of manufacture (Figure 9-1).

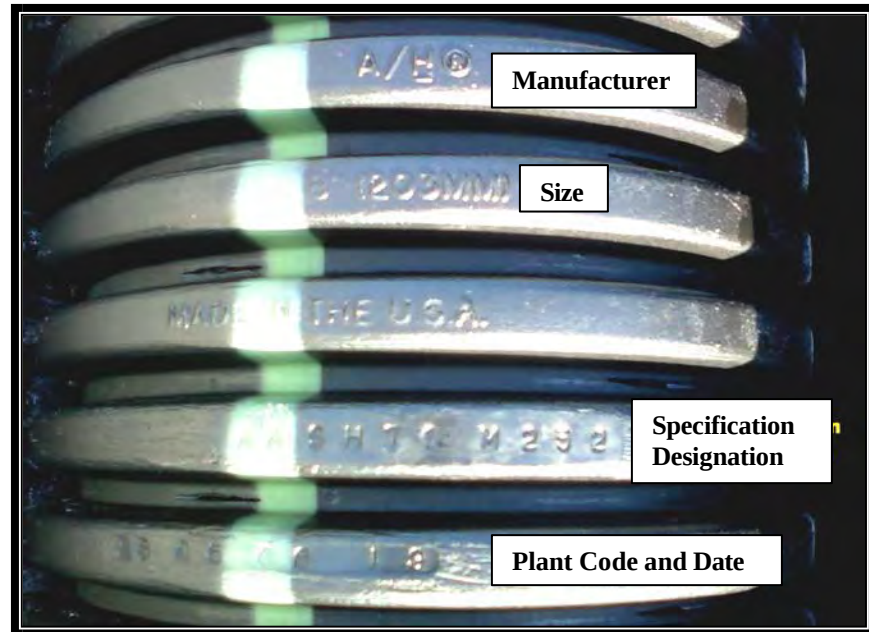


Figure 9-1. Markings on Corrugated Polyethylene Tubing. Top two lines are raised, bottom two are metal tape embossed.

Marking styles vary from manufacturer to manufacturer, facility to facility and within a single plant from size to size. However, the typical systems are somewhat limited and may easily be described. Four types of markings are found on corrugated polyethylene pipe. They are: raised, embossed, pin printing, and dial indicators. Raised markings are typically engraved into the mold blocks used to manufacture pipe. Embossed markings may be raised characters on the blocks or metallic tape applied to the blocks. Pin printers make dot impressions into the pipe to form various characters. These are generally used for indicating date, time, shift and in some cases the plant number.

Dial indicators are instruments incorporated into the mold blocks which may be adjusted. These are typically used to indicate information that regularly changes including year, month, date and shift (Figure 9-2). On occasion, dial indicators are used to indicate the plant number, particularly for manufacturers with multiple plants sharing mold blocks. The dial usually has one or two numerals to guide the reader with dots to indicate the remaining numerals. In some cases, only dots appear and the top is designated as zero or one, depending on the information presented.

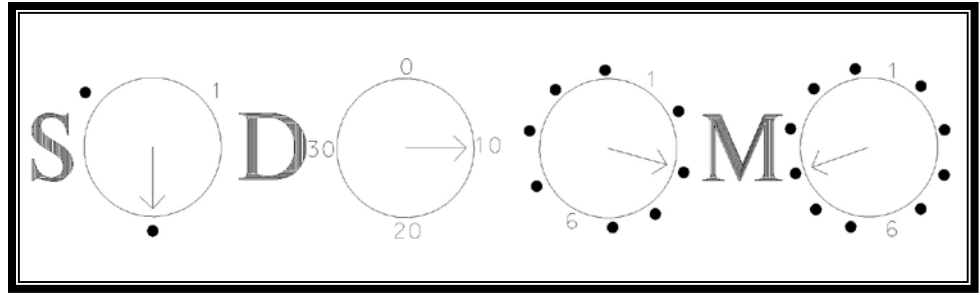


Figure 9-2. Typical Dial Indicators. These represent Shift 2, a date of 13 and month 9, respectively.

APPROVED SOURCES

Sources of Polyethylene Corrugated Pipe and Tubing are approved in accordance with **ITM 806, Procedure O** and may be found on the Plastic Pipe and Liner Sources List. Sources are listed by specification (tubing for **AASHTO M 252** and pipe for **AASHTO M 294**), type and diameter. 907.20 covers Profile Wall Polyethylene pipe and is accepted by means of a Type D Certification. All aspects of the pipe shall be verified with the information provided as approved for the supplying manufacturer.

See Figure 9-3 for a complete summary of Thermoplastic Pipe Specification Requirements, taken from INDOT Standard Specifications 907.16.

CERTIFICATIONS

No certifications are required; however, the invoice and pipe markings should be consistent with contract requirements or as stated in the specifications.

INSTALLATION

Pipe installation shall be in accordance with Section **715.05** and **715.06** including joint seals in accordance Section **907.27** and **ASTM F 477**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with appropriate aggregate material coming from CAPP sources.

POST-INSTALLATION INSPECTION

Polyethylene Corrugated Pipe and Tubing is required to be visual or video inspected and 100% mandrel tested no less than 30 days after installation in accordance with Section **715.09**.

SUMMARY OF THERMOPLASTIC PIPE SPECIFICATION REQUIREMENTS				
Pipe Material	Standard Specification	AASHTO	ASTM	Manufacturer Requirement
Corrugated Polyethylene Drainage Tubing	907.17(a)	M 252		ITM 806, Procedure O
Corrugated Polyethylene Pipe	907.17(b)	M 294*		ITM 806, Procedure O
Corrugated Polypropylene Pipe	907.19	M 330		ITM 806, Procedure O
Perforated PVC Semicircular Pipe	907.18		D3034	~~ITM 806, Procedure A~~ 916, Type D certification
Profile Wall HDPE Liner Pipe	907.25(b)		F894	~~ITM 806, Procedure A~~ or 916, Type A C certification
Profile Wall PVC Liner Pipe	907.25(c)		F949	~~ITM 806, Procedure A~~ or 916, Type A C certification
Profile Wall PVC Pipe	907.22 907.24(c)	M 304		ITM 806, Procedure O
Profile Wall Polyethylene Pipe	907.20		F894	~~ITM 806, Procedure A~~ 916, Type D certification
PVC Plastic Pipe, Schedule 40	907.24(b)		D1785	916, Type C C certification
Slotted Vane Drain Pipe	908.14	M 278	F679	~~ITM 806, Procedure A~~ 916, Type D certification
Smooth Wall Polyethylene Pipe	907.21 907.24(d)		F714	~~ITM 806, Procedure A~~ 916, Type D certification
Smooth Wall PVC Pipe	907.23 907.24(e)	M 278	F679	~~ITM 806, Procedure A~~ 916, Type D certification
Solid Wall HDPE Liner Pipe	907.25(a)		F714	ITM 806, Procedure Q or 916, Type A C certification
Type PSM PVC Pipe and Fittings	907.24(a)		D3034	~~ITM 806, Procedure A~~ 916, Type D certification
* Pipe in accordance with AASHTO M 294 shall be manufactured with virgin materials.				

Figure 9-3

MANDREL TESTING

Mandrel testing is required to determine the severity of deflection, if any, after pipe has been installed and subjected to loading due to backfill. Specifications allow up to a 5% deflection with no remedial action required. For this reason, the mandrel shall be 95% of the nominal diameter of the pipe. Section **715.09** requires that the mandrel have a minimum of nine radial protrusions.



Figure 9-4. Typical 9-arm mandrels

The mandrel testing shall occur no sooner than 30 days after backfill operations are complete. This allows the backfill material time to settle and for any potential deflection to occur. Once mandrel testing is complete, deflections greater than 5% shall be corrected in accordance with Section **715.09** from joint to joint, structure to structure or joint to structure in the affected area. Also see Chapter 5 for additional Mandrel Testing requirements.

10 Polypropylene Pipe

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CHAPTER Ten:

Polypropylene Pipe



MATERIALS

Sources of Polypropylene Corrugated Pipe are approved in accordance with **ITM 806, Procedure O** and may be found on the Thermoplastic Pipe and Liner Sources List. Sources are listed by specification (**AASHTO M 330**), type and diameter. All aspects of the pipe shall be verified with the information provided as approved for the supplying manufacturer.

ACCEPTANCE

IDENTIFICATION

Polypropylene Pipe is a gray plastic material. The gray appearance is due to colorants used to provide UV resistance. The pipe may also have one or more colored stripes to help identify the manufacturer. Various configurations exist depending on the application and strength required of the pipe.

TYPES

Type C

Pipe designated as Type C is corrugated and has only a single wall and is referred to as "single wall".

Type S

Pipe designated as Type S has a single smooth interior wall, a corrugated exterior wall, and is referred to as "dual wall".

Type D

Type D pipe has both an interior smooth liner and exterior smooth liner with corrugations between the two smooth liners. Industry typically refers to this product as "triple wall" pipe, and the main use of the pipe is in sanitary sewer applications.

Perforated Pipe

When either Type C or Type S pipe is also perforated, a "P" is added to the type designation. Thus, perforated Type C becomes Type CP and perforated Type S becomes Type SP.

MARKINGS

The print line on polypropylene pipe (Figure 12-1) should appear every 10 ft or less and shall include the manufacturer, size, specification designation, plant code and date of manufacture.



Figure 12-1: Raised Markings on 24 in. Polypropylene Pipe

Marking styles vary from manufacturer to manufacturer, facility to facility and within a single plant from size to size. However, the typical systems are somewhat limited and may easily be described. Four types of markings are found on corrugated polypropylene pipe as follows:

1. Raised markings are typically engraved into the mold blocks used to manufacture pipe.
2. Embossed markings may be raised characters on the blocks or metallic tape applied to the blocks.
3. Pin printers will make dot impressions into the pipe to form various characters. These are generally used for indicating date, time, shift and in some cases the plant number.

4. Dial indicators (Figure 12-2) are instruments incorporated into the mold blocks which may be adjusted. These are typically used to indicate information that regularly changes including year, month, date and shift. On occasion dial indicators are used to indicate the plant number, particularly for manufacturers with multiple plants sharing mold blocks. The dial usually has one or two numerals to guide the reader with dots to indicate the remaining numerals. In some cases, only dots appear and the top is designated as zero or one, depending on the information presented.

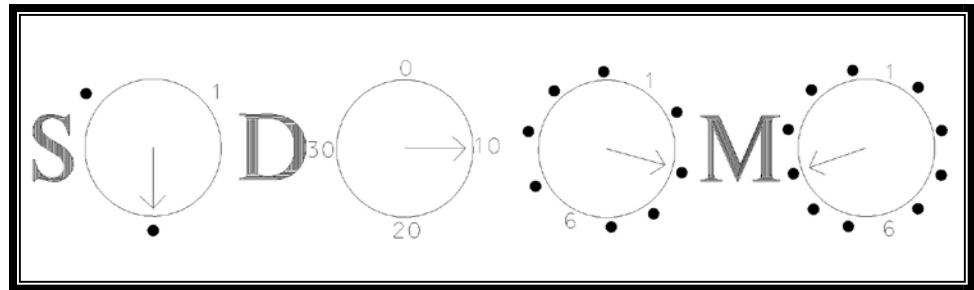


Figure 12-2: Typical Dial Indicators. These represent Shift 2, a date of 13 and month 9, respectively.

APPROVED SOURCES

See Page 9-5 (Figure 9-3) for a summary of Thermoplastic Pipe specification requirements. All polypropylene pipe shall be in accordance with 907.19 and AASHTO M 330, along with being selected from a Supplier listed on the QPL for Thermoplastic Pipe.

CERTIFICATIONS

No certifications are required. The invoice and pipe markings are required to be consistent with contract requirements or as stated in the specifications.

INSTALLATION

Pipe installations are required to be in accordance with Sections **715.05** and **715.06** including joint seals in accordance Section **907.27** and **ASTM F 477**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with aggregates from CAPP sources.

POST-INSTALLATION INSPECTION

Polypropylene Pipe shall be visual or video inspected and 100% mandrel tested no less than 30 days after installation in accordance with Section **715.09**.

MANDREL TESTING:

Mandrel Testing will be in accordance with 715.09 and as shown on pages 5-4 & 9-6 of this Manual.

11 Polyvinylchloride (PVC) Pipe

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CHAPTER ELEVEN:

Polyvinyl Chloride (PVC) Pipe

MATERIALS

Profile Wall PVC Pipe and Schedule 40 PVC Pipe are the two polyvinyl chloride (PVC) pipe products: Profile Wall PVC is covered by Section **907.22**, which references **AASHTO M 304** and **ASTM F 949**. These standards are similar, but have a few distinct differences of which stiffness is the most notable, and for this reason pipe made to each standard is treated somewhat differently in the specifications. Schedule 40 PVC is covered by Section **907.24(b)**, which references **ASTM D1785**. In addition, several other PVC pipes are used on INDOT projects and are worth noting. Perforated PVC Semi Circular Pipe in accordance with 907.18 and ASTM D3034, DR 35. Smoothwall PVC Pipe in accordance with 907.23 and AASHTO M 278 for 4 in to 15 in and ASTM F679 for 18 in to 27 in. Smoothwall PVC will also include Slotted Vane Drain Pipe, per 908.14. Along with Type PSM PVC Pipe and Fittings in accordance with 907.24 (a) & ASTM D 3034, DR 23.5 and are both accepted by means of a Type D Certification.

ACCEPTANCE

FREQUENCY MANUAL

Acceptance for profile wall PVC pipe is found under Reference 63, Sub Reference 02 of 07 in the Frequency Manual. Schedule 40 PVC is found under Reference 63, Sub Reference 03 of 07.

IDENTIFICATION

Profile Wall PVC Pipe may be white, light green or light blue depending on the manufacturer and application. For white pipe, the color is a result of the use of Titanium Dioxide used to provide UV resistance. For colored pipe, yellowing and/or fading are indications that the pipe has had significant UV exposure which is cause for rejection of the pipe. The pipe will have either a corrugated, ribbed or smooth exterior configuration. The smooth profile will be a cellular structure with two smooth liners and periodic internal ribs for strength.

Schedule 40 PVC Pipe is typically white and is also so colored due to the presence of titanium dioxide. The pipe is a single wall pipe with a smooth interior and exterior.

Markings

The print line on profile wall PVC pipe should appear every 5 ft or less and include the manufacturer, size, minimum cell classification, the legend "DRAIN PIPE", and the specification designation.

Schedule 40 PVC pipe is required to include the manufacturer and specification designation as a minimum.

APPROVED SOURCES

Sources of Profile Wall PVC Pipe are approved in accordance with **ITM 806, Procedure O** and are included on the Thermoplastic Pipe and Liner QPL.

There is no QPL for Schedule 40 PVC Pipe.

Perforated PVC Semi Circular Pipe, Smoothwall PVC Pipe, Type PSM PVC Pipe & Fittings will be considered for inclusion on the QPL by completing requirements set forth in ITM 806 Procedure A.

See Page 9-5 (Figure 9-3) for a summary of Thermoplastic Pipe specification requirements.

CERTIFICATIONS

No certifications are required for Profile Wall PVC Pipe; however, the invoice and pipe markings should be consistent with contract requirements or as stated in the specifications.

Schedule 40 PVC Pipe is accepted by a Type C Certification provided the pipe specification designation appears in the print line on the pipe.

Slotted Vane Drain Pipe, per 908.14. Along with Type PSM PVC Pipe and Fittings in accordance with 907.24(a) and Smoothwall PVC Pipe in accordance with 907.23 are accepted by means of a Type D Certification.

INSTALLATION

Pipe installation is required to be in accordance with Sections **715.05** and **715.06** including joint seals in accordance Section **907.27** and **ASTM F477**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with aggregates from CAPP sources.

POST-INSTALLATION INSPECTION

Pipe shall be inspected in accordance with Section **715.09** with visual or video inspection performed as required therein. In addition, 100% mandrel testing is required no less than 30 days after installation in accordance with Section **715.09** for **AASHTO M 304** material only. No mandrel testing is required for Schedule 40 PVC or pipe identified as **ASTM F 949** compliant, including pipe meeting **AASHTO M 304** specifications.

12 Reinforced Thermosetting Resin Pipe

Materials

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Identification

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CHAPTER TWELVE:

Reinforced Thermosetting Resin Pipe



MATERIALS

Reinforced thermosetting resin pipe is constructed of plastic resin and a reinforcing medium, such as glass fiber, in multiple layers to form the pipe wall. Properties such as strength are modified through the inclusion of the reinforcing medium. Currently this type of pipe is only approved for use in bridge deck drainage systems. Therefore, the material is stabilized by incorporating a UV inhibitor, which may vary from manufacturer to manufacturer. The pipe is covered in Section **907.28**, which references **ASTM D 2996**.

ACCEPTANCE

FREQUENCY MANUAL

Acceptance information for reinforced thermosetting resin pipe is located in Reference 73, Sub Reference 03 of 04 of the Frequency Manual.

IDENTIFICATION

Reinforced Thermosetting Resin Pipe is a composite material and is required to match color No. 26400 of the Federal Standard 595 which is a gray color. Painting, gel-coating, or exterior coating of the pipe to obtain the specified color is not allowed.

Markings

The print line or durable label on reinforced thermosetting resin pipe should appear on each section and include the nominal size, designation code, specification (**ASTM D 2996**) and manufacturer identification.

Designation Code

The designation code as defined in **ASTM D 2996** is constructed by the letters “RTRP” for Reinforced Thermosetting Resin Pipe followed by two sets of information separated by hyphens. The first set is a five digit alphanumeric code indicating type, grade, class, hydrostatic design basis and type of end closure. Of these, only the first digit is defined in the specifications and shall be "1". The second set is a four digit numeral indicating the cell classification. Each digit represents short-term rupture strength, longitudinal tensile strength, longitudinal tensile modulus and apparent stiffness, respectively. When left unspecified, the value may be zero. Since only the short-term rupture strength is defined in the specifications, the cell classification could read "2000". Thus, project personnel should look for a code of:

RTRP-1 _ _ _ _ - 2000*.

**Note that the underscores indicate unspecified values and could vary and that each of the last four digits is a minimum and each could be greater than the digits displayed herein.*

APPROVED SOURCES

There is no QPL for sources of Reinforced Thermosetting Resin Pipe.

CERTIFICATIONS

A Type A Certification is required by specifications in accordance with 916 and shall include the results for measurement of wall thickness and diameter in accordance with **ASTM D 3567** and short-term hydrostatic failure strength in accordance with **ASTM D 1599**. Though direct bury of this material is not currently allowed, the stiffness factor (in accordance with **ASTM D 2412** at 5% deflection) would also be required if used in such an application.

In addition to the Type A Certification, the pipe should also be accompanied by test results indicating that the product meets accelerated weathering requirements after 2500 hours of exposure at Cycle 2 in accordance with **ASTM G 154**. The test results need not be current but should be indicative of the formulation used to manufacture the pipe delivered.

INSTALLATION

Pipe installation shall be in accordance with the manufacturer recommendations. Installation instructions should accompany the pipe at time of delivery.

POST-INSTALLATION INSPECTION

No mandrel testing or other post-installation inspection process is specified for Reinforced Thermosetting Resin Pipe.

13 Metal Pipe

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Pipe Order

Metal Pipe Types

Metal Pipe Inspection

Inspection

Workmanship

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CHAPTER THIRTEEN:

Metal Pipe

Metal pipe is covered in Section **908** and includes corrugated steel pipe, corrugated aluminum alloy pipe, fully bituminous coated corrugated and lined steel pipe, polymer precoated galvanized steel culvert pipe, structural steel and aluminum plate pipe, cast iron soil pipe, steel pipe, and slotted drain or slotted vane drain pipe.

MATERIALS

BASE METAL

Galvanized Steel

Galvanized steel used to construct corrugated metal pipe is covered by Section **908.02**, which references **AASHTO M 36** and **M 218**.

Aluminized Steel

Aluminized steel used to construct corrugated metal pipe is covered by Section **908.02**, which references **AASHTO M 36** and **M 274**.

Aluminum

Aluminum or Aluminum alloy used to construct corrugated metal pipe is covered by Section **908.04**, which references **AASHTO M 196**.

LINING

Bituminous

Bituminous lining of metal pipe is covered by Section **908.07**. The material is specified in Section **902.01(e)** and is located under Reference 1, Sub Reference 03 of 03 of the Frequency Manual.

Polymer

Polymer lining of metal pipe is covered by Section **908.08** which references **AASHTO M 245** and **M 246**.

ACCEPTANCE

The table from 908.01 lists the acceptance requirements for each kind of metal pipe.

<i>SUMMARY OF METAL PIPE SPECIFICATION REQUIREMENTS</i>				
<i>Pipe Material</i>	<i>Standard Specification</i>	<i>AASHTO</i>	<i>ASTM</i>	<i>Manufacturer Requirement</i>
Required to be furnished from a manufacturer on the QPL include:				
<i>Corrugated Aluminum Alloy Pipe and Pipe-Arches</i>	908.04	M 196		ITM 806, Procedure O
<i>Corrugated Steel Pipe and Pipe-Arches</i>	908.02	M 36		ITM 806, Procedure O
<i>Fully Bituminous Coated Corrugated and Lined Steel Pipe and Pipe-Arches</i>	908.07	M 36		ITM 806, Procedure O
<i>Polymer Precoated Galvanized Corrugated Steel Culvert Pipe and Pipe-Arches</i>	908.08	M 245		ITM 806, Procedure O
<i>Slotted Drain Pipe</i>	908.14	pipe: M 36	grate: A36, Grade 36	ITM 806, Procedure O

Not required to be furnished from the QPL:				
<i>Cast Iron Soil Pipe</i>	908.10		A74	Buy America Certification
<i>Steel Pipe</i>	908.11		A139, grade B or A53 Type E, grade B	Type C Certification; Buy America Certification
<i>Structural Plate Pipe, Pipe-Arches, and Arches; Aluminum Alloy</i>	908.09(b)	M 219		Certified Mill Report; Fabricator Certification; Buy America Certification
<i>Structural Plate Pipe, Pipe-Arches, and Arches; Steel</i>	908.09(a)	M 167 and LRFD Bridge Construction Specifications		Certified Mill Report; Fabricator Certification; Build America Certification

Figure 13-1

FREQUENCY MANUAL

Acceptance and sampling information for metal pipe is located under Reference 70, Sub Reference 01 of 01 in the Frequency Manual.

CERTIFICATIONS

When a Certified Mill Report and Fabricator Certification is Specified, the manufacturer is required to furnish to the fabricator a certified mill report for materials shipped to the fabricator. The certified mill report lists the type of base metal, actual test results of the chemical analysis, mechanical tests of each heat, and thickness and weight of coating. The report is required to certify compliance of the material with specified requirements for the type of metal furnished.

Even though manufacturers are required to be selected from the Qualified Producer List, a Buy America or Build America Certification shall be provided for Metal Pipe in accordance with 916 or as stated herein.

APPROVED SOURCES

A QPL of Metal Pipe sources for the identified pipe materials is specified in 908.01. This table also specifies additional metal pipe that is not covered by the QPL. Metal Pipe end sections should be in accordance with AASHTO M 36 or M 196, along with providing a Mill Report and Fabricator Certification as specified above. Buy America or Build America Certs are also required for each type of pipe and end section. All materials used on INDOT contracts and purchase orders are required to be approved prior to being incorporated into a contract.

PIPE ORDER

Once the Contractor determines that metal pipe will be used or metal pipe is specified in the plans, a pipe order is established by the Contractor by structure number, length, diameter, metal gauge, and any coating required. The pipe order is sent to the pipe supplier or manufacturer requesting delivery of the pipe required for the contract. At this point, the Contractor notifies the on-site INDOT Technician.

METAL PIPE TYPES

Corrugated Steel Pipe and Pipe-Arches

Are manufactured in accordance with AASHTO M 36 and shall be zinc coated steel or aluminum. Acceptable types of pipe are I, IA, IR, II, and IIA.

Corrugated Aluminum Alloy Pipe and Pipe-Arches

Are manufactured in accordance with AASHTO M 196. Acceptable types of pipe are I, IA, II or IIA.

Metal End Sections

Are manufactured in accordance with AASHTO M 36 or M 196. A sheet manufacturer's certified mill report and the fabricators certification will be provided. All steel pipe end sections shall have a .138 inch thick galvanized steel toe plate. Straps for the end section shall be either galvanized No. 6 reinforcing bars or zinc coated 3/8 inch diameter aircraft cable. Multiple panels shall have a lap seam tightly jointed with 3/8 inch galvanized rivets or bolts.

Structural Plate Pipe, Pipe-Arches and Arches

Shall be constructed from individually galvanized corrugated steel plates. The individual plates shall be in accordance with AASHTO M 167 and AASHTO LRFD Bridge Construction Specifications. Materials and fabrications shall be in accordance with 908.09. A sheet manufacturer's certified mill report and the fabricators certification will be provided.

Steel Pipe

This item shall be electric fusion, arc-welded steel in accordance with ASTM A139, grade B or electric-resistance welded pipe in accordance with ASTM A53, Type E, grade B. A Type C Certification is required for acceptance.

Cast Iron Soil Pipe

The pipe shall be in accordance with ASTM A74 and 908.10.

Slotted Drain Pipe

Shall be manufactured in accordance with 908.14 and AASHTO M 36. The grated assembly shall be made of structural steel in accordance with ASTM A36 and as shown on the plans with appropriate galvanization.

Bituminous Coated Corrugated Metal Culvert Pipe

There are four types of pipe that may be specified using a bituminous coating. INDOT routinely uses Types A, B, and C. Section **902.01(e)** includes the requirements for coating.

Pipe may be ordered as “Fully Bituminous Coated”, “Fiber Bonded Bituminous Coated”, and an additional note may be added for “with paved invert”. For these materials, the pipe source has a “dip” tank of asphalt material that allows sections of the pipe to be coated with a layer of asphalt material. Asphalt for coating corrugated metal pipe is accepted by tests conducted by the Supplier. A Type A certification is required to be supplied to the pipe manufacturer.

METAL PIPE INSPECTION

District Testing & Pipe Inspectors should routinely check metal pipe for appropriate material and workmanship that is manufactured and delivered onsite:

Dimension Checks

- 1) The diameter (if pipe arch: span and rise) on the inside crest of the corrugations.
- 2) The length of the pipe. Any material used to produce an end finish is not included.
- 3) The thickness of the pipe with a micrometer on the tangent of the corrugations not less than 3/8 in. from the end of the pipe (Figure 13-2).

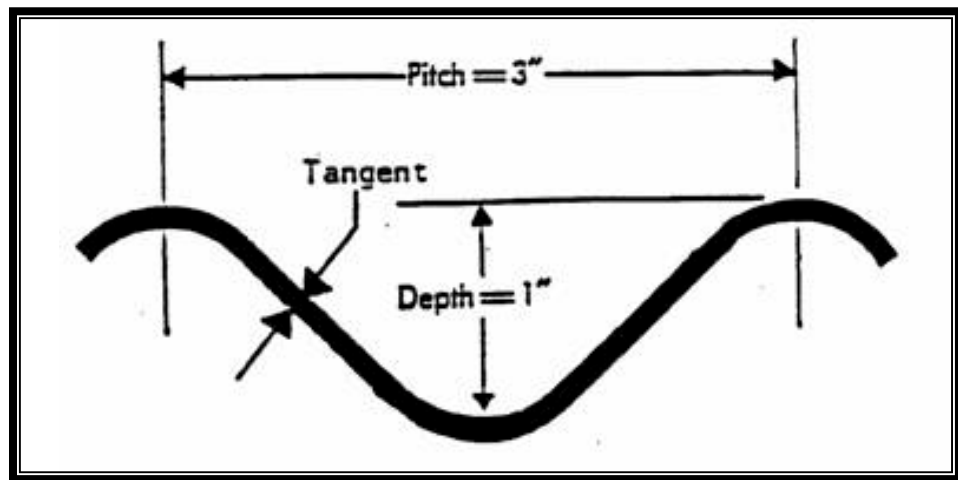


Figure 13-2: 3 x 1 in. Corrugation

The galvanizing thickness is checked with a thin film thickness gauge. The thickness requirements are in the appropriate AASHTO specification.

When a pipe fails the thickness or coating requirements, the Technician is required to inspect all of the pipes with the same heat number.

Corrugations

Corrugations are required to be checked for correctness at the start of production. Once in continuous production, District Testing is required to visually inspect each pipe and occasionally spot check a pipe for compliance.

The three corrugation checks that are done are:

- 1) Corrugation depth - measured on the outside of the pipe from a straightedge laid along the crest of the corrugations parallel to the longitudinal axis of the pipe. The distance from the straightedge to the valley of the corrugation is the corrugation depth (Figure 13-2).
- 2) Corrugation pitch - the distance from crest to crest of successive corrugations (Figure 13-2).
- 3) Corrugation angle - measured from a straightedge parallel to the longitudinal axis of the pipe. The angle formed by the straightedge and the crests and valleys of the corrugation is the corrugations angle.

Corrugations are required to form smooth continuous curves and tangents. The corrugations are either annular, spiral, or annular and spiral. The crests and valleys of annular corrugations are required to form circumferential rings (complete or partial) about the axis of the culvert. Spiral corrugations form helics about the axis. The direction of the crests and valleys of the spiral corrugations in the pipe with diameters greater than 21 in. are required to be not less than 60 degrees from the longitudinal axis of the pipe.

Seams

Three types of seams are acceptable:

- 1) Riveted seams are required to use rivets from the same base metal as the pipe and be thoroughly galvanized or standardized. All rivets are driven cold in such a manner that the plates are drawn tightly together throughout the entire lap. The center of a rivet is required to be no closer than twice the diameter from the edge of the sheet. All rivets are required to have neat, full hemispherical shape. The rivets are required to completely fill the hole and be driven without bending.

Longitudinal seams for riveted pipe are required to be staggered so no more than three plates are held by one rivet. For pipe arches, the seam is in the upper part of the pipe, not in the corners, radius, or inverts. Longitudinal seams are riveted with one rivet in the valley of each corrugation. The longitudinal seams of all pipes 42 in. or greater in diameter and all sizes of pipe having 3 in. x 1 in. corrugation are double riveted in the valley of each corrugation.

The longitudinal seams of all pipe having 5 in. x 1 in. corrugations are double riveted in both the valley and on the crest of each corrugation.

Circumferential, shop-riveted seams have a maximum rivet spacing of 6 in. on centers, except that 6 rivets are sufficient in 12 in. pipe.

- 2) A Lock Seam is a continuous spiral where the seams are made as the corrugations are being formed. The technician visually inspects the lock seam to check that the lapped surfaces are in tight contact. Roller indentations are not allowed to cause cracks in the sheet or loss of metal contact within the seam. Damaged metallic coating is repaired in accordance with **AASHTO M 36**. Sampling and testing of continuous lock seams is required to conform to **AASHTO T 249**. Figure 13-3 lists examples of satisfactory and unsatisfactory continuous lock seams.
- 3) Welded seams are required to be visually inspected. Welded seam pipe is required to have a continuous welded seam extending from end to end of each length of pipe section. Cracks, skips, or deficient welds are not allowed. The combined width of weld and adjacent coating burned by welding is required to not exceed three times the metal thickness. Sampling and testing of welded seam is required to be in accordance with **AASHTO T 241**.

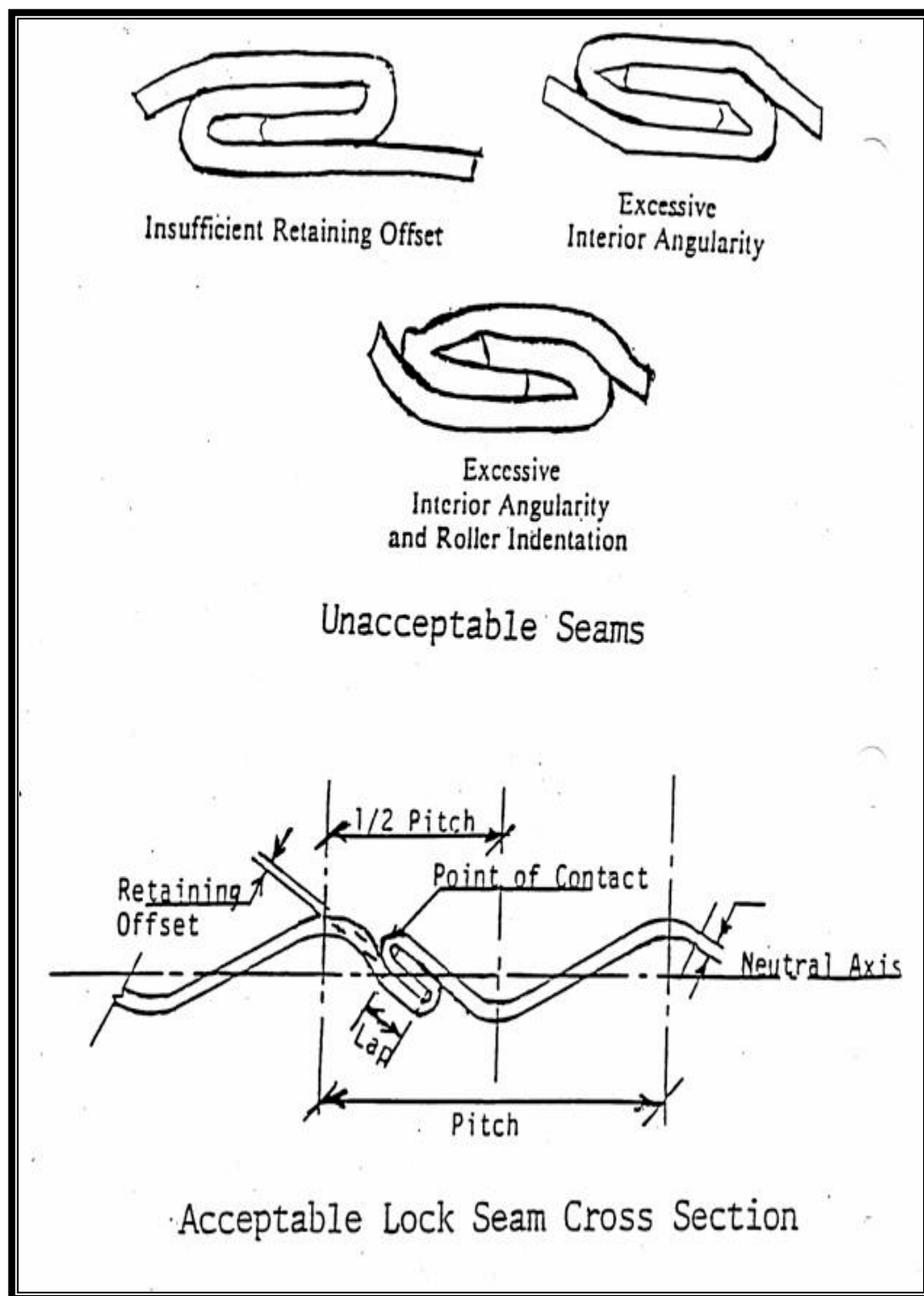


Figure 13-3: Lock Seams

End Finish

The end finish allows the field jointing of the individual pieces. When the ends of helically corrugated lock seam pipe have been re-rolled to form circumferential corrugations, the lock seam in the re-rolled end may not contain any visible cracks in the base metal. The diameter of re-rolled ends may not exceed that of the pipe barrel by more than the depth of the corrugation. All types of pipe ends, whether re-rolled or not, are required to be matched in a joint such that the maximum difference in the diameter of abutting pipe ends is 1/2 in.

Coupling Band

Coupling bands for metal pipe are required to comply with the following:

- 1) Conform to the requirements of **AASHTO M 36, M 218, or M 274**, depending on the type of metallic coating on the pipe
- 2) Have corrugations that mesh with corrugations of the pipe
- 3) Be more than three nominal sheet thicknesses lighter than the pipe to be connected and in no case less than 0.052 in.
- 4) Be constructed as to lap an equal portion of each culvert section to be connected

WORKMANSHIP

In addition to compliance with the details of construction, the completed pipe is required to show careful, finished workmanship in all particulars. The metallic coating adherence is required to be such that no peeling occurs while the sheets are corrugated and formed into culverts. Culvert pipe that has metallic coating bruised or broken, either in the shop or in shipping, is rejected or repaired to the satisfaction of INDOT. Culvert pipe on which the metallic coating shows defective workmanship is rejected.

The following defects are specified as constituting poor workmanship. The presence of any of the defects in any individual culvert pipe constitutes sufficient cause for rejection.

- 1) Uneven laps
- 2) Elliptical shaping, unless specified
- 3) Variation from a straight center line
- 4) Ragged or diagonal sheared edges
- 5) Loose, unevenly lined, or spaced rivets or bolts
- 6) Poorly formed rivet heads
- 7) Unfinished ends
- 8) Illegible brands
- 9) Lack of rigidity
- 10) Bruised, scaled, or broken spelter coating
- 11) Dents or bends in the metal itself
- 12) Spelter rust (white rust)
- 13) Poorly formed helical lock seams
- 14) Unsatisfactory welded seams
- 15) Twisted so that ends do not lay on bedding satisfactorily

The metalizing is required to be done so that the completed pipe shows careful finished workmanship in all particulars. Pipes that have not been cleaned or coated satisfactorily are not accepted. Repairs to metallic coating are required to be in accordance with **AASHTO M 36**.

Section **717** details furnishing and placing structural plate pipe, pipe arches, and arches. Material specifications are included in Section **908.09** and in **AASHTO M 167**. Structural plate pipe is often called multi-plate pipe.

Multi-plate pipe consists of individual corrugated and galvanized steel plates that when bolted together form an arch shaped pipe of any length specified. Normally, the manufacturer cuts plates of the required thickness and type of corrugations, cuts bolt holes for the assembly, and furnishes bolts for assembly. The plates include a bottom plate, side plates, and a top plate delivered to the job-site for assembly in place. Sampling and testing of the plates is required to be in accordance with the Frequency Manual.

INSTALLATION

Pipe installation, including coupling bands for joints, is required to be in accordance with Sections **715.05** and **715.06**. Bedding and backfill shall be in accordance with the standard drawings and Section **715.09** with appropriate material from Certified Aggregate Producer sources.

For a new structure or a pipe extension, the base metal and coating are required to be the same material throughout the structure and any end sections to prevent galvanic action.

POST-INSTALLATION INSPECTION

Metal pipe is required to be inspected in accordance with Section **715.09** with visual or video inspection performed as required therein.

14 Metal Pipe Structures

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Base Metal
Sample Sizes

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Testing

Installation

Plates
Bolts
Plate Identification and Location
Pipe-Arch Assembly
Bolting

Post-Installation Inspection

CHAPTER FOURTEEN:

Metal Pipe Structures

MATERIALS

BASE METAL

Galvanized Steel used to construct structural plate pipe, pipe-arches and arches is covered by Section **908.09(a)**, which references **AASHTO M167**.

Aluminum or Aluminum alloy used to construct structural plate pipe, pipe-arches and arches is covered by **Section 908.09(b)**, which references the **AASHTO M 219**.

Samples of Base Metal are taken as soon as galvanization of the plates is complete or after delivery to the jobsite, depending on the location of the material. Samples shall be cut by sawing and no samples cut by flame or heat will be accepted.

SAMPLE SIZES

A sample specimen is required to be a minimum of 8 square inches (typically 2 in. x 4 in. or 1 in. x 8 in.) for each gage thickness represented in the structure. Samples will be taken in a lap area or from an exposed plate so that the integrity of the structure will not be compromised.

ACCEPTANCE

FREQUENCY MANUAL

Acceptance and sampling information for corrugated metal pipe is included under Reference 73, Sub Reference 01 of 04 of the Frequency Manual.

IDENTIFICATION

A stamp or stencil by the fabricator includes the AASHTO designation, sheet manufacturer, plate fabricator, gauge (thickness), heat or lot number and coating type and weight/thickness. Each plate is required to also identify the location or design so the plate may be properly placed.

Markings shall be placed on the plates such that they appear on the inside of the structure after erection.

APPROVED SOURCES

There are no approved sources for structural plate pipe, pipe-arches or arches.

CERTIFICATIONS

The sheet manufacturer shall furnish to the fabricator a certified mill report which shall list the type of base metal, actual test results of the chemical analysis and mechanical tests of each heat. The certified mill report shall also include the thickness of the base metal and shall certify that the material complies with the applicable specification. Whether separately or as part of the certified mill report, the manufacturer shall certify to the fabricator the coating type and weight (thickness) as described in Section **916**. Certification of compliance with the Buy America requirement is also required as indicated in Section **106.01(c)** and by the FHWA document **23CFR 635.410**. All certifications shall be provided to the Engineer at the time of material delivery and include:

- 1) Mill Certifications
- 2) Galvanization Certifications
- 3) Buy American Certification (not required for aluminum and aluminum alloy)
- 4) Build America

TESTING

Samples of the base metal are obtained at the fabricator or jobsite and submitted to Materials Management for testing the thickness, coating and the chemistry of the metal. Workmanship of the plate pipe is observed by field personnel and includes checking for smooth edges, bolt alignment, and the depth, pitch, and plate radius of the corrugations. Plates are required to be undamaged, including the coating.

INSTALLATION

Pipe installation shall be in accordance with Section **717**. Bedding and backfill shall be in accordance with the standard drawings and Section **717.04** with aggregates from CAPP sources.

Whether the pipe is a new structure or an extension, the base metal and coating shall be the same material throughout the structure to prevent galvanic action. For this reason, the same shall apply to headwalls or other elements in contact with the structure as.

PLATES

The plates for Multi-Plate pipe are furnished as per the plans, shop drawings and Standard Drawing **715-PIPE-02**. Plate widths are approximately 3 ft, 4 ft, 5 ft, 6 ft, and 7 ft wide. The 3 ft wide plate has 4 holes across each end, the 4 ft has 6 holes, the 5 ft has 7 holes, the 6 ft has 8 holes, and the 7 ft plate has 9 holes.

Each plate is identified by numbers stamped into the inside crest of an end corrugation near the middle of the plate, except plates for special ends have these numbers stamped near each corner before cutting. The first three numbers are the sub item number. The second three numbers are the plate radius in inches. The seventh number is the plate gage number, with the exception that 0 is for 10 gage plate, 2 is for 12 gage plate, and a blank designates a thickness greater than 1 gage. The eighth number is the order item number. The last four numbers are the mill order number (Figure 14-1).

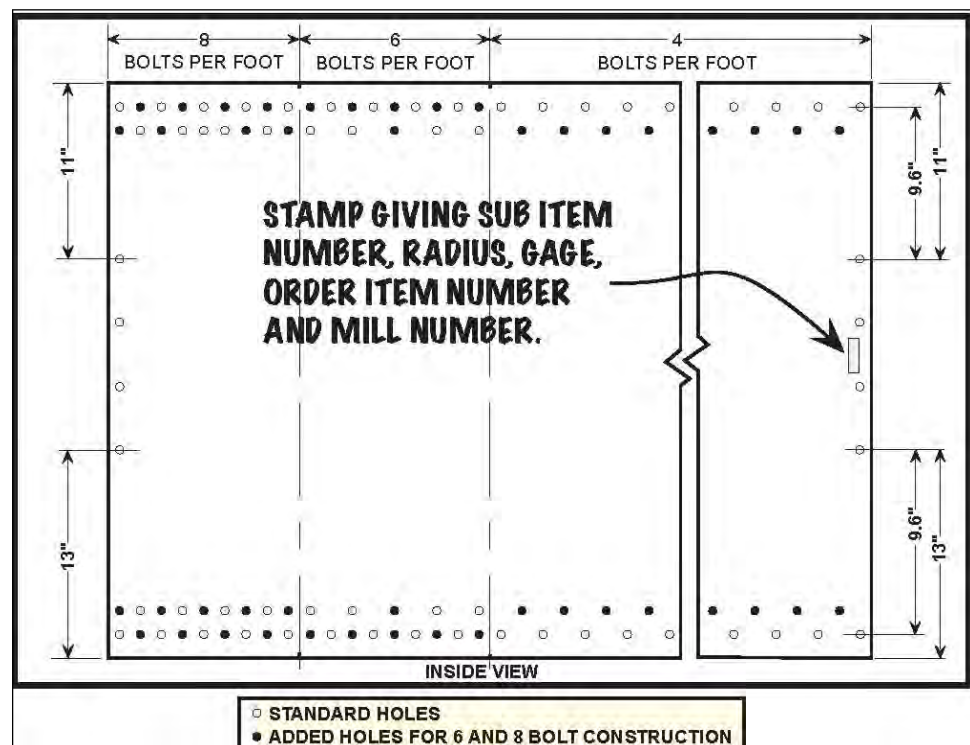


Figure 14-1. Pipe Plate

If the structure is to be erected with skewed or sloped ends, the embossed identification marks are on the inside of each cut plate. Plates to be used in an elbow section are identified with similar embossed numbers on the inside of each cut and welded plate. These numbers correspond to plates marked on the cut end or elbow layout drawing.

BOLTS

For convenience, Multi-Plate bolt and nut containers are stenciled as follows:

3/4 in. x 1-1/4 in.
 3/4 in. x 1-1/2 in.
 3/4 in. x 1-3/4 in.
 3/4 in. x 2 in.
 3/4 in. x 3 in.
 Nuts

Each structure has six 3-in. long service bolts that are used as assembly tools to temporarily draw the plates together where needed. These bolts should not remain in the structure. The required number of bolts for a structure rarely amounts to full keg lots. The carton containing partial amounts of one size also has the required 3-in. bolts. This carton is marked accordingly.

Bolts are furnished in two lengths. The longer length is used for three thicknesses of metal. The length of bolts furnished for the various plate thickness requirements is as follows:

GALVANIZED PLATES

<u>Plate Gage</u>	<u>Thickness</u>	<u>Bolt Lengths</u>
1 Gage	0.280 in.	1-1/2 in. and 2 in.
3 Gage	0.249 in.	1-1/2 in. and 2 in.
5 Gage	0.218 in.	1-1/2 in. and 1-3/4 in.
7 Gage	0.188 in.	1-1/2 in. and 1-3/4 in.
8 Gage	0.168 in.	1-1/4 in. and 1-1/2 in.
10 Gage	0.138 in.	1-1/4 in. and 1-1/2 in.
12 Gage	0.109 in.	1-1/4 in. and 1-1/2 in.

ASPHALT COATED PLATES

<u>Plate Gage</u>	<u>Thickness</u>	<u>Bolt Lengths</u>
1 Gage	0.280 in.	1-3/4 in. and 2 in.
3 Gage	0.249 in.	1-3/4 in. and 2 in.
5 Gage	0.218 in.	1-3/4 in. and 2 in.
7 Gage	0.188 in.	1-3/4 in. and 2 in.
8 Gage	0.168 in.	1-1/2 in. and 1-3/4 in.
10 Gage	0.138 in.	1-1/2 in. and 1-3/4 in.
12 Gage	0.109 in.	1-1/2 in. and 1-3/4 in.

The longer of the two bolt lengths is placed in the corners of the plates where three thicknesses of metal overlap and in the hole next to the corner in the longitudinal seam. The shorter of the two bolts is placed where only two thicknesses of metal overlap (Figure 14-2).

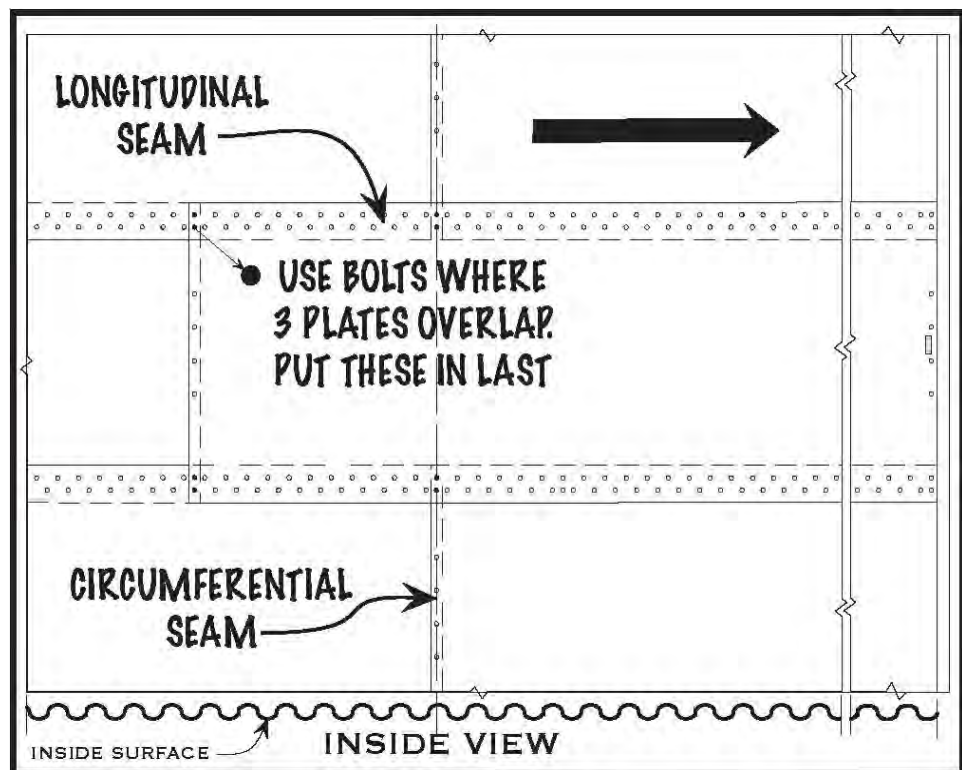


Figure 14-2. Bolt Placement

PLATE IDENTIFICATION AND LOCATION

The various widths of plates are located in the barrel in accordance with the plate layout drawings. The numbers appearing in the barrel area or on the plates are the number of bolt holes across the end of each plate. The line layout and/or plate layout shows total 10-ft and 12-ft-long rings making up the structure.

The beginning and ending rings are indicated in Figure 14-3 for square end structures and these structures contain combinations of 10-ft and 12-ft rings required to obtain the proper plate stagger. Special plates in cut end structures are shown on the plate layout together with the necessary 10-ft and 12-ft long plates required to obtain the proper seam stagger in the barrel. Intermediate barrel rings contain plates which are all the same length. For cut plates and elbow cut and welded plates, the numbers appear on the plate layout corresponding to the embossed numbers on the plates themselves.

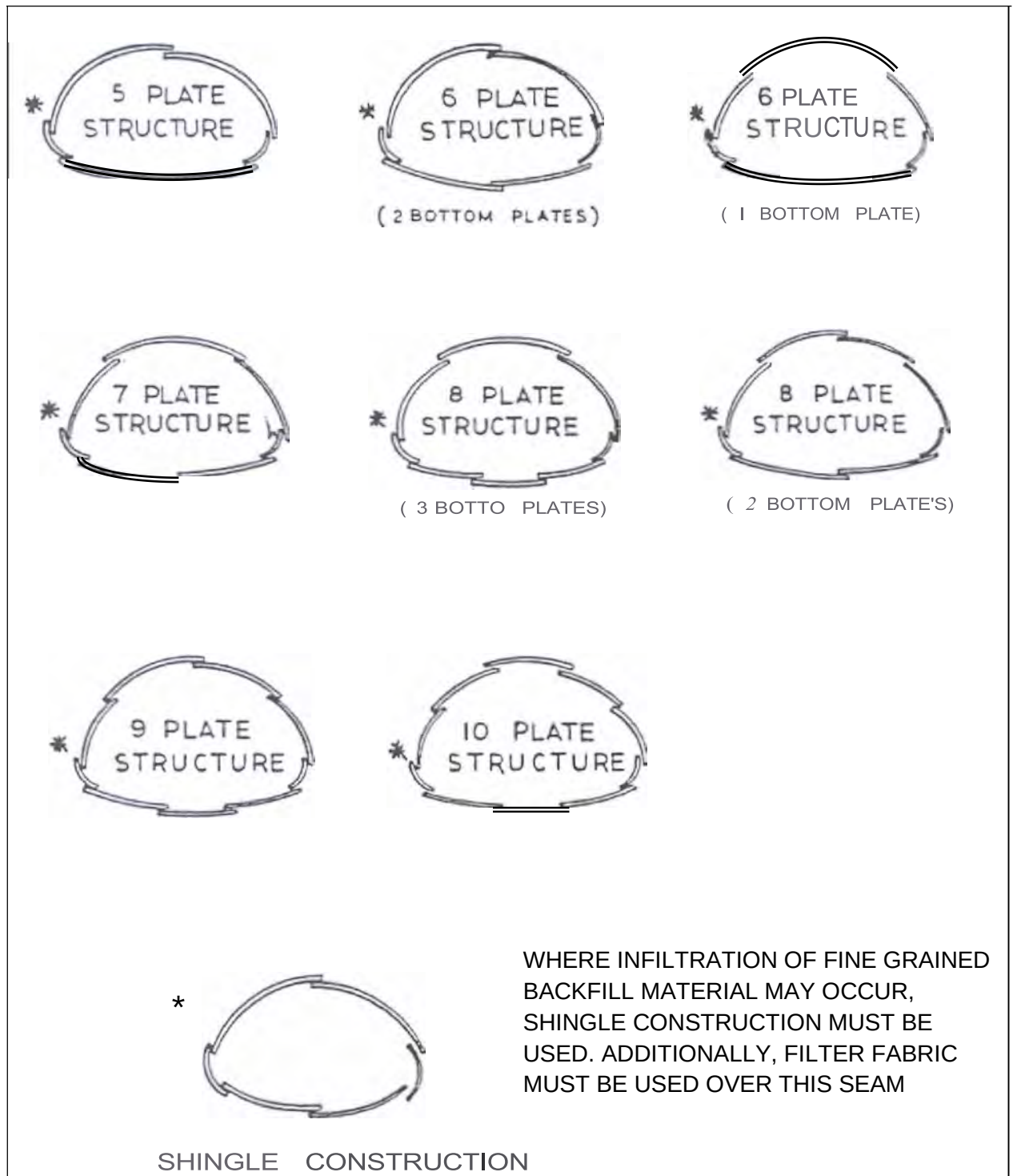


Figure 14-3. Typical Barrel End Views (looking downstream)

PIPE-ARCH ASSEMBLY

The pipe-arch is assembled in three stages as follows:

- 1) bottom
- 2) corners
- 3) top

The bottom (invert) plates are assembled by laying the first bottom plate at the outlet end, then placing each succeeding plate in the longitudinal row so the plate laps one corrugation of the preceding plate (Figure 14-2). The invert plates are positioned accurately with a stringline before tightening the bolts.

The two corner bolt holes (Figure 14-4) are different. One bolt is close to the plate edge and the other bolt is set in from the plate edge. When beginning construction, the corner bolt hole pattern is required to match the pattern shown on the plate layout drawing.

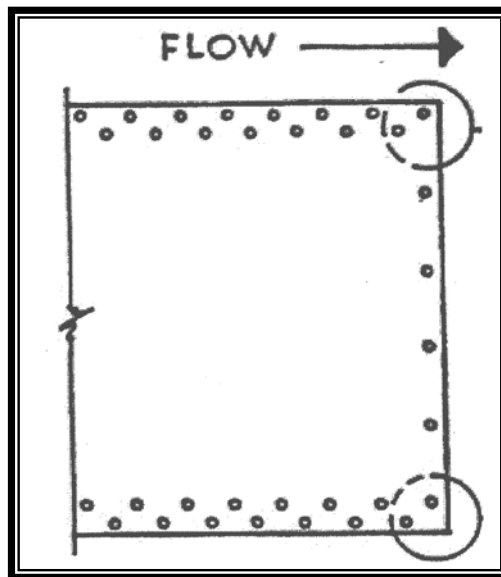


Figure 14-4. Inside View of Pipe

After several invert plates have been laid down, aligned, and bolts tightened, the corner plates are attached to each side at the outlet end. The corner plate may lap either inside or outside the invert plates (Figure 14-4). Also, each additional corner plate is required to lap over the preceding plate by one corrugation.

Finally, the top plates are put in place. The upper half of the pipe-arch is assembled with each plate lapping outside the plate immediately below, except at the top corner plate (Figures 14-2 and 14-5). Each row is extended only far enough to support the next row of plates above to a place where one final plate may be added to complete the ring. Each additional top plate laps over the previous plate by one corrugation.

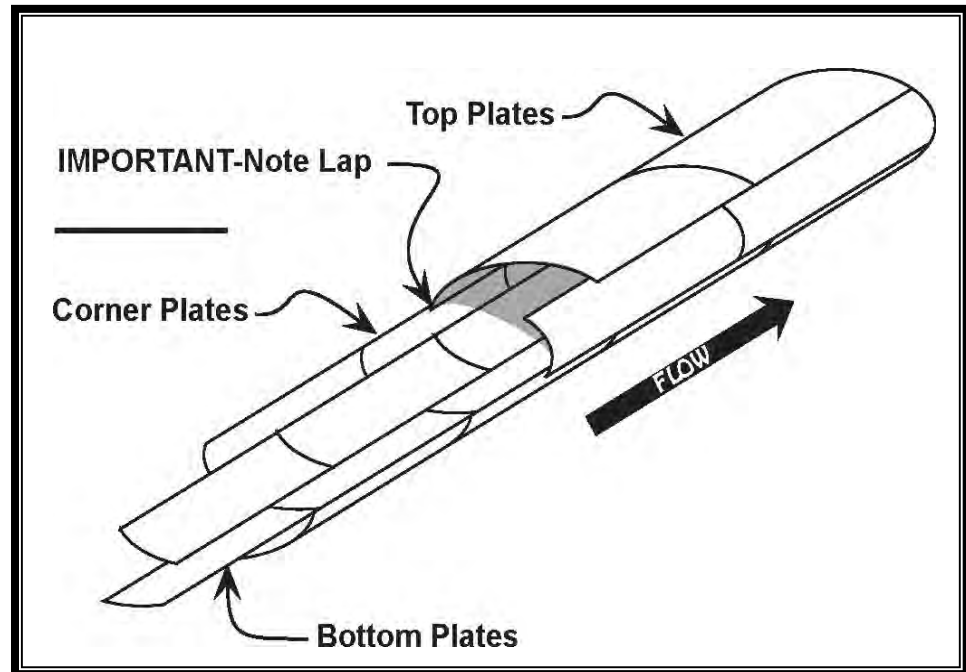


Figure 14-5. Plate Assembly

BOLTING

To facilitate alignment, the initial assembly is done with a minimum number of bolts. Sufficient bolts are inserted in each seam to hold the plates in position; however, the nuts are not tightened, thus leaving the plate free to move slightly to help in matching the remaining bolt holes. Bolting the circumferential seam is best done by first placing the bolts near the middle of the plate. About three rings behind the plate assembly, the remaining bolts are inserted using pins or a pry bar to align the holes. After all bolts are in place, the nuts are tightened. Aligning of bolt holes is done easier when the bolts are loose while drifting of holes is best done with adjacent bolts tight.

Sometimes, tightening all of the bottom plate bolts as the bottom is assembled is desirable. If this procedure is done, certain plates are required to be properly aligned before tightening the bolts. Corner and top plates are always assembled with as few bolts as possible while initially assembling the structure.

The recommended range for bolt torque is between 100 and 300 foot-pounds. A balanced progression of tightening is maintained with respect to the axis of the structure, to prevent a spiraling tendency.

POST-INSTALLATION INSPECTION

Completed structures are required to be visually inspected for workmanship, fit and function.

15 Common Pipe Deteriorations

Joint Failure & Suckholes

Corrosion

Erosion & Scour

Buried Pipe

CHAPTER FIFTEEN:

Common Pipe Deteriorations

This Chapter covers the different types of Pipe Deterioration and Deficiencies that are commonly discovered in the field. The Pipe Inspector's observation, report and review of INDOT facilities before, during and after construction is very valuable and important to preserve the Department's roadways.

JOINT FAILURE & SUCKHOLES

A suckhole is when a hole or void in the pavement or backfill occurs due to drainage that leaks into a constructed pipe structure along the main trunkline and causes a whirlpool effect that allows subgrade & subbase material to enter into the pipe from joint failure, a damaged pipe, corrosion, or improper pipe repair & installation. The following pictures show a variety of suckholes on and alongside mainline pavement.



Figure 15-1



Figure 15-2

Figures 15-1 and 15-2 show a joint failure along the trunkline of a pipe that was likely caused by a utility conflict. Care should be taken by those constructing and inspecting pipe placement to check plans and help corrdinate with surrouding utlities to prevent damage to either the pipe structure or the vital utility that is in the area. Appropriate backfill methods and needed relocations should be considered and used as necessary to promote adequate coverage and seperation between pipe structures and the conflicting utility.



Figure 15-3



Figure 15-4

The Corrugated Metal Pipe (CMP) shown in Figures 15-3 & 15-4 indicate a joint separation from a pipe extension. The existing pipe was likely extended years after construction to promote a safe slope from edge of pavement and stop potential erosion. See Figure 2-4 for appropriate placement of a CMP joint band. When joining pipe to other sections of pipe or to structures, take care to review the manufacturers recommended method of properly creating a joint.



Figure 15-5



Figure 15-6

Figures 15-5 and 15-6 show a suckhole in mainline pavement due to Reinforced Concrete Pipe (RCP) trunkline separation at the joints. Constructing and maintaining appropriate RCP joints is crucial for creating a long-lasting structure. RCP joints require joining bell & spigot with needed sealant that must fit together tightly and are secured with appropriate ends. It is then essential to properly compact backfill that completely surrounds the pipe.



Figure 15-7



Figure 15-8

Severe Corrosion to a pipe can cause voids under the pavement that are serious and require attention. Figures 15-7 and 15-8 detail corrosion caused by years of water damage that created a suckhole by material entering into the pipe from under the pavement. Determining how to best utilize funding and when a structure is in need of replacement can be difficult and why inspections are needed on a regular basis.



Figure 15-9



Figure 15-10

Figures 15-9 and 15-10 indicate joint failure in an RCP that was likely caused by settlement that may be due to poor compaction and sealing of tight joints. Several sections of pipe have pulled away from the main trunkline, causing shoulder material on the edge of pavement to drain out through the bottom of the RCP. Edge of pavement erosion will likely continue under the pavement until repairs are made.

CORROSION

Water is the same destructive force that carved out much of the Grand Canyon. This same force will eventually cause Corrugated Metal Pipe (CMP) to corrode and ultimately lead to its replacement. Corrosion is the degradation of a metal due to a reaction with its environment. It is a chemical reaction called oxidation and is when oxygen is removed from the base metal and begins to return to its natural state. There are many ways that pipe can be made to resist corrosion, such as aluminum alloy, bituminous coated, zinc galvanization, and polymer precoated. INDOT can also select Thermoplastic Pipe, however, does not have the strength to resist heavy loads, especially in larger sizes and is not typically used as a standalone culvert pipe. Regular pipe inspections and using appropriate pipe materials during construction, promote longer lasting structures and allow the highest value for the cost. The following Pictures show various types of corrosion and what CMP pipe can look like years after installation.



Figure 15-11



Figure 15-12



Figure 15-13



Figure 15-14



Figure 15-15

EROSION & SCOUR

Britannica defines erosion as the action of surface processes (such as water flow or wind) that removes soil, rock or dissolved material from one location on the Earth's crust and then transports it to another location where it is deposited. Britannica defines scour to be causing parts of (something) to be carried away by the movement of water or ice. When pipe structures are not properly installed and maintained, drainage can infiltrate areas around the structure and undermine ditches, pavement, embankments, slopes and even the structure itself. Joints that are constructed and maintained properly are critical to preventing such erosion & scour. In addition, building rip rap or concrete aprons at inlet and outlet areas can stop erosion & scour in key areas to promote drainage, keeping water in locations that will minimize damage. As a pipe inspector one should be able to identify and predict possible locations that could be problematic and take necessary precautions to prevent erosion & scour. The following pictures show identified areas where erosion & scour have caused damage to ditches, slopes, structures and shoulders.



Figure 15-16



Figure 15-17



Figure 15-18



Figure 15-19



Figure 15-20



Figure 15-21



Figure 15-22



Figure 15-23

BURIED PIPE

When regular inspections and maintenance are not performed on pipe, deterioration will progress beyond critical. The pipe will eventually fill in and or collapse. If the pipe has filled in, the pavement and surrounding areas won't always experience failure. The pipe then becomes buried and is very difficult to locate. Drainage will filter through the remaining trunkline, but can take a long time to fully remove standing water. The following pictures display drainage structures that were buried over many years of erosion and degradation.



Figure 15-24



Figure 15-25



Figure 15-26



Figure 15-27