Designation: B788/B788M – 09 (Reapproved 2014)

Standard Practice for Installing Factory-Made Corrugated Aluminum Culverts and Storm Sewer Pipe[1]

This standard is issued under the fixed designation B788/B788M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice describes procedures, soils, and soil placement for the proper installation of corrugated aluminum culverts and storm sewers in either trench or projection installations. A typical trench installation is shown in Fig. 1, and a typical embankment (projection) installation is shown in Fig. 2. The pipes described in this practice are manufactured in a factory and furnished to the job in lengths ordinarily from 10 to 30 ft [3 to 9 m], with 20 ft [6 m] being common, for field joining. This practice applies to structures designed in accordance with Practice B790/B790M.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.2.1 *SI Units*—SI units are shown in the text in brackets, and they are the applicable values for metric installation.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B745/B745M Specification for Corrugated Aluminum Pipe for Sewers and Drains

B790/B790M Practice for Structural Design of Corrugated Aluminum Pipe, Pipe-Arches, and Arches for Culverts, Storm Sewers, and Other Buried Conduits

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method

D6938 Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bedding, n*—the earth or other material on which a pipe is supported.

3.1.2 *haunch, n*—the portion of the pipe cross section between the maximum horizontal dimension and the top of the bedding.

3.1.3 *invert, n*—the lowest point on the pipe cross section; also, the bottom portion of a pipe.

3.1.4 *pipe, n*—a conduit having full circular shape; also, in a general context, all structure shapes covered by this practice.

3.1.5 *pipe–arch, n*—a pipe with an approximate semicircular crown, small-radius corners, and large-radius invert.

4. Significance and Use

4.1 Corrugated aluminum pipe functions structurally as a flexible ring which is supported by and interacts with the compacted surrounding soil. The soil constructed around the pipe is thus an integral part of the structural system. It is therefore important to ensure that the soil structure or backfill is made up of acceptable material and is well-constructed. Field verification of soil structure acceptability using Test Methods D1556, D2167, D2937, or D6938 as applicable, and comparing the results with Test Method D698 in accordance

[1] This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.08 on Corrugated Aluminum Pipe and Corrugated Aluminum Structural Plate.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

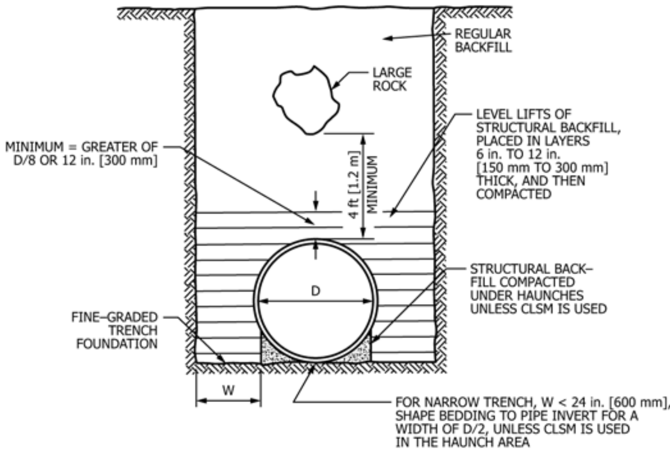


FIG. 1 Typical Trench Installation

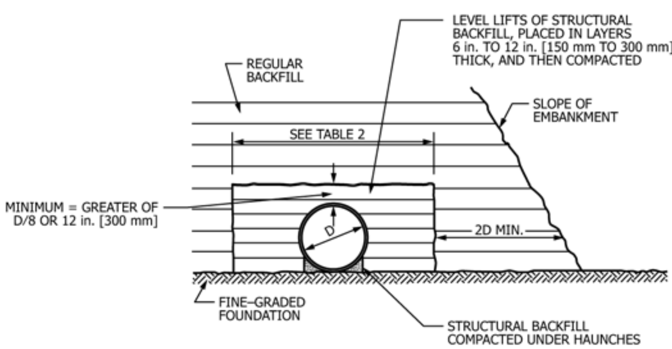


FIG. 2 Typical Embankment (Projection) Installation

with the specifications for each project, is the most reliable basis for installation of an acceptable structure. The required density and method of measurement are not specified by this practice, but they must be established in the specifications for each project.

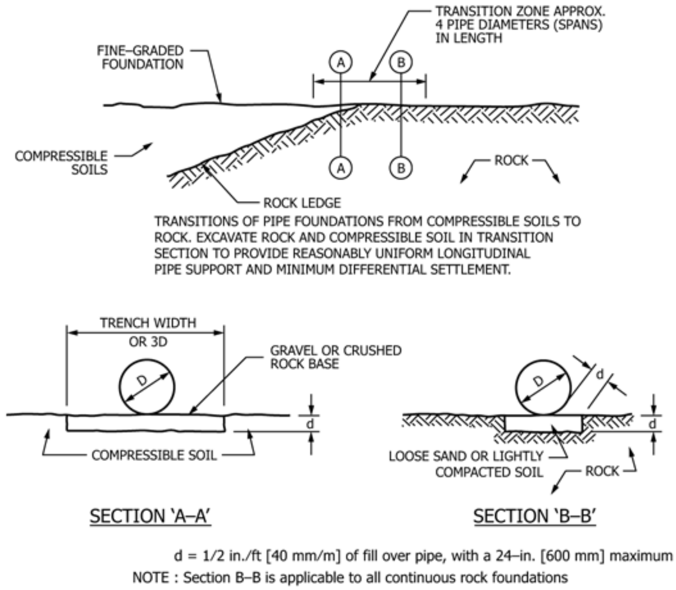
5. Trench Excavation

5.1 To obtain anticipated structural performance of corrugated aluminum pipe it is not necessary to control trench width beyond the minimum required for proper installation of pipe and backfill. However, the soil on each side beyond the excavated trench must be able to support anticipated loads. When a construction situation calls for a relatively wide trench, it shall be made as wide as required, for its full depth if so desired. However, trench excavation must be in compliance with any local, state, and federal codes and safety regulations.

6. Foundation

6.1 The supporting soil beneath the pipe must provide a reasonably uniform resistance to the imposed load, both longitudinally and laterally. Sharp variations in the foundation must be avoided. When rock is encountered, it must be excavated and replaced with soil. If the pipe runs along a continuous rock foundation, it is necessary to provide a suitable soil bedding under the pipe. See Fig. 3.

6.2 Lateral changes in foundation should never be such that the pipe is firmly supported while the backfill alongside is not.



d = ½ in./ft [40 mm/m] of fill over pipe, with a 24-in. [600-mm] maximum.

NOTE 1—Section B-B is applicable to all continuous rock foundations.

FIG. 3 Foundation Transition Zones and Rock Foundations

When soft material is encountered during construction and must be removed in order to provide an adequate foundation, remove the soft material for a distance of three pipe widths, unless the engineer has set another limit. See Fig. 4.

6.3 Performance of buried pipe is enhanced by allowing the pipe to settle slightly under load compared to the columns of soil alongside. Thus, for larger pipes it can be beneficial to purposely create a foundation under the pipe itself which will yield under load more than will the foundation under the columns of soil to each side. It can usually be obtained by placing a layer of compressible soil of a suitable thickness, less densely compacted than the soil alongside, beneath the structure. This creates favorable relative movement between pipe and the soil on each side. It is of particular importance on pipe-arches.

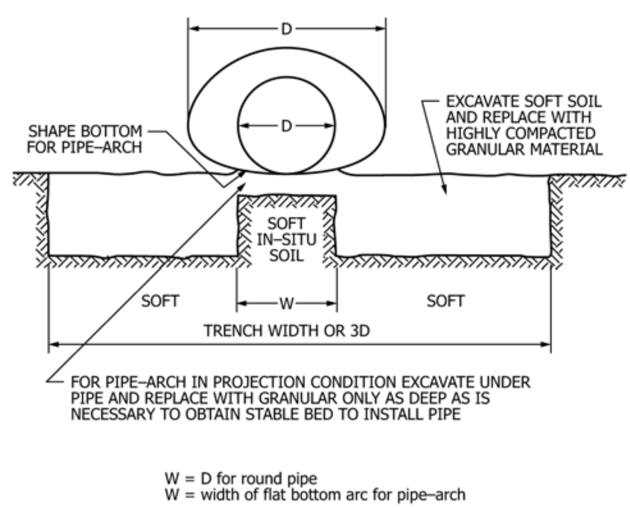


FIG. 4 Soft Foundation Treatment

6.4 *Pipe-Arches*—All pipe-arch structures must have excellent soil support at their corners by both the in-situ foundation and the structural backfill. See Fig. 4 and Fig. 5. They do not require the same degree of support under their large-radius inverts.

6.5 The engineer is encouraged to develop details specific to the site based on the general principles for foundation conditions given in 6.1 through 6.4.

7. Bedding

7.1 Material used for bedding beneath the pipe shall meet the requirements of this section. Material in contact with the pipe shall not contain rock retained on a 3-in. [75-mm] ring, frozen lumps, chunks of highly plastic clay, organic matter, corrosive material, or other deleterious material. It is not required to shape the bedding to the pipe geometry. However, for pipe-arches, it is recommended to either shape the bedding to the relatively flat bottom arc or fine-grade the foundation to a slight v-shape. This avoids the problem of trying to backfill the difficult area beneath the invert of pipe-arches. See Fig. 5.

8. Pipe Installation

8.1 All pipe shall be unloaded and handled with reasonable care. Pipe shall not be rolled or dragged over gravel or rock and shall be prevented from striking rock or other hard objects during placement on bedding. Pipe with protective coatings shall be handled with special care to avoid damage. Paved inverts shall be placed and centered in the invert.

8.2 *Joining Systems:*

8.2.1 *Purpose of Joining systems*—Joining systems for corrugated aluminum pipe serve several purposes: *(1)* to maintain pipe alignment during installation; *(2)* to join the ends of pipe sections that will subsequently be buried; *(3)* to create a continuous flow line; and *(4)* to limit the amount of infiltration of backfill material into the pipe and to limit exfiltration of the flow through the pipe.

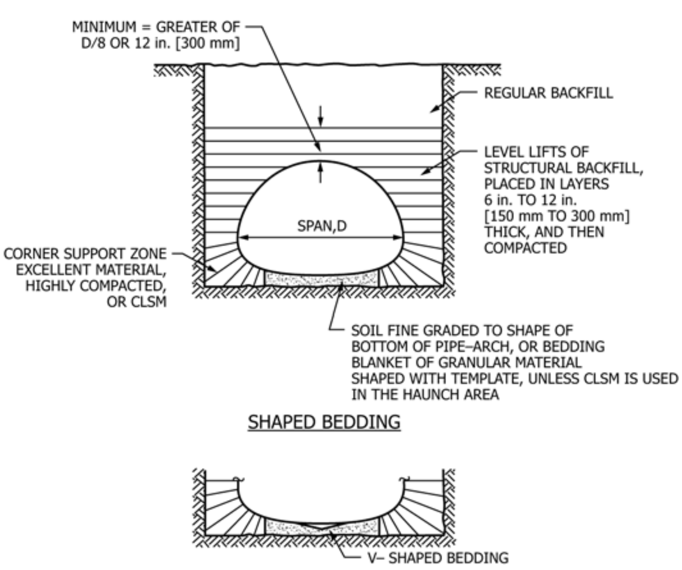


FIG. 5 Bedding and Corner Zone Treatment for Pipe-Arch Structures

8.2.2 *Joint System Components*—The joining system shall be specified by the project engineer. The components shall conform to the requirements of Specification B745/B745M. The pipe fabricator shall provide the components specified for the project or as designated by the fabricator in accordance with Specification B745/B745M, Ordering Information. Conformance of the joining system components with the project requirements shall be verified upon delivery to the project site.

8.2.3 *Joining System Installation*—The performance of the pipe line and the joining system will be achieved only when all components of the pipe system are properly installed. As an integral portion of the pipe system, the joining system must be assembled in accordance with the details in the project drawings or the recommendations provided by the pipe fabricator.

8.2.3.1 *Gaskets*—If gaskets are a required component of the joining system, they shall be placed on the pipe ends, at the required location on the pipe, prior to installation of the coupler or bands, or prior to stabbing a bell and spigot joint. For joining systems incorporating o-rings(s), the o-ring shall be placed on the spigot end of the pipe when the joint is a stab-type joining system, or one shall be placed on each end of the pipes that form a joining system that incorporates a coupling band. If the joining system includes a flat gasket, the gasket shall be placed over the end of the pipe previously placed and extended over the end of the adjacent pipe after it is positioned. In lieu of a single flat gasket, two smaller flat gaskets may be used with one gasket on the end of the pipe forming the joint. For pipe supplied with a factory installed band or coupler, no field installed gasket will be required on the pipe end with the factory installed device. When recommended by the manufacturer, lubricant shall be applied to the designated surfaces. Once installed, the gasket shall be protected against damage until the joint is completely installed.

8.2.3.2 *Coupling Bands*—Coupling bands shall be placed on the end of the last pipe installed. When installing two-part bands, the first portion of the band shall be placed to cover the bottom portion of the pipe. When the subsequent pipe is placed, the installation of the joining system is completed to ensure proper alignment of the pipeline. The width of the opening between pipe ends shall be as recommended by the pipe fabricator. The band shall be tightened around the pipe ends to the extent necessary to achieve proper performance of the joining system. The band shall be placed over the pipe being joined in a manner that matches any corrugations or dimples in the band with the corrugations in the pipe. Follow the pipe fabricator's instructions and methods for tightening the bands.

8.2.3.3 *Sleeve Coupler and Bell and Spigot Joining Systems*—When a field installed sleeve coupler is utilized, it shall be placed on the end of the pipe previously placed. With a bell and spigot system, the first pipe is to be oriented so the bell is open in a direction in which installation will proceed. The subsequent pipe is installed by inserting the spigot, or pipe end without the sleeve coupler, to the maximum depth permitted by the joining system. Follow the pipe fabricator's instructions for the method of assembly and use of insertion force.

8.2.4 *Joint Backfill*—The joining system was selected based on the expected site conditions, specifically the type and gradation of backfill material. The structural backfill material used around the pipe shall be in accordance with the project specifications. Backfill material shall conform to that specified in Section 9, and shall be placed in accordance with Section 10. Care shall be exercised during backfill placement not to damage or dislodge the joining system.

9. Structural Backfill Material

9.1 Structural backfill is that material that surrounds the pipe, extending laterally to the walls of the trench, or to the fill material for embankment construction, and extending vertically from the invert to an elevation of 1 ft [300 mm] or ⅛ the diameter or span, whichever is greater, over the pipe. The necessary width of structural backfill depends on the quality of the trench wall or embankment material, the type of material and compaction equipment used for the structural backfill, and in embankment construction, the type of construction equipment used to compact the embankment fill. The width of structural backfill shall meet the requirements given in Table 1.

9.2 Structural backfill material shall be readily compacted soil or granular fill material with no material retained on a 3-in. [75-mm] ring. Select materials such as bank-run gravels or other processed granular materials with excellent structural characteristics are preferred. Desired end results are obtainable with this type of material with a minimum of compaction effort over a wide range of moisture content, lift depth, and compaction equipment characteristics. Excavated native soils used as structural backfill shall not contain frozen lumps, highly plastic clay, organic material, corrosive material, or other deleterious foreign materials. Soil classifications are defined in Classification D2487. Soils meeting the requirements of groups GW, GP, GM, GC, SW, and SP are generally acceptable, when compacted to the specified percent of maximum density as determined by Test Method D698. Test Methods D1556, D2167, D2937, and D6938 shall be used to determine the in-place density of the soil. Soil types SM and SC are acceptable, but they will require closer control to obtain the specified density. Soil Groups ML and CL are not preferred materials, while soil Groups OL, MH, CH, OH, and PT are not acceptable.

9.3 Special materials other than soil are acceptable when used as described in 10.1.

TABLE 1 Structural Backfill Width Requirements[A,B]

Adjacent Material	Required Structural Backfill Width
Normal highway embankment compacted to minimum of 90 % Test Method D698 density, or equivalent trench wall.	As needed to establish pipe bedding and to fill and compact the backfill in the haunch area and beside the pipe. Where backfill materials that do not require compaction are used, such as cement slurry or controlled low strength material (CLSM), a minimum of 3 in. [75 mm] on each side of the pipe is required.
Embankment or trench wall of lesser quality.	Increase backfill width as necessary to reduce horizontal pressure from pipe to a level compatible with bearing capacity of adjacent materials.

[A] For pipe arches and other multiple radius structures, as well as for all structures carrying off-road construction equipment, the structural backfill width, including any necessary foundation improvement materials, must be sufficient to reduce the horizontal pressure from the structure so that it does not exceed the bearing capacity of the adjacent material.

[B] In embankment construction, the structural backfill width must be adequate to resist forces caused by the embankment construction equipment. Generally, the width on each side of the pipe should be no less than 1 diameter, or span, or 2 ft [600 mm], whichever is less.

10. Structural Backfill Placement

10.1 Structural backfill shall be placed in non-compacted layers from 6 to 12 in. [150 to 300 mm] in depth depending on the type of material and compaction equipment or method. Each layer or lift shall be compacted before adding the next lift. On flat bedding, care must be taken to place material under the pipe haunches and compact it firmly. Structural backfill on each side of the pipe shall be kept in balance. Generally, no more than one lift difference will be permitted. Construction equipment shall not be used over or alongside the pipe without sufficient compacted soil between it and the pipe to prevent distortion, damage, or overstressing. Mechanical soil compaction of layers is preferred. However, when acceptable end results are achieved with water consolidation, this method is acceptable with permission of the project engineer. When water consolidation methods are used, care must be taken to prevent flotation. Water consolidation methods shall be used only on free-draining structural backfill material. When cohesive soils are used as structural backfill, good compaction will only be obtained with a proper moisture content. Shallower lifts are generally required for acceptable end results with cohesive soils than with granular or mixed soils. In general, much closer inspection and testing must be exercised to ensure good results with cohesive structural backfill material. Water compaction is not acceptable with cohesive material. Unusual field conditions will, under some circumstances, make higher cost special backfill material or methods more practical. Materials that set up without compaction, such as cement slurry, controlled low strength material (CLSM), and various foamed mixtures, provide excellent structural backfill provided they are designed to yield the compressive strength required. As with water compaction, care must be taken to avoid flotation.

10.2 The compaction of structural backfill shall provide a soil structure around the pipe to uniformly apply overburden pressures on the crown of the pipe and provide uniform bearing for the pipe side walls and lower haunches. The required degree of compaction will vary with the job and structural backfill material. The structural backfill is an integral part of the design process. Therefore, required end results regarding in-place density of structural backfill shall be in accordance with job specifications. Most structural design tables for corrugated aluminum pipe establish maximum overfill depths based on a specified field density of 90 % in accordance with Test Method D698 with good structural backfill material. However, the majority of sewer pipe installations do not require deep overfills. For relatively shallow buried pipes not subject to live load, an acceptable structural backfill material and its degree of compaction shall be determined by the character of the adjacent ground. A balanced design making the conduit homogeneous with the ground on either side is often desirable. For this reason, it is not practical to establish arbitrary minimums for soil characteristics of structural backfill for all installations.

10.3 *Pipe-Arches*—Special attention must be given to the material used and compaction obtained around the corners of pipe-arches. Vertical load over the pipe is transmitted into the soil principally at the corners. Therefore, the quality of structural backfill is particularly important adjacent to pipe-arch corners. In the case of higher fills (greater than 15 ft) or deep trenches, special designs will likely be required for corner backfill zones.

10.4 Generally, construction experience and a site appraisal will establish the most economical combination of material, method, and equipment to yield acceptable end results. Test Method D698 is the preferred means of determining maximum (standard) density and optimum moisture content. A construction procedure must then be established that will result in the specified percent of maximum density. Once that is established, direct the primary inspection effort to ensure that the established procedure is followed. Such a procedure will likely involve material, depth of lift, moisture content, and compactive effort. Only occasional checks will then be required, as long as the material and procedures are unchanged. In situ density shall be determined by Test Methods D1556, D2167, D2937, and D6938, as applicable, for field verification. Testing shall be conducted on both sides of the structure. Construction methods and equipment that achieve required end results without damage to or distortion of the pipe shall be acceptable.

10.5 *Shape Control*—Excessive compaction, unbalanced loadings, loads from construction equipment, as well as inadequate compaction or poor backfill materials, are likely causes of excessive pipe distortion. For larger pipe, the construction contractor has the option of establishing a shape monitoring system, prior to placement of structural backfill, to aid in establishing and maintaining proper installation procedures. Direct measurement of span and rise, offset measurements from plumb bobs hanging over reference points, and similar types of measurements are effective means for monitoring shape change during backfill placement and compaction. In general, it is desirable for the crown of the pipe to rise slightly, in a balanced concentric manner, during placement and compaction of soil beside the pipe. Under the load of the completed fill and the service load, vertical deflections will be a small percentage of the pipe rise dimension with adequate backfill compaction.

11. Regular Backfill

11.1 Regular backfill in trench installation is that material replaced in the trench above the structural backfill. In projection conditions, it is also the embankment fill adjacent to the structural backfill.

11.2 Regular backfill shall consist of native materials and shall be placed and compacted as required by job specifications. Large rocks or boulders shall not be placed within 4 ft [1.2 m] of the pipe. Large boulders are not permitted in regular backfill in trenches that are under surface structures, including pavements. Construction equipment shall not be used over or alongside the pipe without sufficient compacted soil between it and the pipe to prevent distortion, damage, or overstressing.

12. Multiple Structures

12.1 When two or more structures are installed in adjacent lines, the minimum spacing requirements given in Practice B790/B790M must be provided.

13. Keywords

13.1 aluminum pipe; corrugated aluminum pipe; culvert; installation—underground; joining systems; sewers

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B788/B788M–04) that may impact the use of this standard. (Approved Nov. 1, 2009)

(1) Section 2.1 was revised to remove D2922 and replace with D6938. This change has also been made throughout B788.