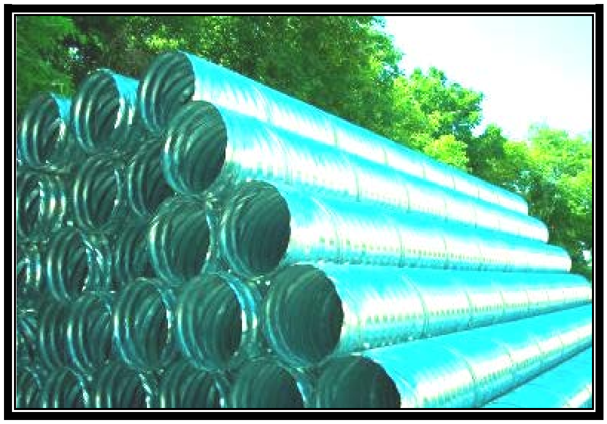
Inspection Manual
For
Pipe



INDIANA DEPARTMENT OF TRANSPORTATION

INDOT

April 2014

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1 Pipe Structures

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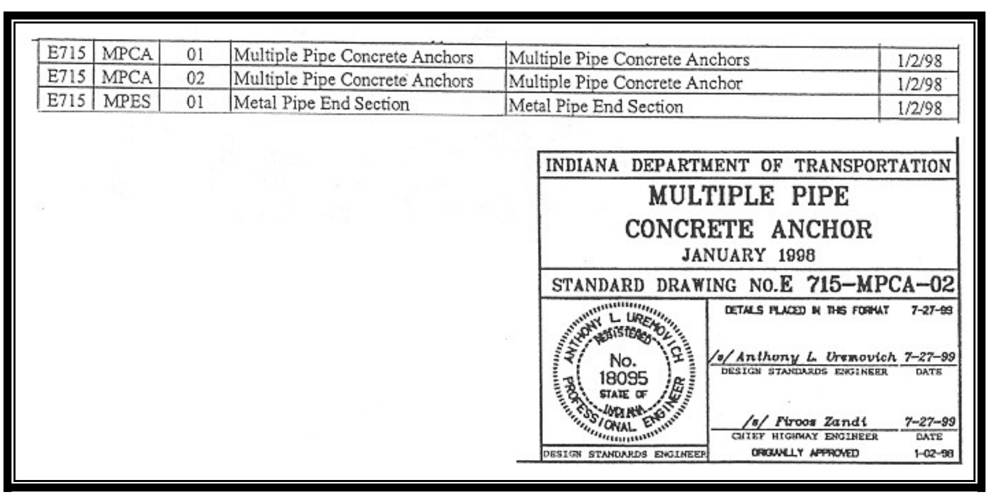
CHAPTER ONE:
Pipe Structures

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

Pipe is specified by types, according to the pipe use, as set out in the miscellaneous Standard Sheets. 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. 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 pipe is 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, the Standard Drawing index in the proposal is checked for the effective date of the standards required for the contract. The effective date on the standard sheet is required to be prior to the contract letting date for that standard to apply to the contract. On the plans, this date appears on the same sheet as the general notes. In a proposal, the date is listed in the Standard Drawing Index.



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
DESIGN STANDARDS ENGINEER
ANTHONY L. UREMOVICH REGISTERED No. 18095 STATE OF INDIANA PROFESSIONAL ENGINEER

Figure 1-1. Standard Drawing

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:

1) Metal pipe end sections (Figure 1-2 & Figure 1-3)

Figure 1-2. Concrete Wing Wall

Figure 1-3. Toe Anchors

2) Safety metal sections

3) Concrete pipe anchors

4) Grated box end sections (Figure 1-4)

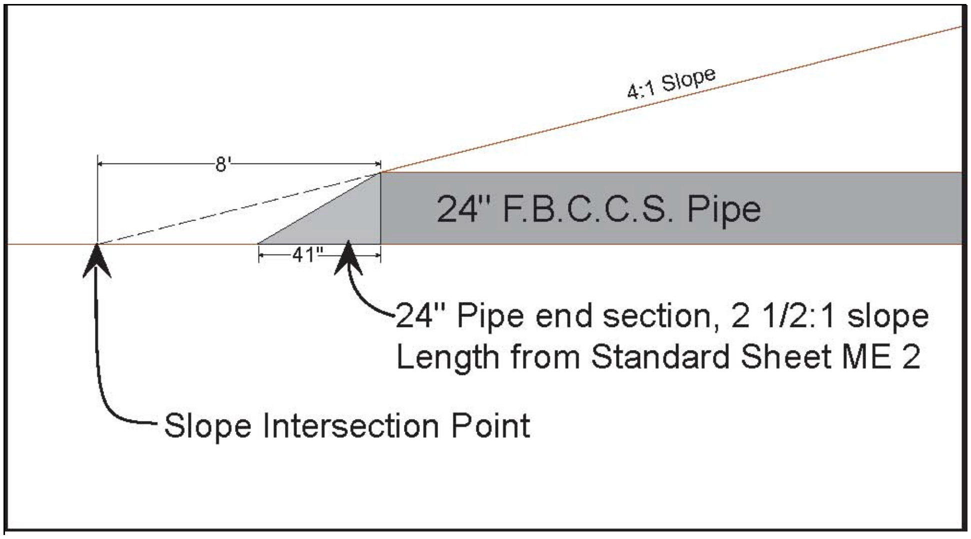
Figure 1-4. Grated Box End Section

5) Inlets or Catchbasins

6) Manholes

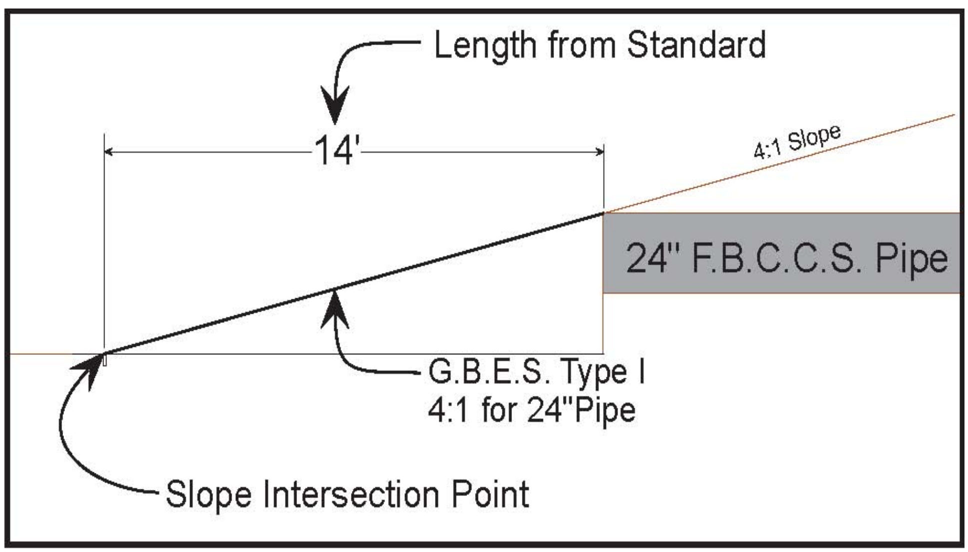
Of the units indicated above only concrete pipe anchors do not affect the overall length of a pipe structure significantly. The following drawings indicate how different pipe end treatments affect the pipe length.

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.

STRUCTURE ORDER

PIPE ORDER

The pipe order is required to include the pipe types, sizes, and lengths. The PE/PS is responsible for reviewing all of the structures thoroughly before ordering. This review may involve site surveys to verify the pipe lengths are correct, and to check for possible problems in the pipe size.

In new construction, most structure lengths may be computed using cross sections and the proposed flowline elevations. Special notes, such as locations for Tees or Elbows, are shown.

There is no special form for a pipe structure order. The order may be written as shown in the following example:

Contract B-13799

Pipe Order Date May 21, 1990

Str #	Pipe Type	Diam	Length	Remarks
1	Concrete Pipe	36"	164'	
2	Corregated Steel	6"	180'	
3	Type II Pipe	24"	46'	
4	Pipe end section	36"	2 ea	
5	Pipe end section	24"	2 ea	

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

Following are two 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

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

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

Length of pipe required would be 165 ft

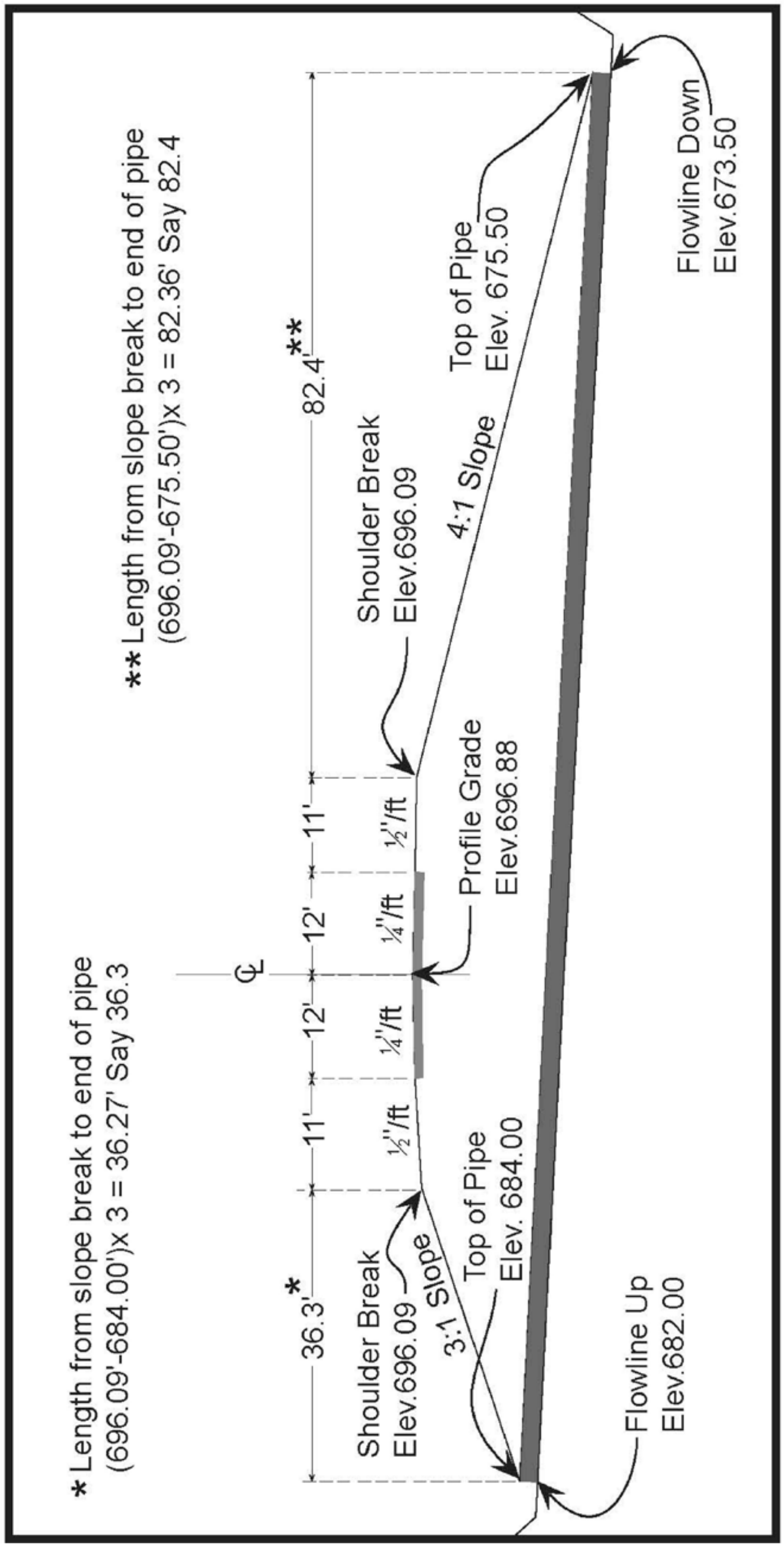
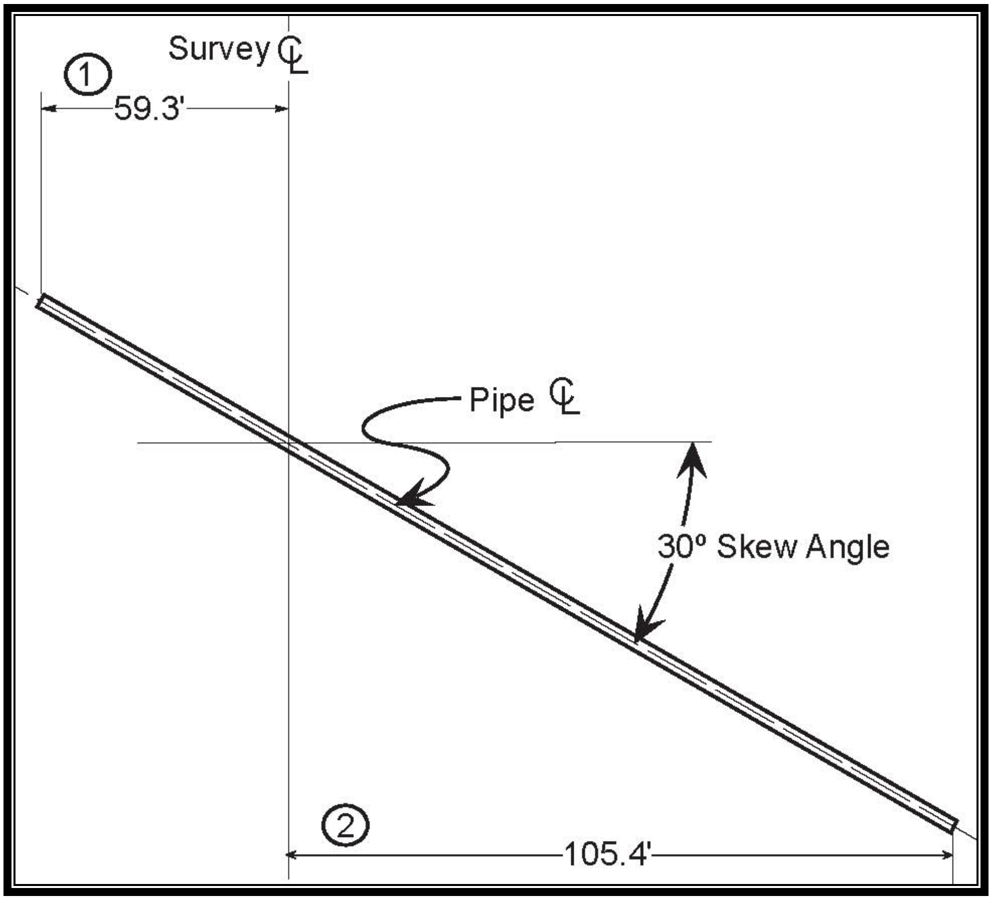


Figure 1-5. Pipe Cross Section View

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 1-5, the affect of a skew on the structure is indicated below.



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

1) 59.3 ft / Cosine 30° = 68.47 ft (Say 68.5 ft)
2) 105.4 ft / Cosine 30° = 121.7 ft (Say 121.7 ft)

Skew length = 190.2 ft

3) Adjustment for flowline fall:

$$\sqrt{((8.5)^2 + (190.2)^2)} = 190.39 \text{ ft} \qquad (\text{Say } 190.4 \text{ ft})$$

Order length would be 190 ft

COMPUTING STRUCTURE LENGTH USING ELBOWS

Sometimes structures use elbows or bends to decrease the depth of cut in large fills. The following example (Figure 1-6) displays the proper method for computing pipe lengths when bends or elbows are used.

E-7 Inlet inside measure = 2.5 ft/ 2 = 1.25 ft on CL to end of pipe
If elbows = 4 ft measured along CL:

Section (1) = 75 ft – Inlet offset (1.25 ft) – Elbow

= 75 – 1.25 – (4/2)

= 71.75 (Say 72 ft)

Section (2) = FL up 696.29 – FL Down 677.96 = 18.33 ft

$$\text{Length} = \sqrt{((18.33)^2 + 55)^2)} = 57.97\text{ ft}$$

57.97 ft – (8/2 ft for 2 elbows) = 53.97 ft (Say 54 ft)

Section (3) = 15 ft – 2 ft for elbow + (680.08 – 676.29)3

= 24.37 (Say 24 ft)

Totals Section	(1)	72 ft
	(2)	54 ft
	(3)	24 ft

150 ft plus 2 elbows & 1 pipe end treatment

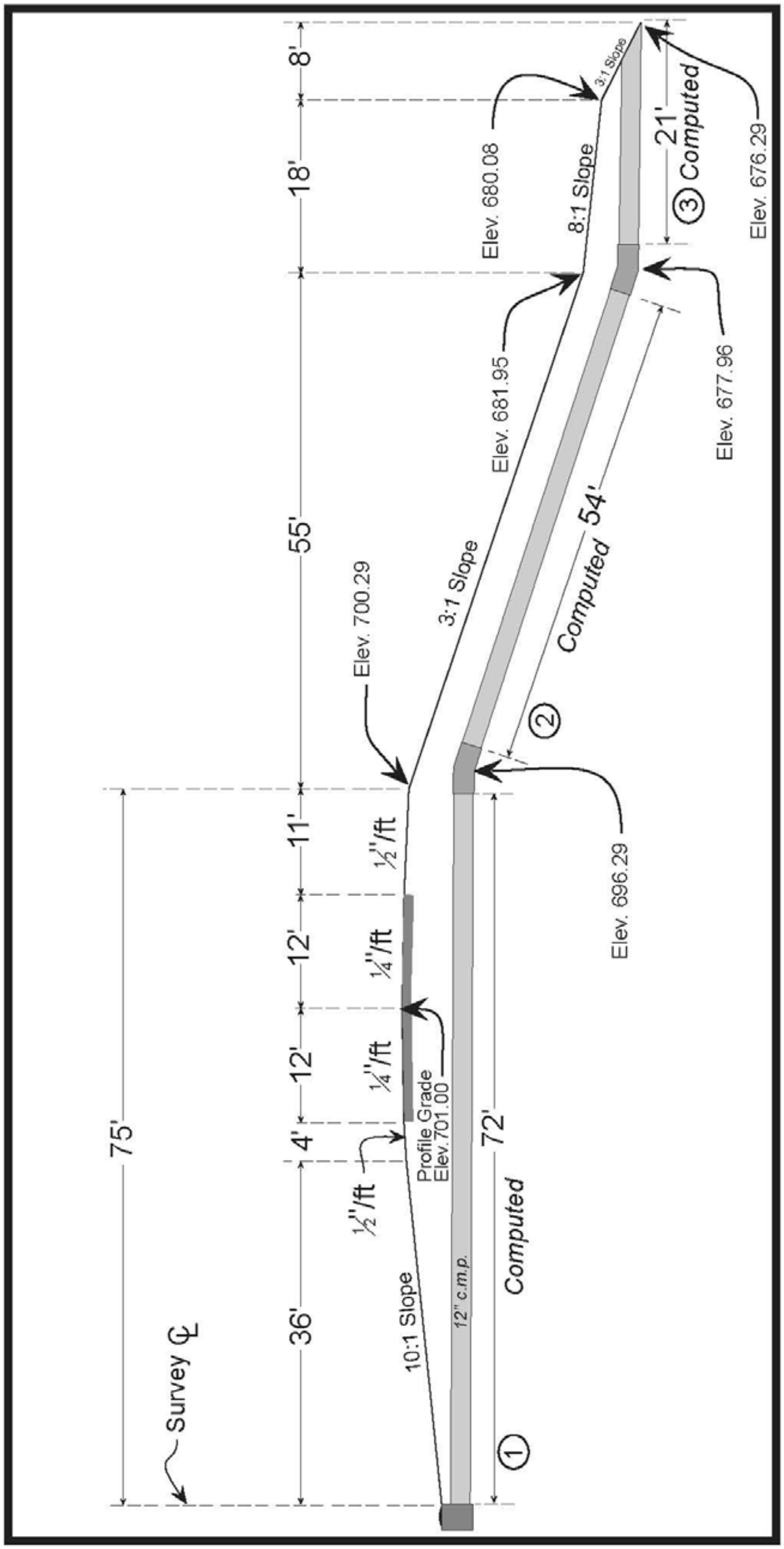


Figure 1-6. Structure with Bend or Elbow

The pipe order indicates the layout on a structure like Figure 1-4 rather than just the total pipe required. Otherwise, the pipe manufacturer would not break down the total length into pieces suitable for the planned assembly.

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 what 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) Level rod readings taken from structure stakes to excavation trench

2) Batterboard and stringline

3) Laser grade control

Batterboard and Stringline

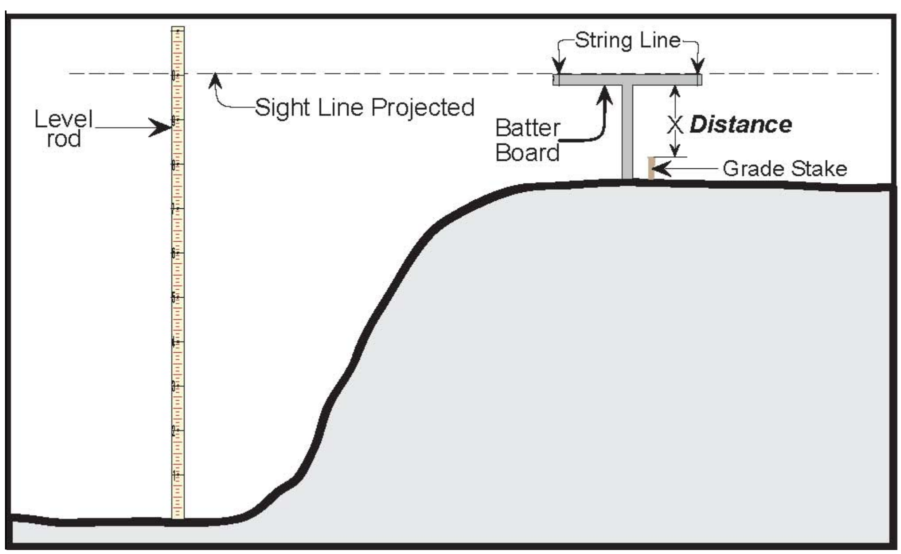
The batterboard and stringline method uses a post and a crossarm mounted a predetermined height above each grade stake. The crossarm is required to be level and have a stringline on either end. The stringlines are stretched from one batterboard to the next, and the grade is checked by sighting across the stringlines to the level rod.

Example:

To set a batterboard for a constant 8 ft cut

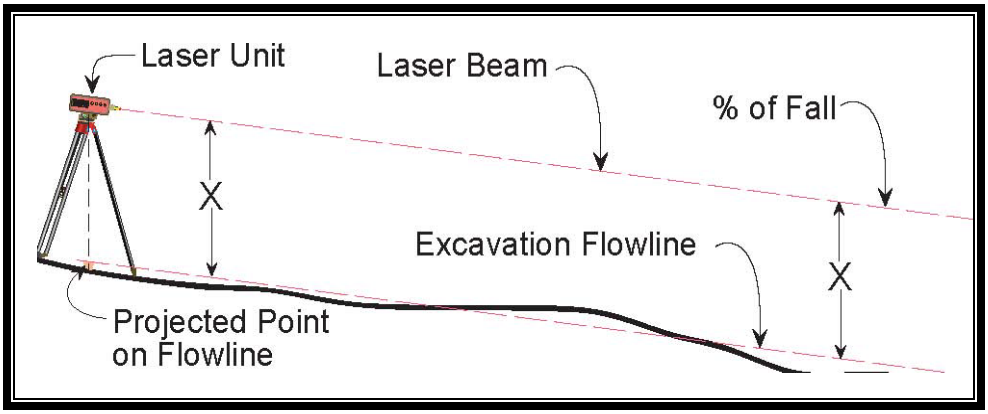
Cut from grade stake #1	= 6.18
Measure up	= 1.82
Reading to FL	8.00

Cut from grade stake #2	= 5.13
Measure up	= 2.87
Reading to FL	8.00



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 percent of fall dialed in. To check the grade anywhere along the flowline, the predetermined distance is measured down from the laser beam.



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
ABS 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 required to be as indicated 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 – 09.**

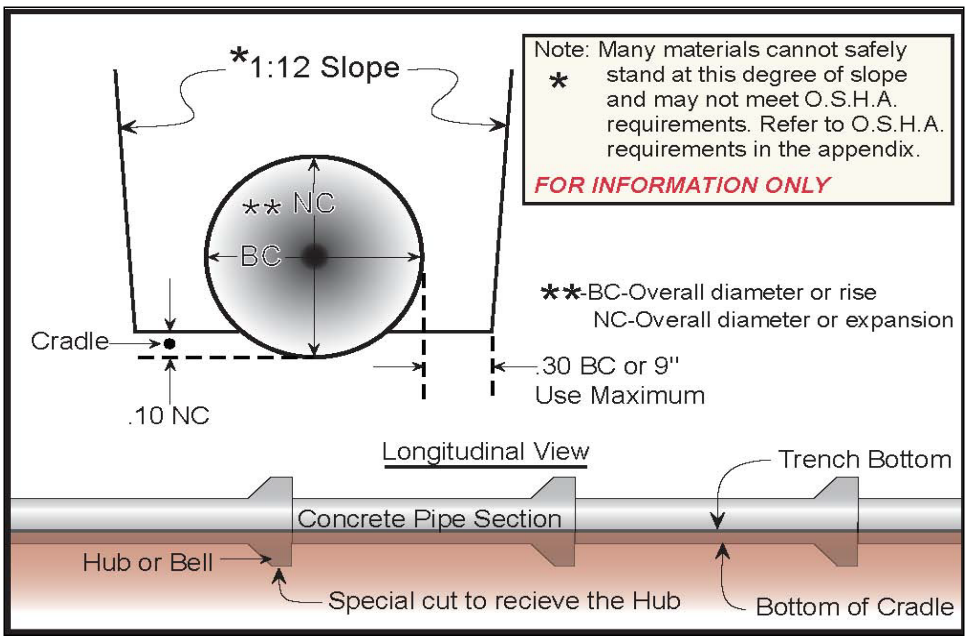


Figure 2-1. Pipe Excavation

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.

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

1) Up to and including 18 in. diameter or equal – 1 ft 6 in. cover

2) 21 in. diameter or equal up to and including 54 in. diameter or equal – 3 ft cover

3) Over 54 in. diameter or equal – 4 ft cover

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. below the required elevation, 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 EXCAVATION PAYMENT

Cut volumes and B borrow for replacing soft areas are required to be recorded. If the quantity of excavation exceeds 10 yd^3, the quantity is paid as three times the excavation class required.

REMOVAL OF EXISTING STRUCTURES

Normally, removal of an existing structure is included in the cost of a new structure item unless a special item is included for the removal. This procedure consists of removing the existing pipe, head walls, box culvert, and footings to outside the limits of excavation for the new structure.

SAFETY

A special concern for safety is required for deep pipe trenches. The Contractor is require 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.

LAYING PIPE

STRUCTURE BEARING

Each section of pipe is required to have full bearing 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.

ABS PIPE

If ABS pipe (plastic) is used, all joints are required to be of the solvent cement type and installed according to the recommendations of the manufacturer.

METAL PIPE

Prior to placing corrugated metal pipe, the sections are required to be checked for the 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 Suppliers 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 Supplier for the 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.

When joining pipes of different strengths, the pipe of lesser strength than the main pipe is required to be incased 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 sections

4) Grated box end sections

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.

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

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 2-3) 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.

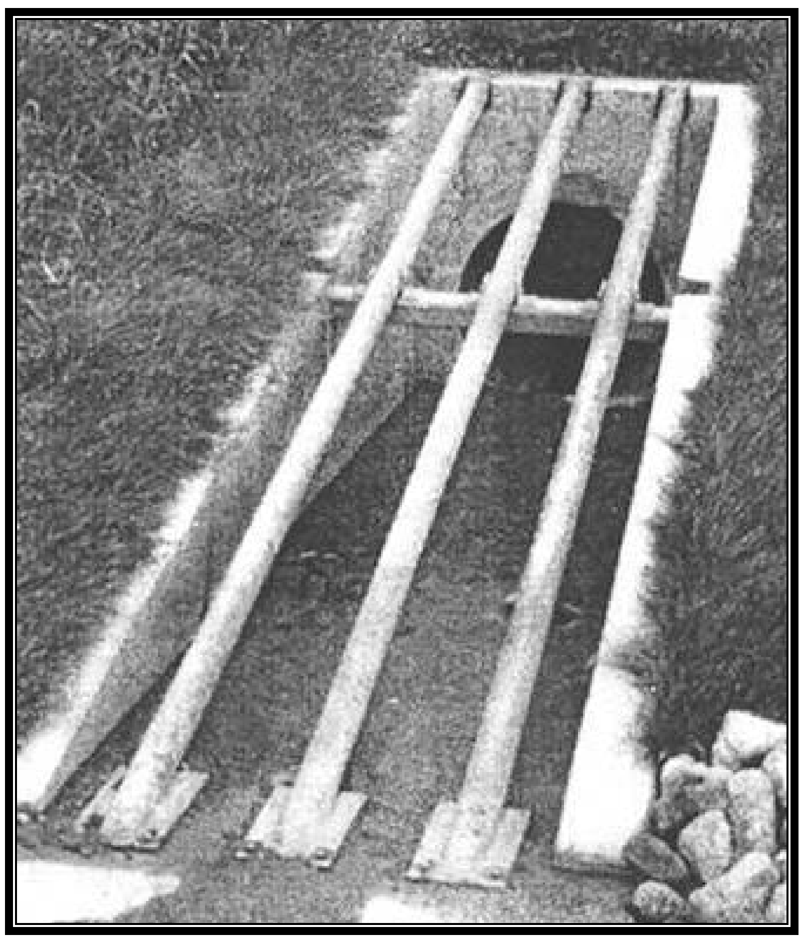


Figure 2-3. GBES Type I

GBES Type II

Type II grated box end sections (Figure 2-4) 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 2-4. GBES Type II

3 Measurement of Pipe Items

CHAPTER THREE:
MEASUREMENT OF PIPE ITEMS

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 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.

4 Manholes, Inlets, and Catch Basins

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-CBCA-01, E 720-INST-01, E 720-INCA-01 & 02, E 720-MHCA-01 & 02,** and **E 720-MHST-01** contain diagrams for each type of structure.

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 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 7^{th} course is required to be laid as a header course (Figure 4-1).

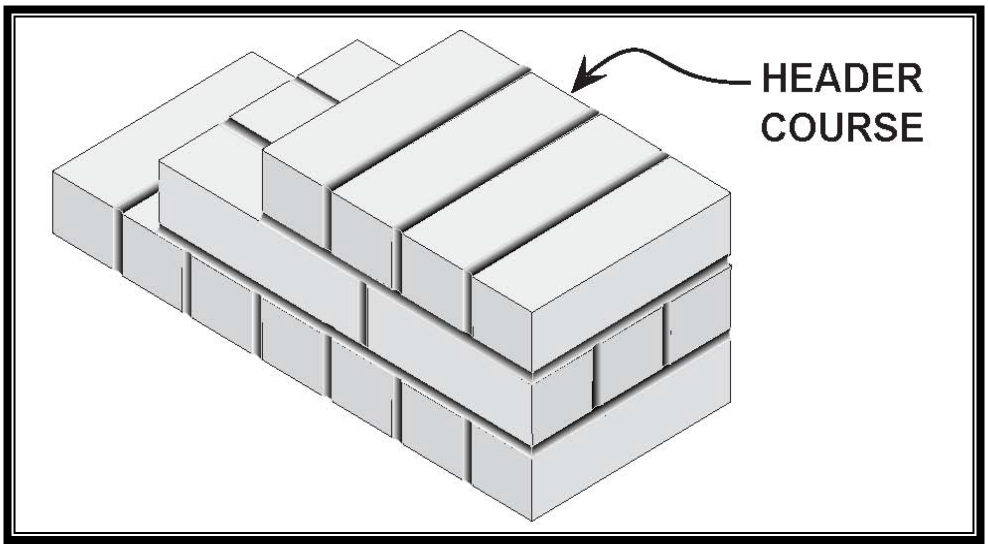


Figure 4-1. Brick Manhole, Inlet, or Catch Basin

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 Supplier 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.

PAYMENT OF MANHOLE, INLETS, AND CATCH BASINS

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

Excavation, backfill, reinforcing steel, replacing pavement, and other miscellaneous items necessary to complete the work are not paid, but are included in the cost of the other items.

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 - 08**.

TRENCH DETAILS

The basic trench details are indicated on Standard Drawings **E 715-BKFL-01** through **E 715-BKFL-08**.

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, -03, -05**, and **-07** the proper limits and dimensions for backfilling with structure backfill are indicated. On Standard Drawings **E 715-BKFL-02, -04, -06** and **-08** the proper limits and dimensions for backfilling with flowable mortar are indicated.

BACKFILL PLACEMENT

All plastic pipes that are not fabricated with hydrostatic design basis resins, except underdrains, are to be backfilled with flowable mortar (Figure 5-1) when the pipes are within 5 ft of the mainline or public road approaches.

Figure 5-1. Flowable Backfill for Box Structure

Structure backfill material is required to be placed in no greater than 8 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, 2, and 3 structural backfill are explained in Section **211.04.**

Flowable mortar is required to be uniformly placed up to the fill line as indicated on the plans or Standards. Before flowable mortar 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 is placed under the mainline pavement or is within 5 ft or less of the pavement, sidewalk, curbs or gutters, Method 1 Backfill is used. Pipes placed under public road approaches also use Method 1 Backfill. Method 1 requires that flowable mortar 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 a fill section is indicated on Standard Drawings **E**

715-BKFL-01 and **715-BKFL-02** and for a cut section is indicated in Standard Drawings **E 715-BKFL-03** and **E 715-BKFL-04**. The proper elevation of backfill material is always maintained as indicated in the these Standards. 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 is placed under commercial or private drive approaches, Method 2 Backfill is used. Method 2 requires that B borrow or flowable mortar be placed at a height of over one-half the outside diameter of the pipe structure. The length of the backfill material is the same as Method 1 Backfill. Method 2 Backfill for a cut and a fill section is indicated on Standard Sheets **715-BKFL-07** and **715-BKFL-08**. The remaining area may be backfilled with suitable materials in layers of not more than 6 in. when inside the slope stake area.

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 5-3). 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.

Figure 5-3. 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:

1) Up to and including 18 in. diameter or equal -- 1 ft 6 in. cover

2) Greater than 18 in. up to and including 54 in. diameter or equal -- 3 ft 0 in. cover

3) Over 54 in. diameter or equal -- 4 ft 0 in. cover

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.

LIMITATIONS

Flowable mortar is not to be placed on frozen ground and is required to be protected from freezing for 72 hours. Flowable mortar may not be loaded or disturbed by construction until an average penetration resistance of 70 psi under a PCCP pavement or 1200 psi under a HMA pavement is obtained.

PAYMENT FOR BACKFILL

STRUCTURE BACKFILL

When the proposal contains an item for structure backfill, the material is paid for by the cubic yard based on a theoretical measurement. The Construction Record Guide has charts indicating different cover heights and the amount of structure backfill per linear foot required for different pipe diameters and material types. This guide is for pipe backfill limits only. The cost of backfilling manholes, inlets and catch basins is included in the item cost.

FLOWABLE BACKFILL

When the contract contains an item for flowable backfill, this material is paid for by the cubic yard based on a neat line theoretical measurement. If flowable backfill is used as a substitute for structure backfill, the flowable backfill is paid for as structure backfill.

EXAMPLE PROBLEM

A Contractor placed a 30 in. diameter corrugated metal pipe which measured 152 Lft. outside to outside of the inlets. The Technician measured the cover in several locations and found the coverage to be an average of 5.8 ft. The theoretical pay quantity for structural backfill would be:

Using the table for backfill, factor = 1.2203 yd^3/Lft.

152 Lft. x 1.2203 yd^3/Lft. = 185.5 yd^3

6 Relining Existing Pipe Structures

Solid Wall HDPE Liner Pipe

Markings

Profile Wall HDPE Liner Pipe

Markings

Profile Wall PVC 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:
RELIGNING 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:

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

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 Plastic Pipe and Pipe Liner Sources. 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 12 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 Plastic Pipe and Pipe Liner Sources. The procedure for being placed on the Approved List is included in **ITM 806, Procedure A**.

MARKINGS

The print line on Solid Wall HDPE liner pipe should appear every 12 ft or less. The markings include the manufacturer, size, dimension ratio, specification designation, plant code and date of manufacture (Figure 6-2).

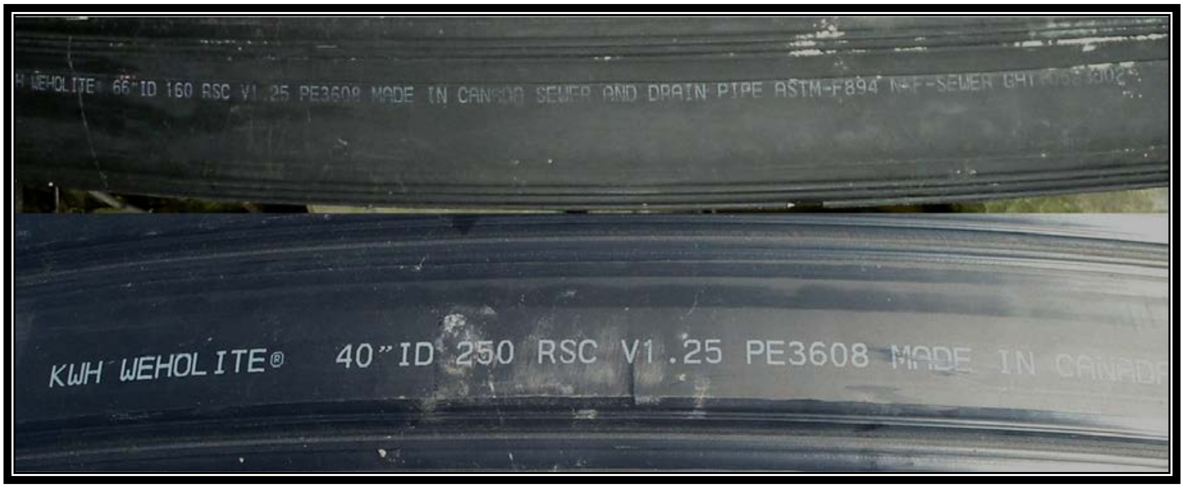


Figure 6-2. Markings on Profile Wall HDPE liner pipe

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 Plastic Pipe and Pipe Liner Sources. 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 05 of 07 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 spigot, screw type, grooved press-on (Figure 6-3), 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.

Figure 6-3. Jointing a Liner

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 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.

GROUT

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.

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 yd^3 are mixed and pumped in a continuous operation.

For each day worked or for each 100 yd^3 placed, four test cylinders measuring 3 in. by 6 in. are cast. The cylinders are prepared, cured, and transported in accordance with **ASTM C 31** and **ASTM C 192**. The cylinders are tested in accordance with **ASTM C 39**, except the test specimens are broken within the permissible tolerance prescribed as follows:

Test Age	Permissible Tolerance
24 hours	1/2 h
3 days	1 h
7 days	3 h
28 days	22 h

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

All equipment necessary for the satisfactory performance of religning existing pipes is required to be approved by the PE/PS. 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

Figure 6-5. Pushing Pipe Liner over Water

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 PE/PS.

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 PE/PS. 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 has been completely inserted and has been inspected by the PE/PS, the liner is cut off flush with the ends of the existing culvert or as directed by the PE/PS and grouted in place. If the liner had been exposed to the sun before insertion is made, the liner is allowed to cool to the temperature of the existing culvert before being cut off and grouted.

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.

Liner storage areas are required to be approved by the PE/PS. 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 PE/PS 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.

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.

JACKED PIPE

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

CONSTRUCTION REQUIREMENTS

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 casting 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 water tight. The minimum wall thickness of the pipe is as follows:

Outside Diameter(in.)	Wall Thickness (in.)	
	Casing Contains Carrier	Casing Used as Carrier
18 or less	1/4	1/4
19-20	1/4	5/16
21-26	1/4	3/8
27-30	3/8	1/2
31-42	3/8	1/2
43-48	1/2	9/16

JACKING CONCRETE PIPE

Only reinforced concrete pipe of 30 in. inside diameter and larger may be jacked. The pipe is required to be class IV or stronger with 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

7 Calculating Pipe Lengths

Example Problem

Skew Pipes

CHAPTER SEVEN:
CALCULATING PIPE LENGTHS

Pipe lengths are calculated using the elevation differences of the pipe and the roadway grade above the pipe.

Three items are required to figure the pipe length.

1) The inlet and outlet elevations of the pipe

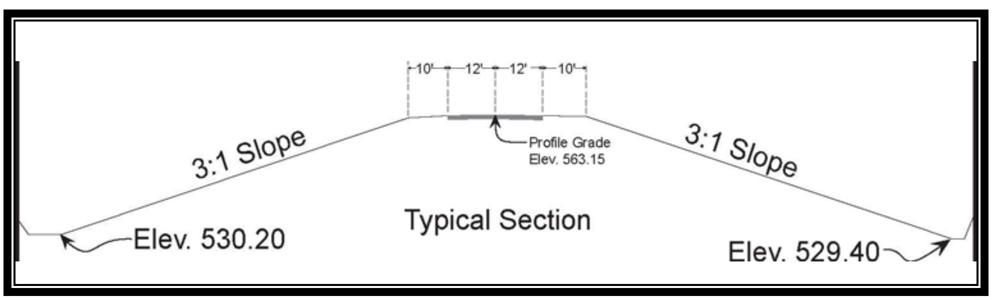
2) The profile grade of the roadway at the station of the pipe

3) The typical cross section for the roadway

EXAMPLE PROBLEM

A 24 in. CS pipe is to be placed under the fill at station 12+25 at an elevation of 563.15. The typical section is indicated below:

There is a 2 ½ in. crown in the pavement. Shoulders slope at ½ in. per ft and the side slopes are 3:1.



STEP 1

Fill in the profile grade and determine the shoulder elevation. (Figure 7-1). Mark the left and right side of the form.

2 ½ in. crown = (2.5 in./12) = 0.2083 ft = 0.21 ft

563.15 -0.21 = 562.94 Edge of Pavement Elevation
10 ft x 0.5 in./ft = 5 in. = 0.42 ft
562.94 – 0.42 = 562.52 ft Shoulder Elevation
Place this elevation on the form

Pipe Length

Contract Number ____________________ Project Number ____________________________

Structure Number ____________________ Station _________________ Line _____________

Plan Length ________________________ Calculated Length __________________________

LEFT				RIGHT
563.15	**Profile Grade**			**563.15**
562.52	**Shoulder Elevation**			**562.52**
530.20	**Flow Line Elevation**			**529.40**
32.32	**Gross Fill (ft)**			**33.12**
2.00	**Deduction for Pipe (ft)**			**2.00**
30.32	**Net Fill (ft)**			**31.12**
90.96	**3:1**	**Slope**	**3:1**	**93.36**
22.00	**Distance from C.L. to Shoulder (ft)**			**22.00**
112.96	**Total (ft)**			**115.36**
Total Length of Pipe (ft)	**112.96 + 115.36 = 228.32 ft**			
Skew Factor				
Total Length of Pipe with Skew (ft)				

Order _______228___________ ft

Connect to Structure No. ____________________ Inlet Type ____________________________

Figure 7-1. Pipe Length Problem

STEP 2

Place the inlet and outlet elevations on the proper sides of the form on the flowline elevation lines (inlet on the left and outlet on the right). Subtract this elevation from the shoulder elevation to obtain the gross fill.

inlet: 562.52- 530.20 = 32.32 ft

outlet: 562.52 - 529.40 = 33.12 ft

STEP 3

Deduct the diameter of the pipe from the gross fill to obtain the net fill for each half of the roadway (24 in. pipe = 2 ft). Place this figure on the net fill line for each side.

inlet: 32.32 - 2.00 = 30.32 ft

outlet: 33.12 - 2.00 = 31.12 ft

STEP 4

Place the rate of slope in the parentheses on the next line for the 3:1 slope. Multiply this times the net fill for each side:

Left = 30.32 ft x 3 = 90.96 ft

Right = 31.12 ft x 3 = 93.36 ft

Place these values on the slope line for each side. These values represent the length of the pipe required for the point from the shoulder break to the end of the pipe for each side.

STEP 5

Place the distance from the centerline to the shoulder on the next line:

12 ft lane + 10 ft shoulder = 22 ft

This is the same for each side. Add this to the slope distance computed in Step 4:

Left = 90.96 ft + 22.00 ft = 112.96 ft

Right = 93.36 ft + 22.00 ft = 115.36 ft

STEP 6

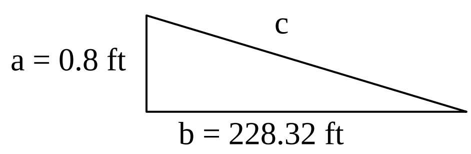
Add the two sides together for the total length:

112.96 ft + 115.36 ft = 228.32 ft

Check for an increase in length due to pipe fall:

530.2 ft inlet elevation – 529.4 ft outlet elevation = 0.8 ft fall

Use $a^2 + b^2 = c^2$, where



$c^2 = (0.8)^2 + (228.32)^2$

$= 0.64 + 52130.022 = 52130.662$

c = 228.32 ft (no substantial increase)

The amount of pipe to order is 228 ft.

SKEW PIPES

For pipes on a skew (Figure 7-2), the calculations are the same as before except the length of pipe is calculated using the skew angle as follows:

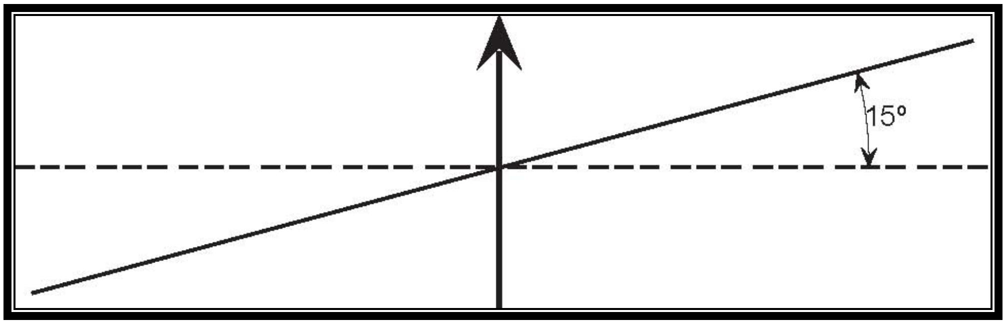
length on skew = perpendicular length / cos skew angle

Figure 7-2. Pipe on a Skew

EXAMPLE:

Using the previous example, all of the data is the same except the pipe is skewed 15 degrees to the left.

Plan View



The length of skew is calculated as follows:

length of skew = 228.32/cos 15 degrees

= 228.32/ 0.965925826

= 236.37 ft

Round to 236 ft. This is the length of pipe to order (Figure 7-3).

If riveted pipe is used, the pipe is required to be ordered in even 2 ft lengths. Spiral crimped seam pipe may be ordered to the nearest 1 ft length.

Pipe Length

Contract Number ____________________ Project Number ____________________________

Structure Number ____________________ Station _________________ Line _____________

Plan Length ________________________ Calculated Length __________________________

<table>
<tr><th>LEFT</th><th colspan="3"></th><th>RIGHT</th></tr>
<tr><td>563.15</td><td colspan="3">Profile Grade</td><td>563.15</td></tr>
<tr><td>562.52</td><td colspan="3">Shoulder Elevation</td><td>562.52</td></tr>
<tr><td>530.20</td><td colspan="3">Flow Line Elevation</td><td>529.40</td></tr>
<tr><td>32.32</td><td colspan="3">Gross Fill (ft)</td><td>33.12</td></tr>
<tr><td>2.00</td><td colspan="3">Deduction for Pipe (ft)</td><td>2.00</td></tr>
<tr><td>30.32</td><td colspan="3">Net Fill (ft)</td><td>31.12</td></tr>
<tr><td>90.96</td><td>3:1</td><td>Slope</td><td>3:1</td><td>93.36</td></tr>
<tr><td>22.00</td><td colspan="3">Distance from C.L. to Shoulder (ft)</td><td>22.00</td></tr>
<tr><td>112.96</td><td colspan="3">Total (ft)</td><td>115.36</td></tr>
<tr><td>Total Length of Pipe (ft)</td><td colspan="4">112.96 + 115.36 = 228.32 ft</td></tr>
<tr><td>Skew Factor</td><td colspan="4">0.965925826</td></tr>
<tr><td>Total Length of Pipe with Skew (ft)</td><td colspan="4">236.37</td></tr>
</table>

Order ______**236**__________ ft

Connect to Structure No. ____________________ Inlet Type ____________________________

Figure 7-3. Pipe Length Problem with Skew

8 Concrete Pipe

Materials

Non-Reinforced Concrete Pipe
Reinforced Concrete Pipe

Acceptance

Frequency Manual Reference
Identification
Approved Sources

Certified Precast Concrete Producer

Pre-Inspection
Inspection
Rejection
Physical Testing

Installation

Post-Installation Inspection

CHAPTER EIGHT:
Concrete Pipe

All precast concrete pipe is required to be produced by a Certified Precast Concrete Producer. Certification is obtained by meeting the requirements of **ITM 813**.

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 01 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 B1 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, in accordance with **AASHTO T 67**.

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 10-3). 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).

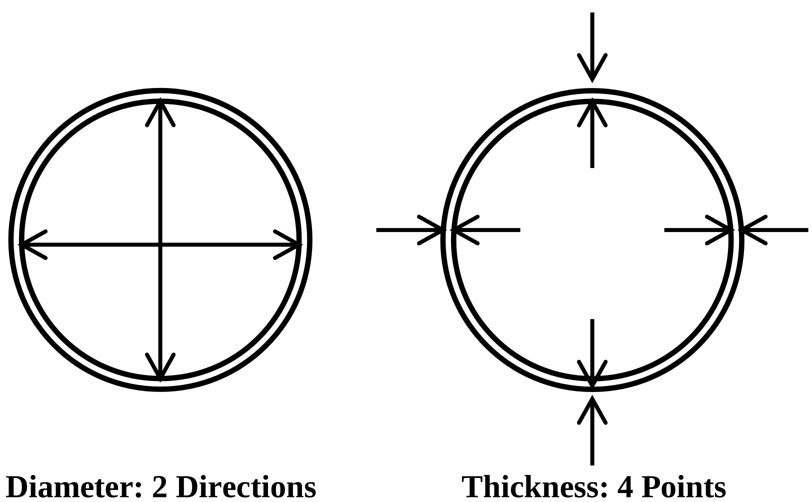


Figure 8-3. Pipe Diameter and Wall Thickness

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 ½ 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 ½ 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.

Pipe 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).

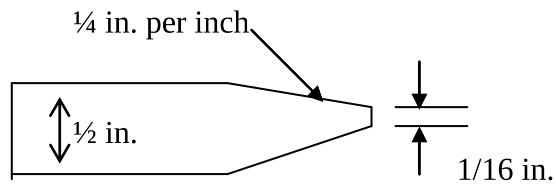


Figure 8-4. Gauge Leaf

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 in^2 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 in^2 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.

POST-INSTALLATION INSPECTION

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

9 HDPE Pipe

Materials

Acceptance

Frequency Manual
Types
Markings
Approved Sources
Certifications

Installation

Post-Installation Inspection

Mandrel Testing

CHAPTER NINE:
High Density Polyethylene (HDPE) Pipe

MATERIALS

There are two specifications for corrugated High Density Polyethylene pipe. Smaller diameters (less than 12 in.) are designated as "tubing" in the specifications and elsewhere on INDOT documentation. Corrugated HDPE tubing is covered in Section **907.17**, which references **AASHTO M 252**. Larger diameters (12 in. and greater) are simply designated "pipe" and covered by Section **907.19**, which references **AASHTO M 294**.

An additional specification found in Section **907.21** covers smooth wall HDPE pipe in accordance with **ASTM F 714**. However, smooth wall HDPE pipe is almost never used in direct-bury applications for INDOT storm sewers. Smooth wall HDPE pipe is accepted from sources on the approved list. The product is used as a pipe lining material, for which information may be found in Section **907.25(a).**

ACCEPTANCE

FREQUENCY MANUAL

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

TYPES

HDPE 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 HDPE 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 HDPE 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).

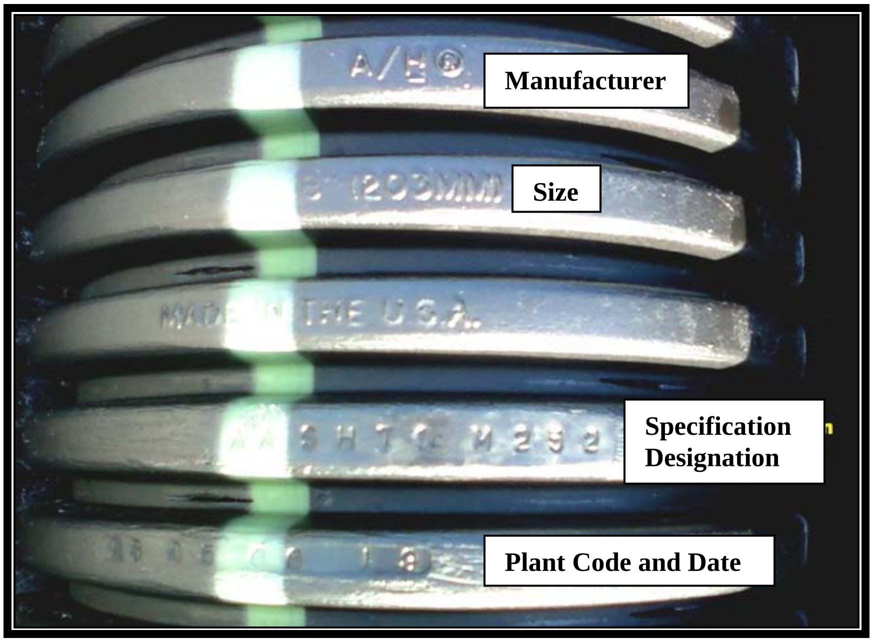


Figure 9-1. Markings on Corrugated HDPE Tubing. Top two lines are raised, bottom two are metal tape embossed.

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 HDPE 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.

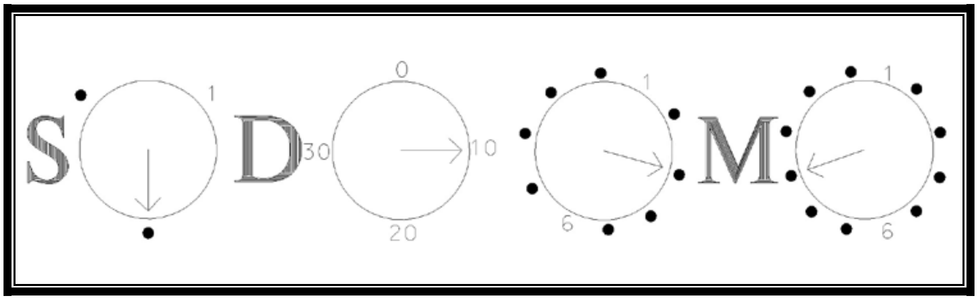


Figure 9-2. Typical Dial Indicators. These represent Shift 2, a date of 13 and month 9, respectively.

APPROVED SOURCES

Sources of HDPE 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. All aspects of the pipe shall be verified with the information provided as approved for the supplying manufacturer.

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

HDPE 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**.

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 9-2. 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.

10 Metal Pipe

Materials

Base Metal
Lining

Acceptance

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Certifications

Testing

Pre-Inspection
Inspection
Workmanship

Installation

Post-Installation Inspection

CHAPTER TEN:
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

There are several different types of pipe end treatments that are allowed for use. The type is required to be known 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.

FREQUENCY MANUAL

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

IDENTIFICATION

The pipe source is required to have an INDOT identification number. The sheet manufacturer certified analysis and guarantee, as specified, is submitted to the Office of Materials Management on or before January 1 and any time there is a change in chemical composition. 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.

APPROVED SOURCES

There is not a list of approved sources for corrugated metal pipe.

CERTIFICATIONS

The sheet manufacturer is required to furnish the fabricator a certified mill report which lists the type of base metal, actual test results of the chemical analysis and mechanical tests of each heat. The certified mill report also includes the thickness of the base metal and certifies that the material complies with the applicable specifications. Whether separately or as part of the certified mill report, the manufacturer certifies to the fabricator the coating type and weight (thickness) as well as compliance with the Buy America requirements of Section **106.01(c)**. All certifications are provided to the Engineer at the time of material delivery and include:

1) Mill Certifications

2) Galvanization Certifications

3) Buy American Certifications (not required for aluminum and aluminum alloy)

TESTING

PRE-INSPECTION

Metal pipe and end sections are required to be supplied from an approved INDOT source. Some sources manufacture pipe and component parts for multi-plate pipe (structural plate pipe) and end sections. Some sources may receive pre-made items and only redistribute items that may have been manufactured out-of-state. If pre-made items are delivered to an in-state source for redistribution, the District Testing Engineer is required to be contacted for sampling and testing procedures. All materials used on INDOT contracts and purchase orders are required to be approved prior to being incorporated into a contract.

INDOT contract pay items typically contain items such as:

1) Pipe, Type 1, Circular, 24 inch

2) Arch, Structural Plate, Min. Area 44.2 square feet

3) Pipe End Section, 24 inch

4) Pipe, Type 1, Deformed, Min. Area 5.40 square feet

Once the Contractor determines that the metal pipe is required, a pipe order is established by the Contractor by structure number, length, diameter, metal gauge, and any coating required. After confirmation with the PE/PS, the pipe order is sent to the pipe supplier or manufacturer requesting delivery of the pipe required for the contract. At this point, the supplier notifies the on-site INDOT Technician.

Generally, the in-state sources do continual business with INDOT and materials are sampled in the spring of the year. During the year, the dimensions and details of items that were constructed with those approved materials are inspected. Circular metal pipe is constructed from “roll stock” which is sheets of flat, smooth, and sometimes coated flat rolls of steel. This roll stock is referred to as steel sheet for pipe in **AASHTO M 36**. AASHTO pipe type classification and INDOT pipe types do not match.

District Testing is required to obtain one verification sample each calendar year for each fabricator and each gauge used. For metal end sections, the base metal is sampled once per calendar year for each fabricator for each gauge.

Samples of Base Metal are required to be taken as early as practical during the calendar year. The samples are required to represent thicknesses of material intended for INDOT use. If not all gauges are available at the time of sampling, additional visits for sampling at the plant are required. For this reason, coordination with the pipe manufacturer is important. Samples are required to represent all materials for manufacture of corrugated pipe to include base metal material (steel or aluminum alloy) and coatings (galvanized, aluminized and polymer precoated). Samples are obtained by cutting and samples cut by flame are not accepted. If samples are taken from the end of a sheet or coil, the first 4 in. are removed or not counted to achieve the minimum sample size.

For flat sheets or coils, a sample is required to be 12 to 16 in. long with the entire width of the sheet or coil included. Corrugated sheet is also sampled for the full width of the sheet and is required to be 6 to 10 in. long. Samples are required to be a length sufficient to capture all markings including manufacturer, specification and coating compliance. Samples of metal end section base metal are required to be a minimum of 4 in. by 4 in. The representative mill report is required to also be submitted with the samples.

Base metal samples are submitted to the Office of Materials Management with a copy of the mill analysis.

AASHTO M 218 lists the required markings on the steel sheet. These markings are placed on the steel at the required frequency by the manufacturer and furnished to the pipe manufacturer pre-marked.

With each inspection, the fabrication representative is required to sign form TD 392 certifying:

1) The fabricated structure has been manufactured in compliance with INDOT Specifications

2) Based on the sheet manufacturer certified mill report, the materials used in fabricating the structure were tested and results conform to the Specification requirements

3) Copies of the sheet manufacturer certified mill reports are kept on file and are required to be available for review for 5 years

Corrugated Steel Pipe for Sewer and Underdrains

The Specifications cover the construction and inspection procedures for accepting steel pipe used for storm water drainage. Typical pipe plants manufacture Type I and Type II pipe as classified in **AASHTO M 36** and use materials specified in **AASHTO M 36**. Measurement of corrugations is also detailed in **AASHTO M 36.**

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. The method of sampling the asphalt material is **AASHTO T 40**. 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.

Corrugated Aluminum Pipe for Sewers and Drains

This Specification details the same process for aluminum pipe that **AASHTO M 36** details for corrugated steel pipe.

Steel Sheet, Zinc Coated (Galvanized) for Corrugated Steel Pipe

This Specification details the material requirements for the base metal sheets used to produce corrugated steel pipe. Section 1 (Scope) and Section 12 (Product Marking) include these requirements.

Corrugated Steel Pipe, Polymer Coated for Sewers and Drains

Section 1 (Scope) and Sections 7 through 14 of **AASHTO M 36** include the requirements for this material.

Steel Sheet, Metallic Coated and Polymer Pre-Coated for Corrugated Steel Pipe

Section 1.1 (Scope) and Section 12 (Marking) of **AASHTO M 36** include the requirements for this material.

INSPECTION

Dimension Checks

District Testing selects one piece of pipe from each line on the TD 392 for dimensional checks. The dimensional checks are recorded on the TD 392 and include the following measurements:

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 10-1).

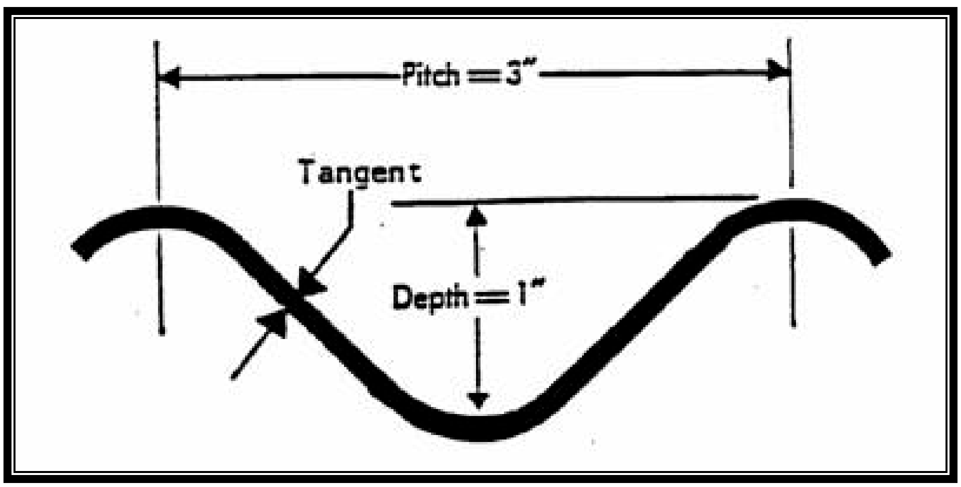

Figure 10-1: 3 x 1 in. Corrugation

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 7-1).

2) Corrugation pitch - the distance from crest to crest of successive corrugations (Figure 7-1).

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 10-2 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**.

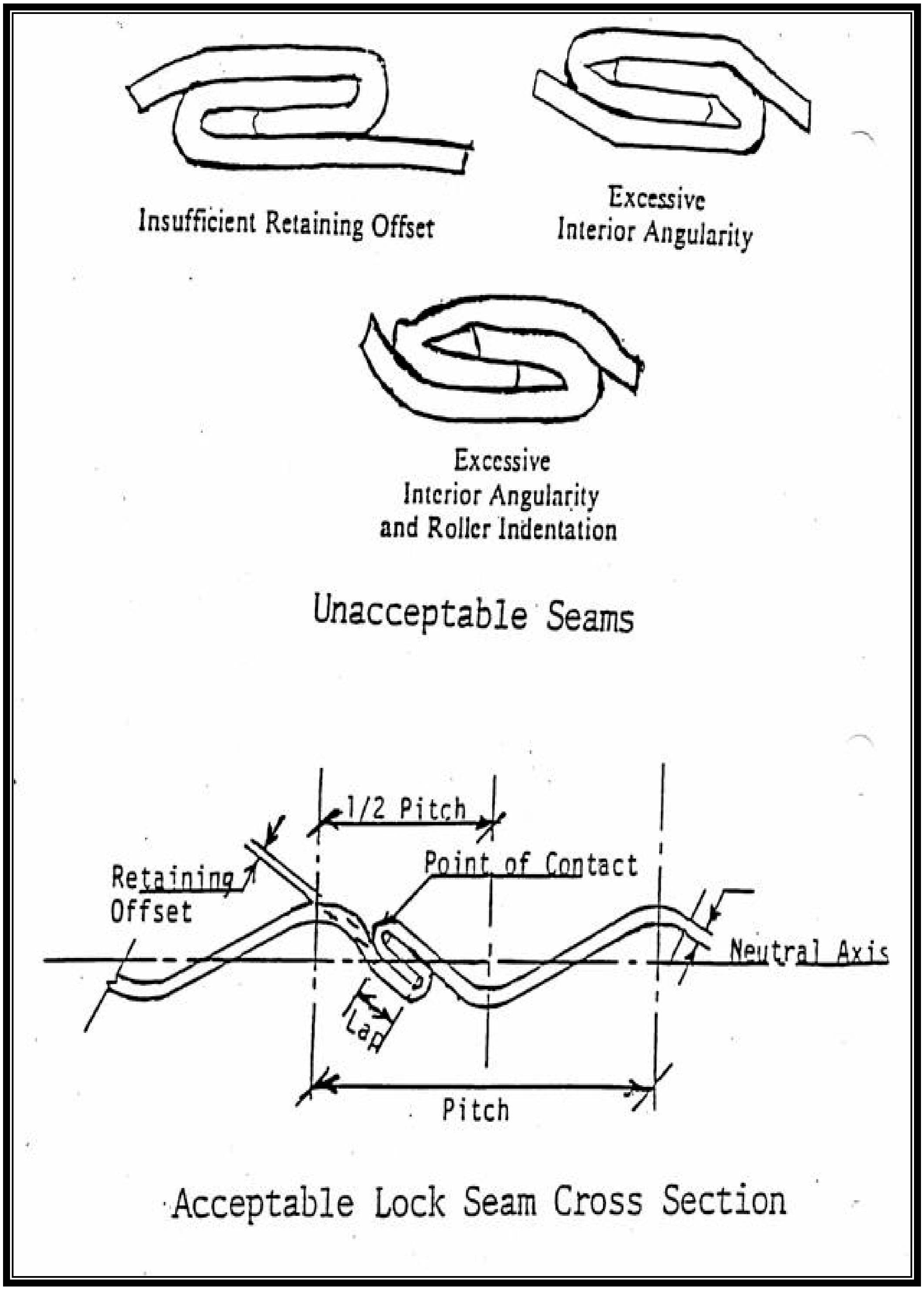

Figure 10-2: Lock Seams

Perforations

Perforations are required to be located properly, and cleanly cut. There are three classes of perforations. Class 1 is circular, Class 2 is circular or slotted, and Class 3 is slotted. Each has specific spacing and size requirements for their designed purpose.

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

3) Variation from a straight center line

4) Ragged or diagonal sheared edges

5) Loose, unevenly lined, or spaced rivets

6) Poorly formed rivet heads

7) Unfinished ends

8) Illegible brands

9) Lack of rigidity

10) Bruised, scaled, or broken metallic coating

11) Dents or bends in the metal itself

12) Spelter rust (white rust)

13) Poorly formed helical lock seams

14) Unsatisfactory welded seams

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

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

11 Metal Pipe Structures

Materials

Base Metal
Sample Sizes

Acceptance

Frequency Manual
Identification
Approved Sources
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Testing

Installation

Plates
Bolts
Plate Identification and Location
Pipe-Arch Assembly
Bolting

Post-Installation Inspection

CHAPTER ELEVEN:
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 03 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)

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 in two lengths, nominally 10 ft and 12 ft long. In special instances, one or more 6-ft long plates may be furnished. 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 I gage. The eighth number is the order item number. The last four numbers are the mill order number (Figure 11-1).

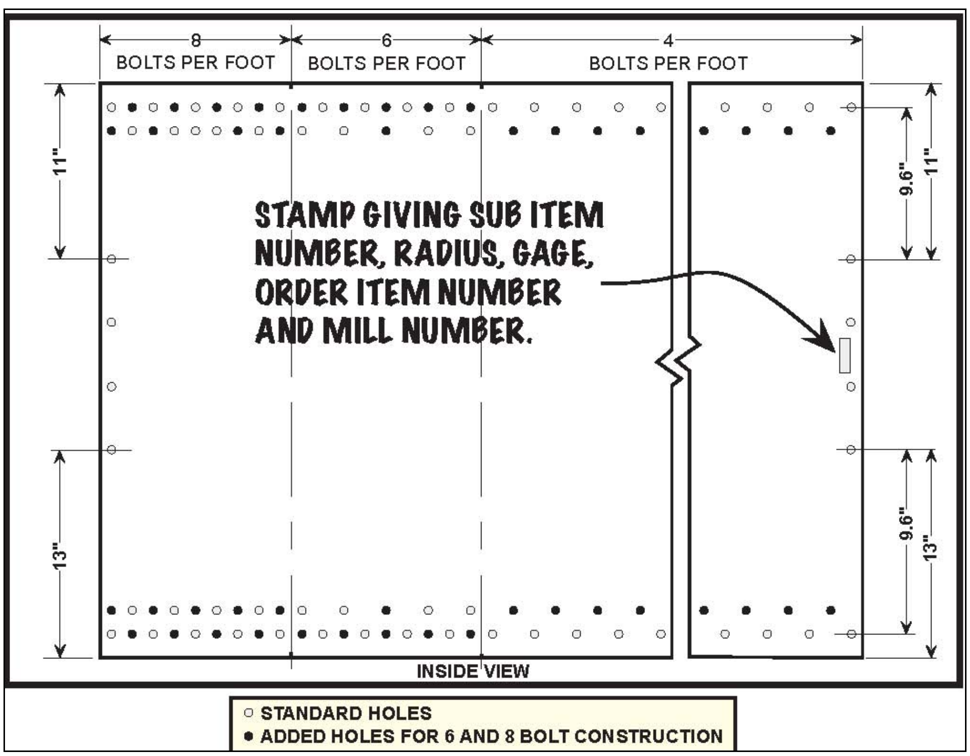

Figure 11-1. Pipe Plate

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

Plate Gage	Thickness	Bolt Lengths
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

Plate Gage	Thickness	Bolt Lengths
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 11-2).

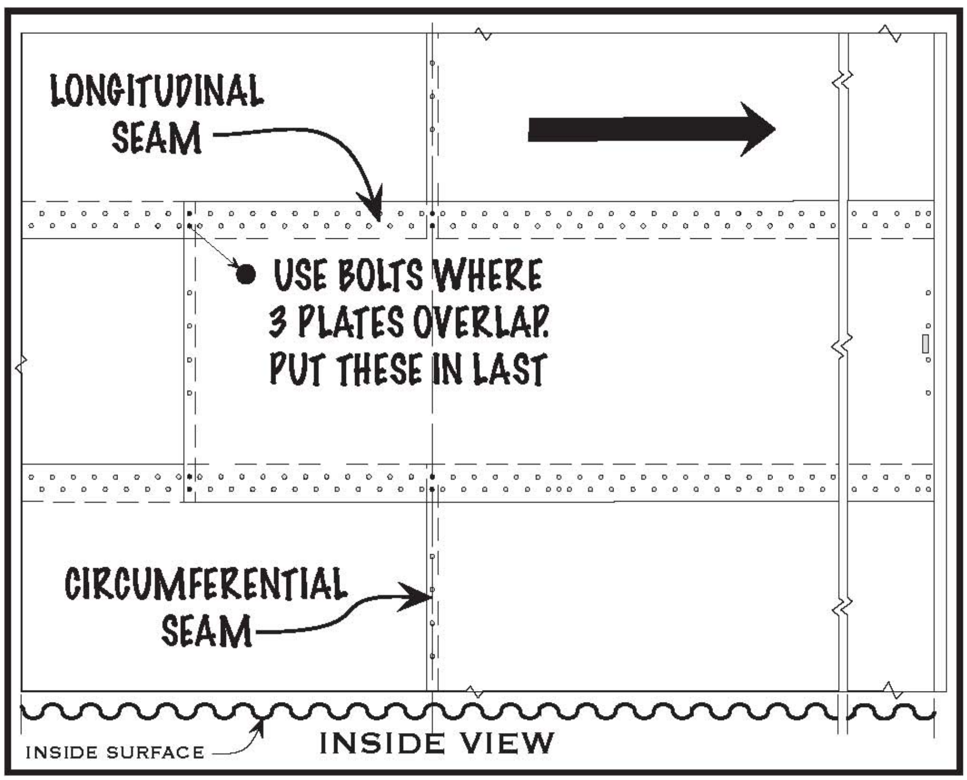

Figure 11-2. Bolt Placement

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 11-3 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.

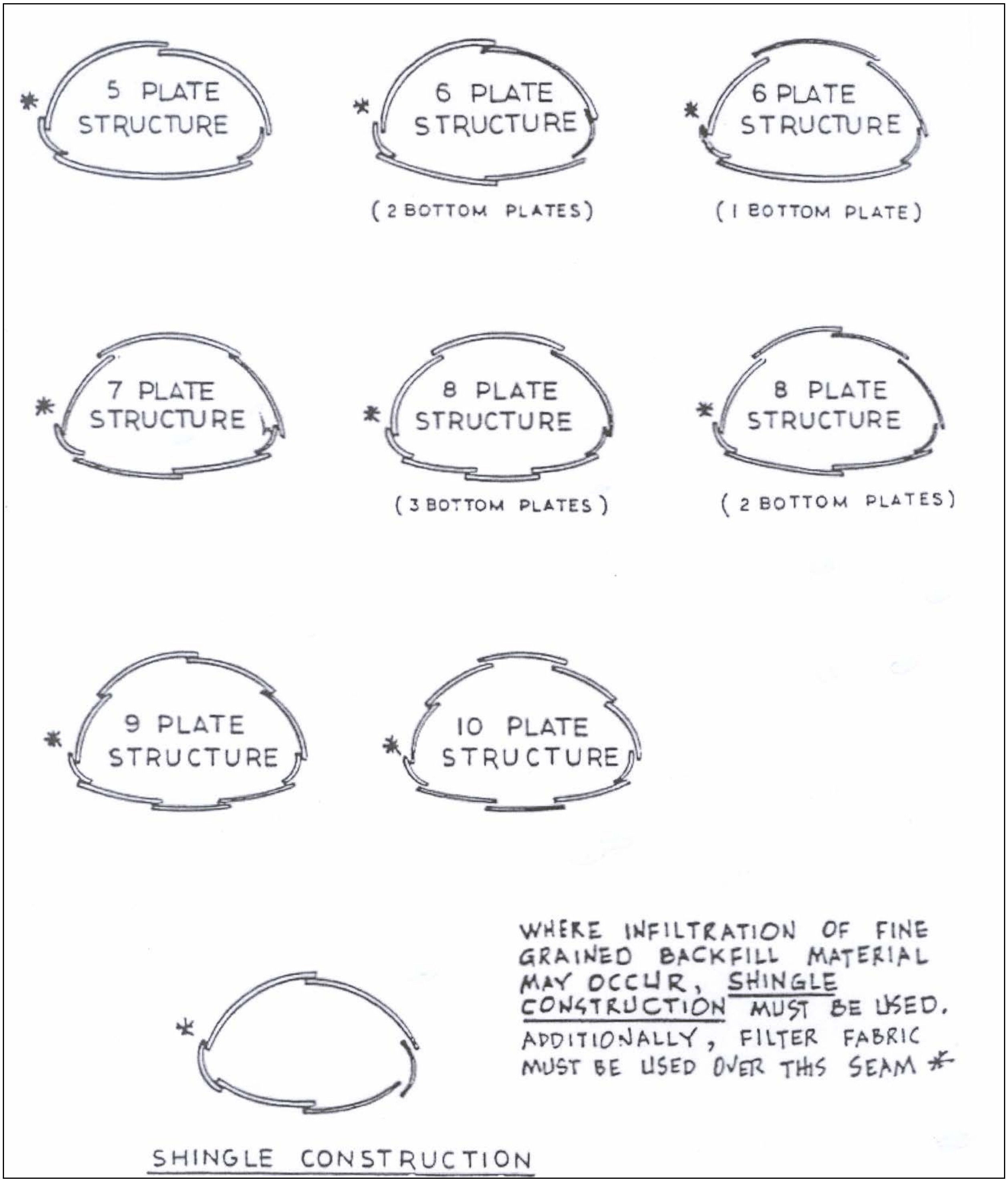

Figure 11-3. Typical Barrel End Views (looking downstream)

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 11-2). The invert plates are positioned accurately with a stringline before tightening the bolts.

The two corner bolt holes (Figure 11-4) 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.

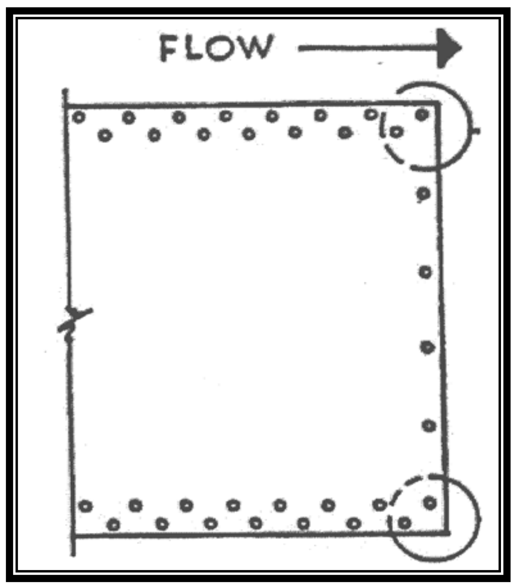

Figure 11-4. Inside View of Pipe

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 -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 11-2 and 11-5). 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.

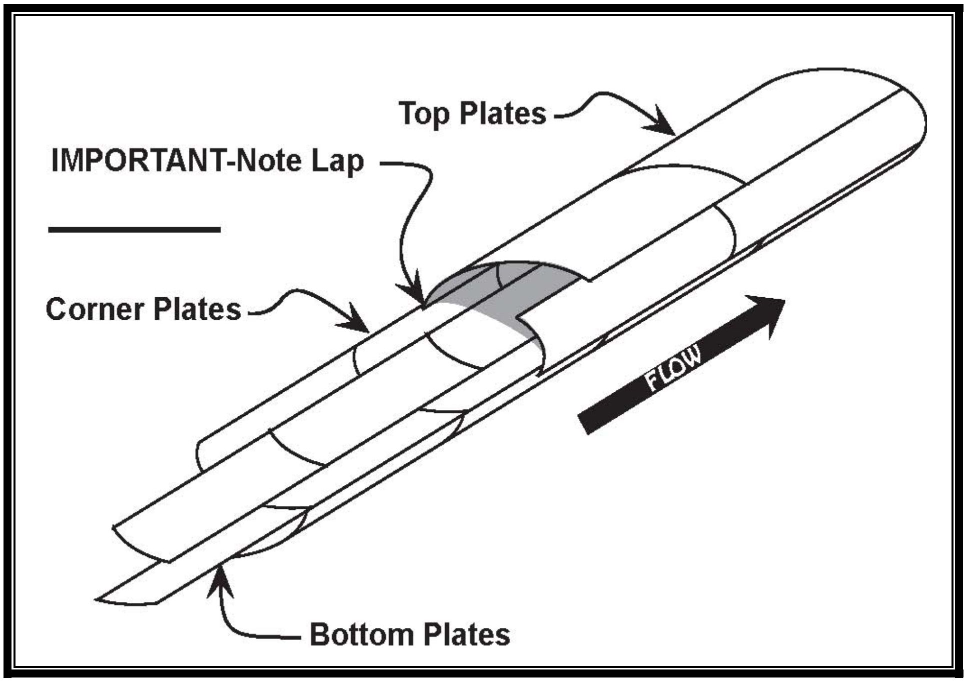

Figure 11-5. Plate Assembly

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

There are no post-installation inspection requirements for metal plate structures. Completed structures are required to be visually inspected for workmanship, fit and function.

12 Polypropylene Pipe

Materials

Acceptance

Identification
Types
Markings
Approved Sources
Certifications

Installation

Post-Installation Inspection

CHAPTER TWELVE:
Polypropylene Pipe

MATERIALS

Currently, Polypropylene Pipe has not been approved by INDOT through the Pipe Committee. However, the material has been installed for evaluation on some contracts. The material specification is included in **AASHTO M 330**.

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.

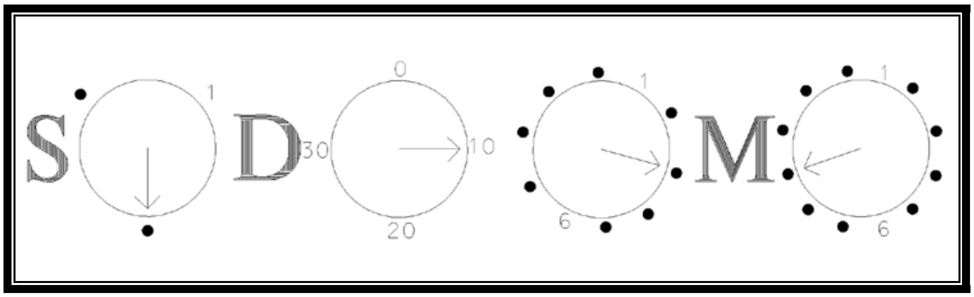

Figure 12-2: Typical Dial Indicators. These represent Shift 2, a date of 13 and month 9, respectively.

APPROVED SOURCES

There are currently no approved sources for polypropylene. However, once approved, polypropylene pipe will be accepted through sources on the INDOT List for Plastic Pipe and Liner Sources.

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 installation 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**.

13 Polyvinylchloride (PVC) Pipe

Materials

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Identification
Approved Sources
Certifications
Testing

Installation

Post-Installation Inspection

Mandrel Testing

CHAPTER THIRTEEN:
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 D 1785**.

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 Plastic Pipe and Liner Sources Approved List.

There is no approved list for Schedule 40 PVC Pipe.

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.

TESTING

No testing is required for either Profile Wall PVC or Schedule 40 PVC Pipe.

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.

MANDREL TESTING

For details on mandrel testing, see the post installation inspection information for Corrugated HDPE Pipe in Chapter 9.

14 Reinforced Thermosetting Resin Pipe

Materials

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Identification
Approved Sources
Certifications

Installation

Post-Installation Inspection

CHAPTER FOURTEEN:
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 by 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 approved list for sources of Reinforced Thermosetting Resin Pipe.

CERTIFICATIONS

A Type A Certification is required by specifications 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.

15 Utility Pipe

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CHAPTER FIFTEEN:
Utility Pipe

MATERIALS

Utility pipe may vary widely in material composition. Utilities often addressed on INDOT projects include (drinking) water distribution lines and wastewater collection (sanitary sewer) lines. In some cases, storm water pipes are required to also be installed in accordance with utility pipe requirements. Typical materials for utility pipes are ductile iron, corrugated HDPE (usually Type D or triple wall), polypropylene (Type D), solid/smooth wall HDPE, or smooth wall PVC. Specifications for utility pipe are typically included as a separate document in INDOT contracts, but may be addressed in the Standard Specifications as well. When contract documents do not include a specification, the following may be used as a guide for these materials:

Material	Standard Specifications	AASHTO	ASTM
Ductile Iron Pipe	N/A	N/A	A 377 A 746
Corrugated HDPE	907.19	M 294	F 2947 F 2762 F 2763
Polypropylene	N/A	M 330	F 2736 F 2764 F 2881
Solid (Smooth) Wall HDPE	907.21	N/A	F 714
Smooth Wall PVC	907.23	M 278	F 679

ACCEPTANCE

FREQUENCY MANUAL

Acceptance information for utility pipe may be found in Reference 62, Sub Reference 01 of 01 of the Frequency Manual.

IDENTIFICATION

Marking styles vary from manufacturer to manufacturer, and from facility to facility.

APPROVED SOURCES

There are no approved sources for utility pipe. Where the Department has approved lists for suitable materials, the approved sources shall be used.

CERTIFICATIONS

A Type A Certification is required for all utility pipes, regardless of intended use. The lot number or other identifying marking on the pipe is required to be consistent with that stated on the certification.

INSTALLATION

Pipe installation shall 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. Additional information may be found in the contract documents for the utility work, which may supersede the Standard Specifications. Pertinent AWWA specifications and municipality specifications may also be referenced.

POST-INSTALLATION INSPECTION

No mandrel testing or post-installation inspection requirements are specified. However, utility pipes are typically required to be pressure tested before acceptance. Refer to contract documents or municipality specifications.