United States Department of Agriculture

Part 645 Construction Inspection
National Engineering Handbook

Chapter 15 Pipe

Issued November 2017

Chapter 15 Pipe

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Part 645 – Construction Inspection

Chapter 15 – Pipe

645.1501 Introduction

A. A buried pipe relies on both the pipe and the soil surrounding the pipe for the support that is critical to the performance of the pipe. The typical pipe and support system will resemble the cross section shown below in figure 15-1.

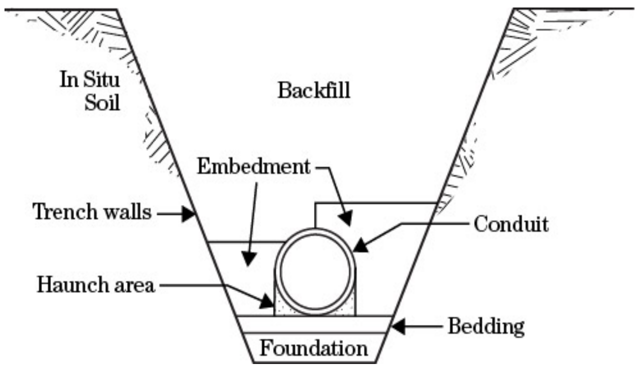

Figure 15-1: Typical pipeline cross-section

B. Pipe is either rigid (e.g., pipe made of steel, concrete, etc.) or flexible (e.g., pipe made of plastic, corrugated metal, etc.). Buried pipelines (a pipeline is simply two or more connected pipes) are designed with pipe rigidity and flexibility in mind. As can be seen in figure 15-2, backfill load applied to the top of rigid pipe is transferred to the bottom of the pipe so that all the load is supported by the foundation. Conversely, flexible pipe must be supported by the embedment soil as well as the foundation. Embedment soil must be well compacted to resist pipe deflection. The type of pipe (rigid or flexible) must be considered when handling and storing the pipe.

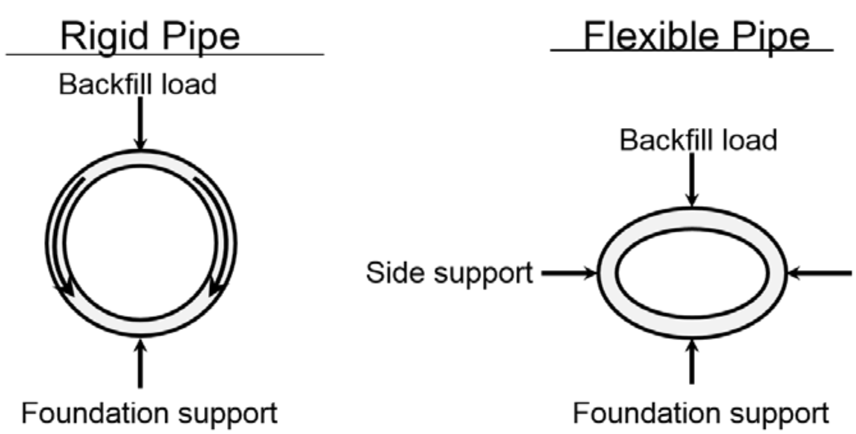

Figure 15-2: Rigid and deflected flexible pipe

C. This chapter is intended as a general reference for inspection of commonly installed pipelines in accordance with applicable NRCS construction specifications and referenced ASTM standards. For a comprehensive guide on pipeline installation see “Pipeline Installation 2.0” by Amster Howard published by Relativity Publishing, Lakewood, CO.

645.1502 Installation

A. Materials

(1) Rigid pipes are made from cast iron, clay, concrete, ductile iron, and steel. Flexible pipes are made from aluminum, fiberglass, steel, and plastics (PVC, PE, and PP). All pipes installed in NRCS engineering measures should meet quality standards specified by either the American National Standards Institute (ANSI), the ASTM International (ASTM), the American Association of State Highway Transportation Officials (AASHTO), or the American Water Works Association (AWWA). Some pipes are manufactured to meet a particular classification defined by the pipe’s quality standard. Pipeline designs should designate the type and class of pipe, the quality standard for the pipe, pipe joint materials, and all appurtenances.

(2) The quality standards generally require that the pipe have specific markings. For example, ASTM C36, “Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe,” requires the following information to be legibly marked on each section of pipe: the pipe class and specification designation, the date of manufacture, the name or trademark of the manufacturer, and the identification of the plant where the pipe was made.

(3) Upon delivery, before unloading if possible, the pipe should be inspected to verify that it is undamaged, marked as required by the quality standard, and is of the specified size, type, and class. Damage that commonly occurs during transportation includes deformed pipe when tiedowns are too tight, damaged coatings, and abraded surfaces.

(4) The inspector must verify that pipe joint materials and pipeline system appurtenances meet specification requirements. After materials have been unloaded from the transport vehicle, they should be inspected for any damage that may have occurred during unloading. Materials that are not new or are damaged must be rejected or repaired. Repaired pipe may only be used with approval from the responsible engineer. The responsible engineer may require that the damaged pipe be inspected by a manufacturer’s representative in person or by photography before and/or after being repaired, to certify that the pipe will still function as intended.

(5) The inspector’s responsibilities related to pipe materials include verifying that—

(i) Pipe is of the specified size.

(ii) Pipe is of the specified type and class.

(iii) Pipe is marked as required by the quality standard.

(iv) Joint materials and pipeline appurtenances meet specification requirements.

(v) Damaged materials are rejected or are repaired if approved by the responsible engineer.

(vi) Repaired materials are repaired as specified and approved by the responsible engineer.

B. Handling and Storage

(1) After cave-ins, unloading pipe is the most frequent cause of pipeline construction accidents. Care and common sense must be employed to avoid damage to the pipe and injury to workers. Trucks should be unloaded on a level surface. Blocks,

chocks, wedges, or notched supports used to keep pipe in place during transport, may not hold the pipe in place during unloading. The contractor should follow the manufacturer's recommendations for unloading when available.

(2) Sometimes smaller diameter pipe is shipped inside of larger diameter pipe. Be aware of the presence of this smaller (nested) pipe as it can slide out of the larger pipe during unloading.

(3) When unloading and handling, pipe should be lifted by mechanical means and not pushed, rolled, or handled with chains or slings that can damage the pipe. Never pass a chain, rope, cable, or other lifting device through the pipe as seen in figure 15-3; this can damage the ends of the pipe. Some proper lifting techniques are shown in figure 15-4. Verify that the safe lifting load of the lifting equipment is not exceeded when lifting pipe. Never stand directly under or downslope from any item being lifted.

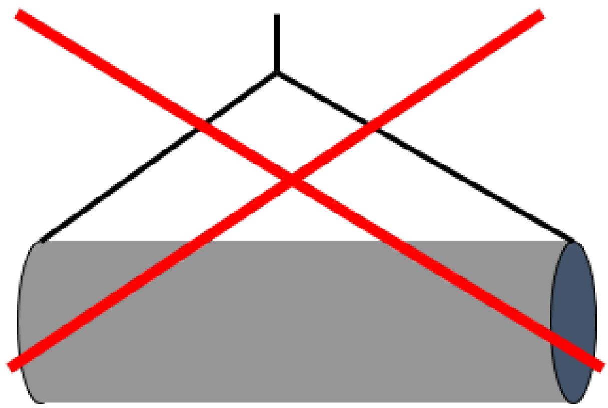

Figure 15-3: Improper lifting of pipe

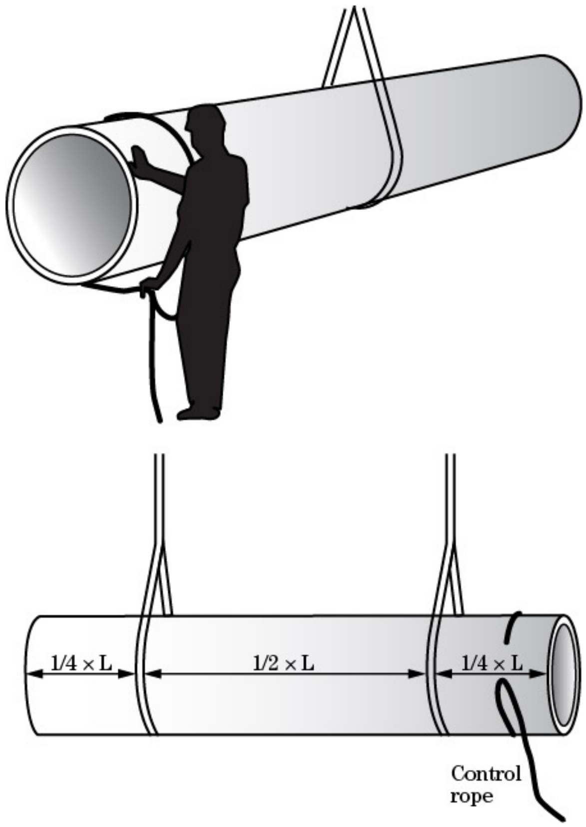

Figure 15-4: Proper lifting of pipe

(4) Care must be taken when handling PVC pipe in cold weather because it becomes brittle and more susceptible to cracking or breaking.
(5) Pipe should be stored in an accessible location as near as possible to the place it will be installed but not where it can interfere with equipment movement and other work. Note any markings on the pipe and follow the manufacturer's instructions concerning pipe storage. Pipe that is stacked must be chocked or otherwise secured. When removing pipe from a stack, always chock or otherwise secure the next pipe in line so it will not roll when the selected pipe is removed.
(6) Some pipelines require specific sections of pipe to be installed before others. This sequencing is typically required for bevel-end pipe (figure 15-5), which is designed to change alignment at the joints. When storing this type of pipe, it is prudent to store the pipe in a sequence that will allow the pipe sections to be removed as they are needed without having to move other pipe out of the way.

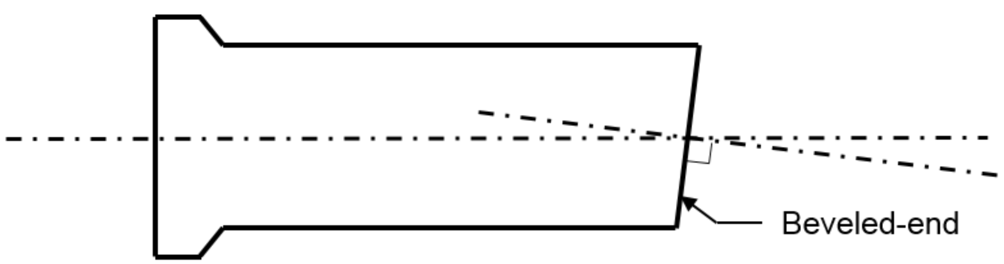

Figure 15-5: Bevel-end pipe

(7) Different pipe materials have different requirements when it comes to the manner of storage. Flexible pipe should be uniformly supported to avoid deformation and should not be stacked so high as to cause the lower sections of pipe to deflect under the weight of the upper pipe. During prolonged storage, it should not be stacked more than 2 feet high because the weight causes it to flatten or go out of round. Unless plastic pipe is specifically manufactured to withstand exposure to ultraviolet radiation, it should be covered with an opaque material when stored in sunlight for more than the specified time or, if not specified, when stored in sunlight for more than 15 days.

(8) Rigid pipe should be supported in two places with equal load on both supports. Pipe with a flared bell must be supported so that it does not rest on the bell. Concrete pipe with bell ends is susceptible to damage if knocked together or dropped.

(9) The inspector's responsibilities related to handling and storage include verifying that—

(i) Trucks are unloaded on a level surface.
(ii) Care is taken when unloading to prevent uncontrolled movement of pipe.
(ii) When available, manufacturer's unloading recommendations are followed.
(iv) Nested pipe is removed or secured before unloading pipe.
(v) Proper lifting is employed to avoid damage to pipe.
(vi) The safe lifting load of equipment is not exceeded.
(vii) No one stands under or downslope from any item being lifted.
(viii) Care is taken when handling PVC pipe in cold weather.
(ix) Pipe is stored in an accessible location near the installation.
(x) Pipe markings and manufacturer's recommendations concerning storage are followed.
(xi) Stacked pipe is secured during storage and removal.
(xii) Pipe is stored so that it can be removed as needed without having to move other pipe or materials out of the way.
(xiii) Flexible pipe is uniformly supported and not stacked too high.
(xiv) Flexible pipe is not stacked over 2 feet high during prolonged storage.
(xv) Plastic pipe is protected from UV exposure.
(xvi) Rigid pipe is supported in two places with equal load on each support.
(xvii) Pipe does not rest on flared bell.
(xviii) Pipe is handled with care to avoid damage to ends.

C. Foundation and Bedding

(1) The foundation must support the pipe, bedding, embedment, backfill, and any *live load*. It must provide support during and after construction, and the support should be fairly uniform with no abrupt changes throughout the full length of the pipeline. Construction specifications should clearly describe the foundation treatment and bedding requirements. The level of foundation treatment, and the need for bedding, is contingent on allowable grade tolerances, type of pipe, type of installation, and the loads that will be imposed on the pipe.

(2) It is generally important to maintain a positive pipe grade to provide drainage. In some cases, only minor variations from the specified grade are tolerated. Overexcavation and backfilling to grade may be required to control pipe grade. Overexcavation may also be required to remove soft materials or to remove rock, rocky soil, or extremely hard soil.

(3) For some installations, attention to the foundation and bedding is not as critical to the function of the pipe. For example, perforated polyethylene subsurface drainage pipe may be installed with little or no regard for foundation preparation or bedding. This

pipe is often laid in the trench and covered as the trencher progresses. Some pipe deflection is anticipated but it does not adversely affect pipe performance. Conversely, foundation and bedding is critical for other installations.

(4) The installation of a spillway conduit in a tall earthfill dam would warrant an extensive evaluation of the foundation conditions and an analysis of the loading imposed on the pipe. Potential for *differential settlement* must be addressed by relocating or realigning the pipe so that it has consistent uniform support from end to end. Specifications should be written to mitigate any foundation problems and to provide the needed support. If the pipe foundation differs substantially from what is anticipated, this information must be given to the responsible engineer.

(5) Although difficult to accomplish in high plasticity and rocky soils, some soils can be shaped with a semicircular or v-notched groove in the foundation to provide better pipe support (figure 15-6). Otherwise, it will be necessary to compact earth backfill under the haunches of the pipe or provide a concrete or *flowable fill* bedding.

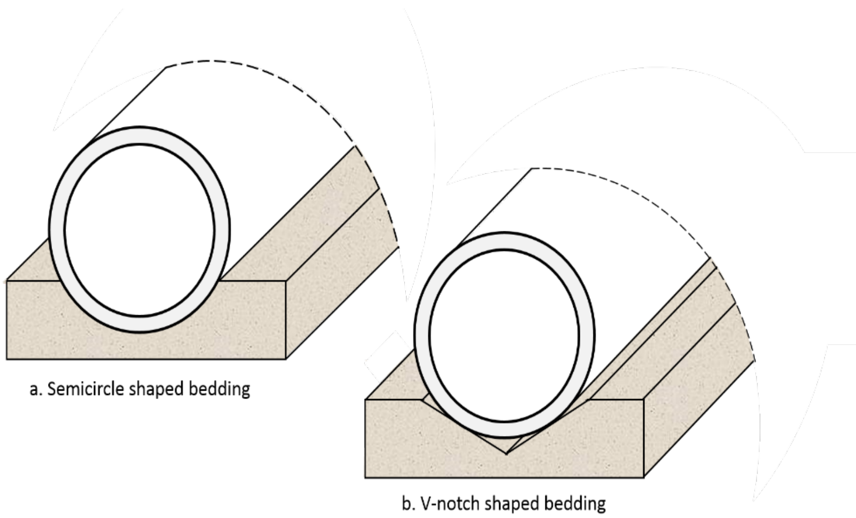

Figure 15-6: Shaped bedding

(6) The inspector's responsibilities related to foundation and bedding include verifying that—
- (i) Rock, rocky soil, or extremely hard material is removed to the specified depth below the pipe.
- (ii) Soft materials are removed to the specified depth below the pipe.
- (iii) Foundation and bedding are compacted to the specified moisture-density requirements.
- (iv) Bedding is graded to the specified grade.
- (v) When specified, bedding is shaped to conform to the pipe or shaped in a v-notch.
- (vi) Unexpected foundation materials are discussed with the responsible engineer.

D. Laying Pipe

(1) Damage can occur when conveying the pipe to its final resting place. All pipe, pipe joining materials, and appurtenances must be checked for damage prior to and after installation. Damaged materials must be rejected or repaired prior to installation or backfilling.

(2) As with unloading, lifting and conveying pipe during installation should be done in a safe manner that will not harm the pipe. A spreader bar and nylon or fabric slings should be used for lifting and conveying heavy pipe (figure 15-7). Pipe may be rolled, but uncontrolled rolling down a slope must be avoided. When maneuvering the pipe into place and joining it to other pipe, care must be taken to avoid damage to the pipe and pipe joints.

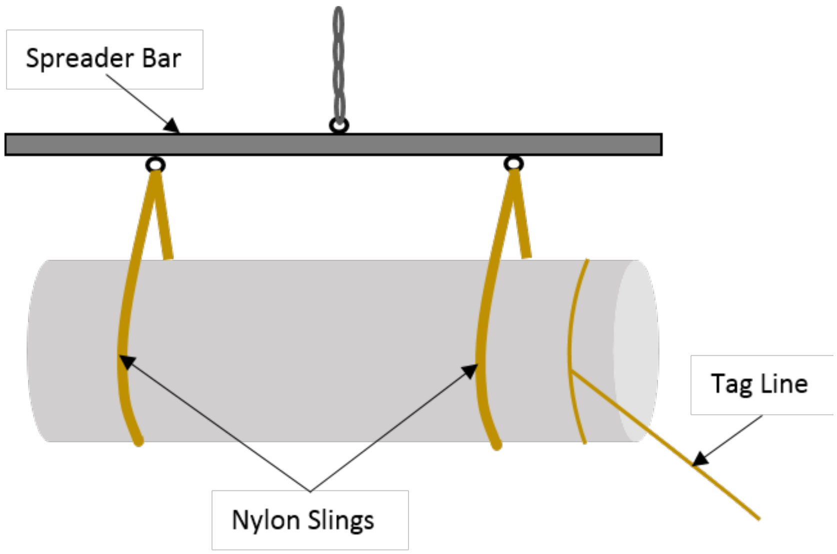

Figure 15-7: Spreader bar and nylon slings

(3) Pipe should be placed on bedding that has been graded to the specified grade and uniformly compacted. Mounds of soil, wood, concrete blocks, bricks, rocks or other items should not be used to adjust pipe grade as this may cause *point-loading* and damage to the pipe (figure 15-8).

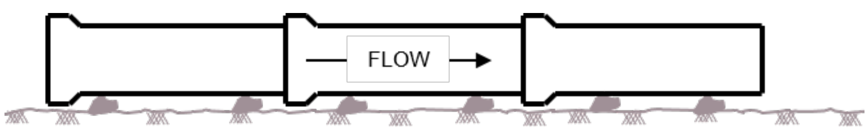

Figure 15-8: Point-loading caused by resting pipe on mounds of soil

(4) Bell and spigot pipe should be oriented with the bell on the upstream end of the pipe. Holes should be dug under flared bells (figure 15-9a) so that the pipe does not rest on the bell (figure 15-9b).

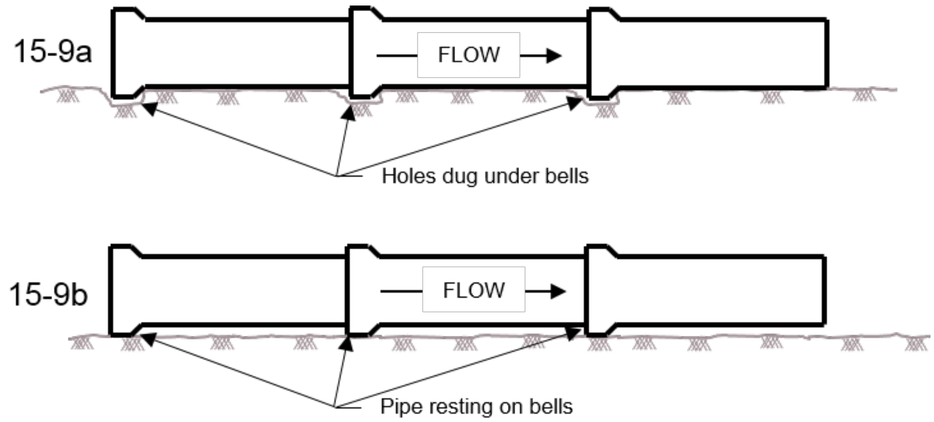

Figure 15-9a: Holes dug under bells to avoid **15-9b**, pipe resting on bells

(5) Bevel-end pipe should have the word "top" or "bottom" stenciled on or in the pipe. Pipes that have a "top" or "bottom" mark should be rotated so the pipe is installed with the mark at the top or bottom as designated. Each pipe will have a specific place in the pipeline when it is strung together, and each end of beveled-end pipe will be marked with a number. For example, the first section of pipe may have its ends numbered "1" and "2." The second section will have its ends numbered "2" and "3." The ends marked with a "2" will be joined together. This numbering convention will continue for each section of pipe in the pipeline even if some sections do not have beveled ends.

(6) For pipe that will be bedded with concrete or flowable fill, specifications may require the pipe to be temporarily supported until concrete is placed under the pipe. For concrete bedding, specifications allow these supports to be blocks of concrete made from the same concrete as that approved for the bedding or cradle. The blocks need to be shaped so that they cradle/conform to the bottom of the pipe. Concrete wedges are also allowed for temporarily supporting the pipe (figure 15-10). Wedges have the added advantage of allowing for minor adjustments in pipe grade without having to remove the pipe to adjust the pipe grade. See appendix E for a discussion on construction tolerances that are typical for pipe grade.

Figure 15-10: Wedges used to temporarily support pipe

(7) Once the pipe is set to specified grade, the concrete bedding can be installed (figure 15-11). It is important that the concrete be consolidated to remove any voids under the pipe so that the pipe is fully supported by concrete. This is also important for flowable fill; however, by definition, flowable fill should have a “flowable” self-consolidating consistency.

Figure 15-11: Pipe bedded with concrete

(8) Some designs call for a concrete cradle under the pipe. A cradle is similar to bedding except that it extends up the sides to the *springline* of the pipe (figure 15-12). An immersion vibrator is generally needed to adequately consolidate the concrete in a cradle. To avoid segregation, concrete should be deposited on both sides of the pipe as opposed to depositing it on one side and using the immersion vibrator to move it to the other side.

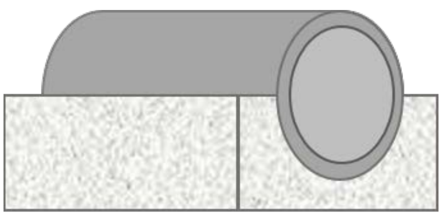

Figure 15-12: Concrete cradle under pipe

(9) Installed pipe should be protected from potential flooding that could erode the foundation or bedding and undermine the pipe. The open ends of installed pipe should be covered to keep out dirt and debris.

(10) The inspector’s responsibilities related to laying pipe include verifying that—

(i) Pipe, pipe joining materials, and appurtenances that are damaged are rejected or repaired.

(ii) Pipe is lifted and conveyed in a safe manner that does not harm the pipe.

(iii) Uncontrolled rolling to convey pipe is prevented.

(iv) Care is taken to avoid damage to pipe joints when joining pipes.

(v) Bedding is graded and uniformly compacted to the specified density.

(vi) Pipe is fully supported without the use of mounds of soil, wood, concrete blocks, etc. under the pipe that could cause point-loading.

(vii) Bell ends are oriented upstream unless otherwise directed by the specifications or drawings.

(viii) Holes are dug under flared bells to avoid resting the pipe on the bells.
(ix) Bevel-end pipe is placed in the proper sequence, oriented, and rotated as designated on the pipe.
(x) Temporary concrete pipe supports (block or wedges) are made from the same concrete as that approved for the cradle or bedding.
(xi) Blocks are shaped to cradle or conform to the bottom of the pipe.
(xii) Concrete placed for bedding or for a cradle is well consolidated.
(xiii) Concrete is deposited on both sides of the pipe, not moved from one side to the other with the aid of the vibrator.
(xiv) Installed pipe is protected from flooding.
(xv) The open ends of installed pipe are covered to keep out dirt and debris.

E. Pipe Joints

(1) Individual sections of pipe are joined to other pipe at the pipe joint. All pipe joints that are required to be leak proof or have limited leakage have one thing in common: they must be clean at the time the pipes are joined. They must also be in good condition with no chips or cracks that could hinder their ability to seal.

(2) There are three general categories of pipe joints typically used in conservation engineering applications: solid joint, fixed joint, and articulating joint.

(3) Solid joints are permanently connected by heat or solvent welding, heat fusing, or adhesive bonding. Steel pipe joints are often heat welded in the field. The welding is done by electrical arc or gas welding. Specifications require welding to be done according to AWWA Standard C206. The amount of testing required to verify welds are adequate depends on the application and requires a qualified inspector. NRCS inspectors are not expected to perform testing that is required to verify welds are adequate. If specified, the NRCS inspector must verify that the welds have been inspected by a qualified inspector and certified to meet specification requirements. After field welding, it is generally specified that any pipe coating that is damaged by welding be repaired and that the pipe joint be coated to protect it against corrosion.

(4) Solvent welding is commonly used for joining polyvinyl chloride (PVC) pipe. Some PVC pipe is supplied with a bell end; if the pipe has no bell end, a properly sized PVC coupler is needed to joint two pieces of pipe. The pipe ends are cleaned with a primer before applying the solvent to both surfaces to be joined. There are different solvents for different types of plastic pipe. The pieces are immediately joined after applying the correct solvent and twisted in opposite directions from each other approximately a quarter of the pipe diameter (1/4 turn) to evenly distribute the solvent. The pieces are allowed to rest undisturbed for a short time (specified by the solvent manufacturer). The solvent melts the PVC, then it re-solidifies so that the pipe is welded together rather than being adhesive bonded. It is important to apply the manufacturer’s recommended amount of solvent to both pieces being joined. If too little solvent is applied the weld will be weak. Conversely, the pipe itself can be weakened at the joint if too much solvent is applied.

(5) Heat fusion can be used for fusing plastics; it is commonly used to fuse solid wall polyethylene (PE) pipe. The pipes are aligned and pressed against a hot steel plate to melt the end of each pipe (figure 15-13a and 15-13b). The steel plate is removed and the pipes are immediately joined and held together until the ends resolidify to form a strong joint (figure 15-13c). If done properly, the joint is as strong and leak-proof as the pipe itself (figure 15-13d). Weak or leaky joints can occur if the steel plate or pipe ends are contaminated, if the plate is not hot enough to fully melt the pipe ends, or if the ends are not joined in a timely manner.

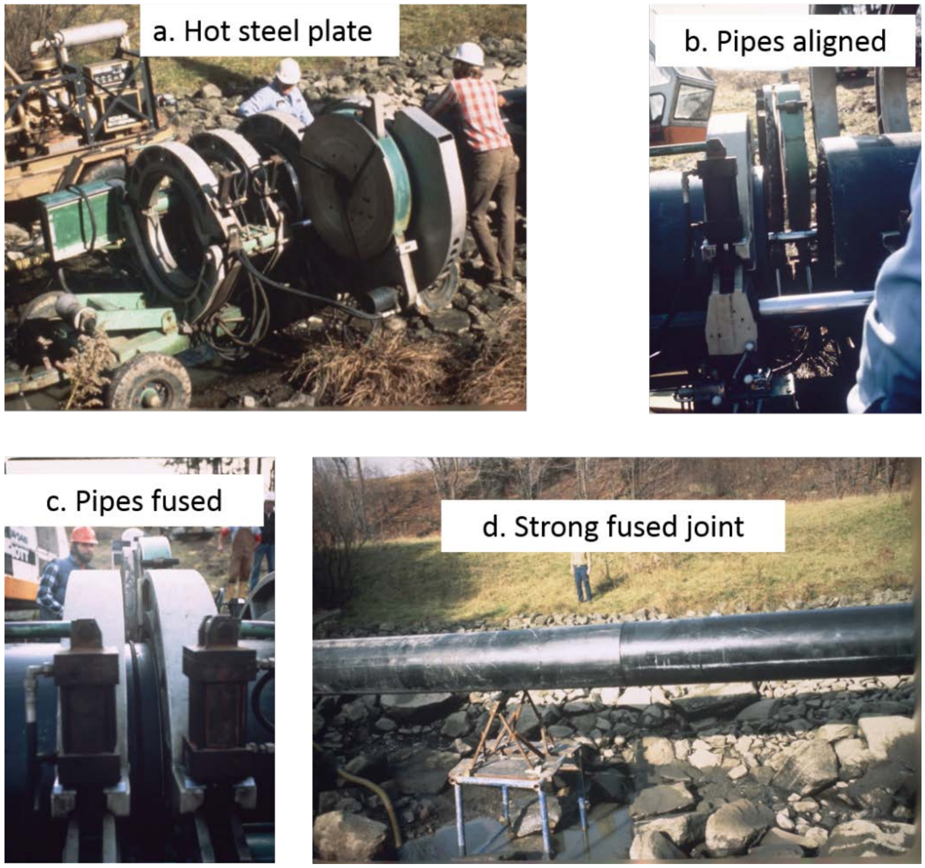

Figure 15-13: Fusing PE pipe

(6) In addition to solvent welding and heat fusion, plastic pipe can also be bonded by adhesive. Fiberglass pipe is generally bonded with adhesive. Unlike solvent welding, adhesive bonding is not meant to melt the pipe, only to bond (glue) the materials together. But, like solvent welding, the success of adhesive bonding is dependent on strict adherence to the adhesive manufacturer's instructions for use. The joining surfaces must be clean and dry and the operation must be completed in a timely manner while the adhesive is still active and before it sets up.

(7) The inspector's responsibilities related to solid pipe joints include verifying that—

(i) For heat-welded joints—

- If required, steel welds have been inspected and certified by a qualified inspector to meet specification requirements.
- Steel pipe coatings are repaired if damaged by welding.
- Specified steel pipe joint corrosion protection is properly installed.

(ii) For solvent-welded and adhesive-bonded joints—

- The coupler, if used, is the proper size and of the same material as the pipe.
- Joining surfaces are cleaned and primed.
- The correct type of solvent or adhesive is being used for the type of materials being welded.
- The manufacturer-recommended amount of solvent or adhesive is applied to both surfaces.
- The pieces are twisted ¼ turn and allowed to rest the specified amount of time.

(iii) For heat-fused joints—
- Pipes to be fused are properly aligned.
- Steel plate and pipe ends are clean and uncontaminated.
- Steel plate adequately melts the pipe ends.
- Ends are joined in a timely manner.

(8) Fixed joints are removable joints that are not designed for joint movement. These may be tongue-and-groove, flanged, or mechanically coupled joints. Tongue-and-groove joints (figure 15-14) may flex if they are not designed and installed to be fixed joints. Whether or not they need to be watertight depends on the application; concrete pipe with tongue-and-groove joints is often used for culverts where temporary flow or open channel flow does not demand a completely watertight joint. These may be installed without any joint sealant.

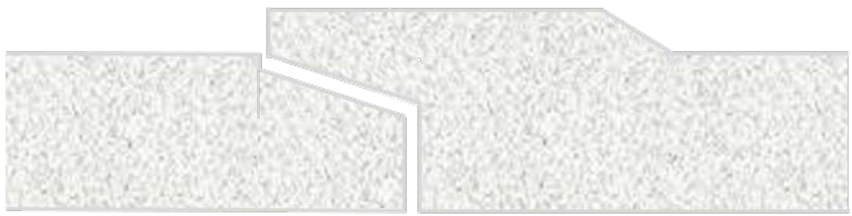

Figure 15-14: Tongue-and-groove joint

(9) If they are to be watertight, tongue-and-groove joints must be fixed so that they do not flex. Making tongue-and-groove joints watertight requires a firm uniform bedding on a stable foundation. The pieces of pipe must be aligned with a common axis so that there is no deflection (or change in alignment) from one pipe to the adjoined pipe.

(10) The joining surfaces must be clean and either moistened for mortar sealing or dry for mastic or gasket sealing. Mortar made from Portland cement, water, and fine sand is used to fill mortar joints. It is applied to the tongue end and in the groove end of the adjoining section and must be of a consistency that it will stick to and remain on the bonding surfaces until the pipes are joined together. Care must be taken to ensure the mortar remains on the bonding surfaces. The mortar should be mixed just prior to its use in small batches so that it is recently mixed (fresh) when the pipes are joined. The amount of applied mortar should be sufficient so that after the pipes are joined it exudes from around the full circumference of the joint on the inside and outside of the pipe joint. Excess mortar is then removed and, on the inside of the pipe, smoothed so that it is flush with the inside wall of the pipe. It should then be cured as specified.

(11) Mastic supplied in rolls is commonly used to seal tongue-and-groove joints. The mastic comes in various diameters; the diameter is specified relative to the size of pipe (more mastic is needed to fill the larger joint profiles of larger pipe). The mastic is applied around the tongue of the pipe with some overlap to ensure complete coverage. Care must be taken when joining the pipes to ensure the mastic ends up between the tongue and groove similar to what is depicted in figure 15-15.

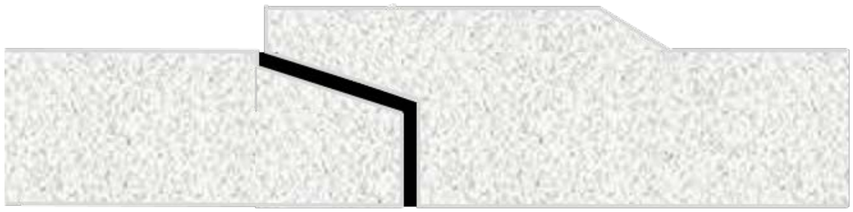

Figure 15-15: Tongue-and-groove joint with mastic

(12) Rubber gaskets may be used to seal tongue-and-groove pipe but these can be tricky to install. Unlike bell and spigot pipe, tongue-and-groove pipe has no step or gasket groove to help hold the gasket in place as the pipes are being joined. Special gaskets that are made for tongue-and-groove pipe should be used. And, as with any rubber gasket, a non-petroleum based lubricant is needed on the gasket and the mating surface to prevent friction from tearing or dragging the gasket out of place as the pipes are pushed together. Never use petroleum-based lubricants as these may damage the gasket material.

(13) Flanged joints (figure 15-16) are used for steel, aluminum, and plastic pipe. These joints are held together by nuts, bolts, and washers and are generally supplied with a gasket made of neoprene or other material that can hold up when squeezed between the flanges. The flanges have a smooth flat mating surface that must be clean before assembly. A couple of bolts are inserted into one flange and through two of the holes in the gasket before mating to the other flange. A lock washer is placed over the threaded end of the bolts before the nuts are spun on and lightly tightened. Then the remaining bolts, washers, and nuts are installed snuggly before all the nuts are tightened to the specified torque. It is essential the nuts be tightened in a pattern similar to tightening the nuts on a wheel with opposing nuts being tightened in sequence as shown in figure 15-17, unless otherwise stipulated in the plans or specifications.

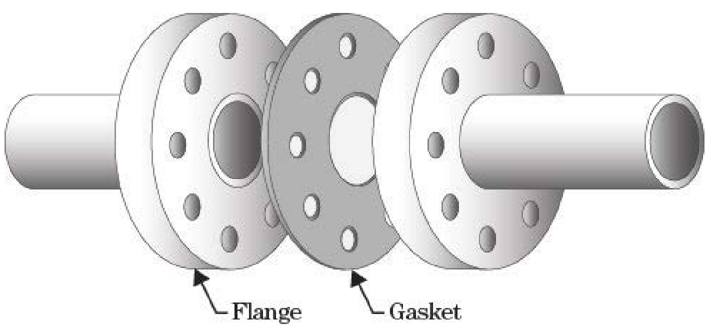

Figure 15-16: Flange joint with gasket

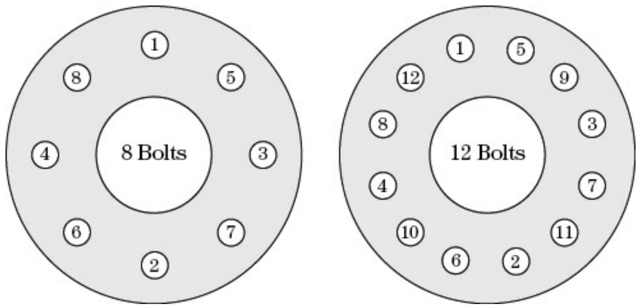

Figure 15-17: Flange tightening sequence

(14) There are various types of mechanically coupled joints. Corrugated metal pipe (CMP) is typically joined with band couplers (figure 15-18). If specified for band couplers, sleeve gaskets that are several inches wide made of elastic material are used. Sleeve gaskets should be lubricated with flax soap or vegetable shortening when they are installed. The gasket, which looks like a big gray or black wide rubber band, is placed onto the end of one of the pipes then pulled over the pipe joint after the pipes are butted together. Equal portions of the gasket should cover the end of each pipe. The band coupler is then installed so that equal parts of the band coupler covers the end of each pipe. One of the pipes may have to be moved in or out to allow the band coupler corrugations to align with the pipe corrugations, so a small gap between the pipe sections is normal. This critical step must not be overlooked. The flanges are then bolted together and generally an encircling rod is placed around the groove on each side of the band coupler. Lugs and nuts are installed on the encircling rods, then the nuts are tightened to the specified torque or tightened so that the band coupler is snug around the joint.

(15) O-rings may be used instead of sleeve gaskets to seal band coupler joints. The O-rings must be lubricated with flax soap or vegetable shortening and positioned as shown in figure 15-18, in the corrugation that is nearest to the grooves at the outer edge of the band.

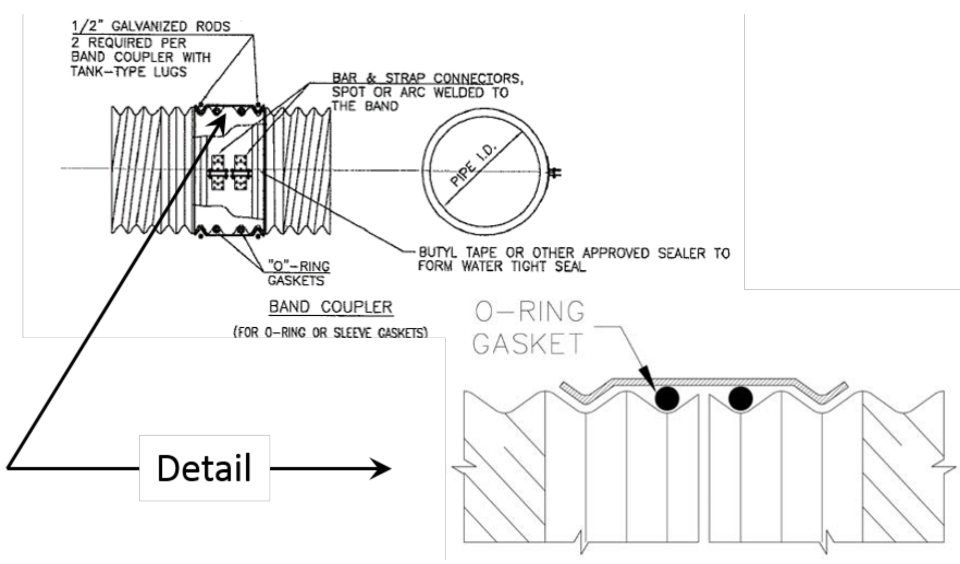

Figure 15-18: Band coupler with O-ring gasket

(16) For CMP with helical (spiral) corrugations, the ends of the pipe must be modified so that the corrugations are annular (figure 15-19).

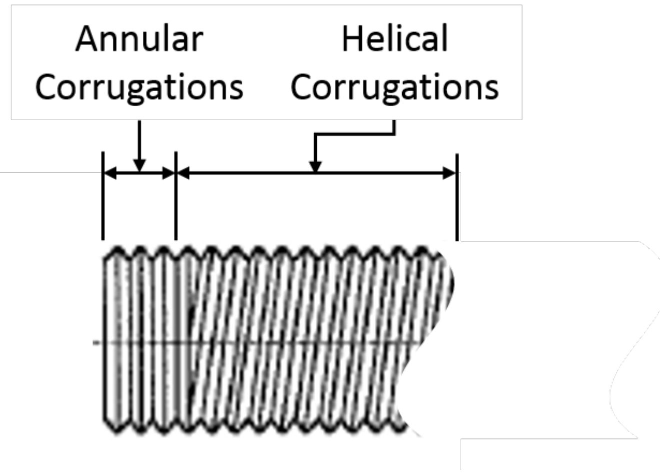

Figure 15-19: Spiral CMP with annular ends

(17) The inspector's responsibilities related to fixed pipe joints include verifying that—

(i) For tongue-and-groove joints that are to be watertight—

- Pipe is installed on a firm, uniform bedding resting on a stable foundation.
- Pipes are aligned with a common axis.
- With mortar sealing—
  - Joining surfaces are clean and moistened.
  - Applied mortar is fresh.
  - Mortar sticks to and remains on the bonding surfaces.
  - While pushing the pipes together, mortar exudes from around the full circumference of the inside and outside of the pipe joint.
  - Excess mortar is removed.
  - On the inside of the pipe, mortar is smoothed flush with the pipe wall.
  - Mortar is cured as specified.
  - Pipe is undisturbed until the mortar is fully cured.
- With mastic or gasket sealing—
  - Joining surfaces are clean and dry.
  - Gasket is the proper size for the pipe being joined.
  - Mastic completely encircles the tongue with some overlap.
  - Care is taken to ensure the mastic stays between the tongue and groove and does not fall out or become displaced as the pipes are pushed together.
- With rubber gasket sealing—
  - Joining surfaces are clean and dry.
  - The correct gasket is used.
  - The gasket and seating surface are lubricated.
  - The gasket remains in the desired location as the pipes are pushed together.

(ii) For flanged joints—

- Flange mating surfaces and the gasket are clean at time of assembly.
- Bolts, nuts, and washers are the correct size and specified grade.
- Gasket is installed.
- All bolts, nuts, and washers are installed.

- Nuts are tightened to the specified torque and in the sequence specified.

(iii) For mechanically coupled joints—

- With band couplers—
  - Ends of pipes, the gasket, and the band coupler are clean.
  - Gasket or O-rings are lubricated.
  - Gasket is positioned with equal parts covering each pipe end.
  - O-rings are positioned in the pipe corrugations that are nearest to the outer grooves of the hugger-band.
  - Corrugations align with those on the pipes.
  - Flanges are tightened to the specified torque.
  - Encircling rods are installed and tightened to the specified torque or tightened so that the band coupler is snug around the joint.

(18) Articulating joints such as bell and spigot joints, are designed to be flexible. Many of the earthen dams built under the Small Watershed Program contain principal spillway pipes with bell and spigot joints. In earthen dams, the base of the dam spreads apart slightly as the dam settles causing the pipe joints to be pulled apart. The pipe joints in these dams are designed to allow for some joint extension. Joint extension, illustrated in figure 15-20, is the distance the pipes can be pulled apart before the joint seal is broken.

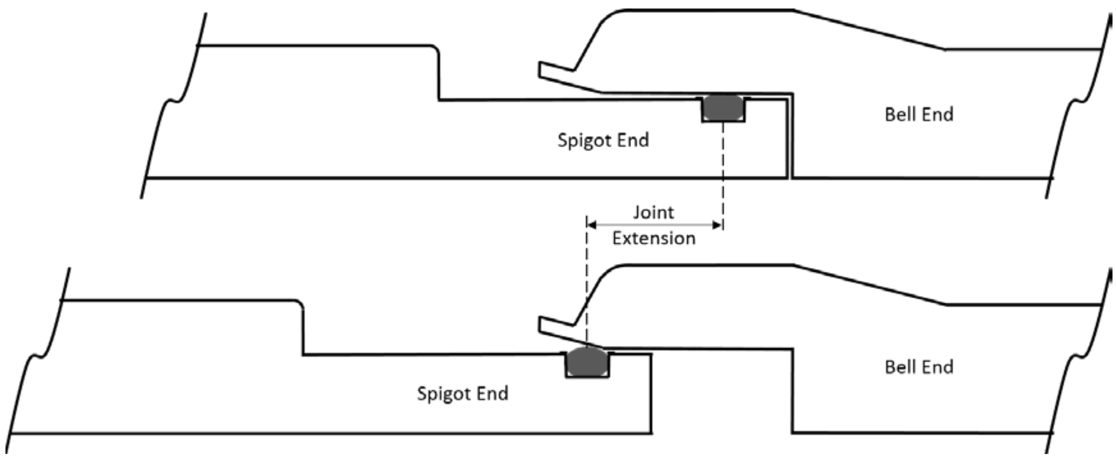

Figure 15-20: Joint extension

(19) The anticipated amount of joint extension is considered during the pipeline design. The designer may specify shorter lengths of pipe so that there will be more pipe joints to satisfy the joint extension demand. Pipeline made up of 10-foot lengths of pipe has twice as many joints as pipeline made up of 20-foot lengths of pipe; thus, joint extension for a pipeline made up of 10-foot lengths of pipe will be half of that for a pipeline made up of 20-foot lengths of pipe. For this reason, any request by the pipe supplier to provide longer lengths of pipe than called for in the design must be submitted to the design engineer for approval.

(20) Bell and spigot joints can be either spigot-groove (figure 15-21) or bell-groove joints (figure 15-22). The groove is a notch in either the spigot or the bell where the O-ring gasket resides. Spigot grooves are common in concrete pipe whereas bell grooves are common in plastic pipe. It is critical that the O-ring remain in the groove after the pipes are joined. As illustrated in figure 15-21, a feeler gauge can be used to determine if the O-ring has remained in the groove.

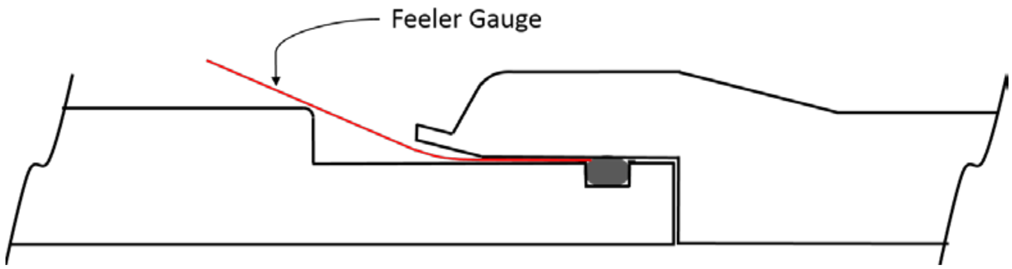

Figure 15-21: Spigot groove with feeler gauge used to locate O-ring gasket

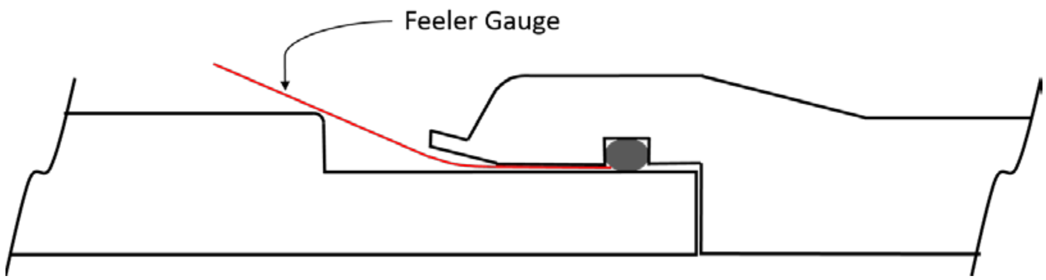

Figure 15-22: Bell groove with feeler gauge used to locate O-ring gasket

(21) As with all other types of pipe joints, bell and spigot joints must be clean and free of any debris as they are being mated. The specified gasket must be installed and well lubricated with flax-soap or vegetable shortening. As mentioned earlier, never use petroleum-based lubricants as these may damage the gasket material. The pipes are then joined and pushed together so that the spigot end is inserted as far as possible (i.e., pushed home) into the bell. After the pipes are pushed together, the feeler gauge is used to verify the position of the O-ring. Pressure testing, if required, should be performed after all pipes are pushed together.

(22) Concrete pressure pipe, such as AWWA C300 series pipe, is constructed of a steel cylinder with steel joint-ring ends. All the pipe is coated or encased in concrete except for the spigot end. It is important that the joints for this type of pipe be sealed on the outside to guard against corrosion of the steel cylinder and steel joint rings. The joint crack is sealed with a bituminous mastic joint filler. Before installing the mastic, the concrete surface must be clean and, if required by the mastic manufacturer, coated with a primer to enhance the bond with the concrete. The preformed bituminous mastic is then stuffed into the outer portion of the joint crack so that it bridges across the crack to insulate the exposed steel at the joint (figure 15-23).

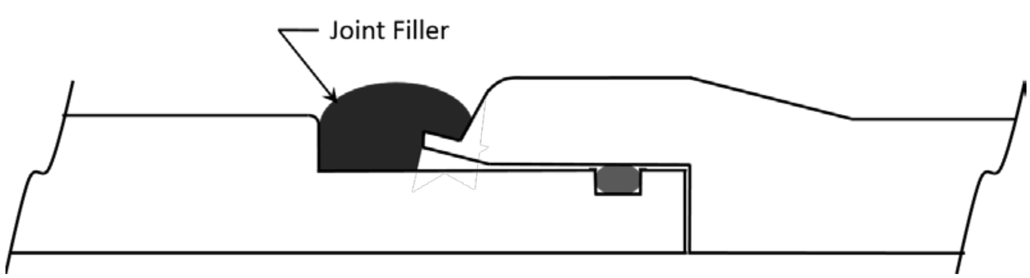

Figure 15-23: Bituminous mastic joint filler

(23) A band of metal or filter fabric is then placed around the joint to protect the mastic. If the embedment soil contains rocky particles, a metal band must be used. Otherwise, geotextile filter fabric may be specified to protect the mastic and to filter out soil that might otherwise migrate into the joint if the joint were to leak. Even if a metal band is required, the specification may also require the filter fabric as an added measure to guard against soil migration into the joint (figure 15-24).

Figure 15-24: Geotextile-wrapped pipe joint

(24) Connecting bell and spigot joints that are sealed with tight fitting gaskets may require substantial force to push the pipes together. A backhoe or bulldozer may be used if the end of the pipe being pushed is adequately protected from damage. A block of wood is often placed between the pipe end and the bucket or dozer blade to protect the pipe from damage. As seen in figure 15-25, a come-a-long may be used to pull the pipes together. If more force than normal is required to make the joint, the work should be stopped and a feeler gauge should be used to determine if the rubber O-ring (or other type gasket) is out of place. If so, disconnect the pipes, reposition the gasket and restart the operation with plenty of lubricant on the gasket and joint surface. Regardless of the method used to push or pull the pipes together, the pipes must be properly supported and aligned to avoid damage to the joining ends. The inspector must verify that pipe assembly is done in a manner that does not damage the pipe. After the pipes are joined, verify that the spigot has been pushed home and the gasket has remained in the gasket groove before moving on to joining the next pipe.

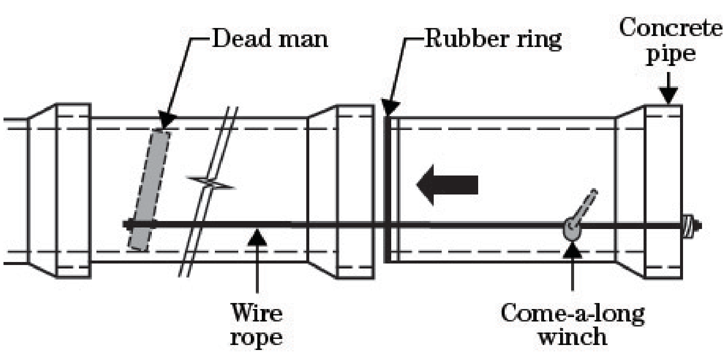

Figure 15-25: Pulling pipe together with a come-a-long

(25) The inspector’s responsibilities related to articulating pipe joints include verifying that—
- (i) All joining surfaces are clean and free of debris.
- (ii) Any changes in pipe length from that specified is approved by the designer.
- (iii) Proper gasket is installed in the groove and lubricated.
- (iv) The spigot is pushed home into the bell.
- (v) Gasket remains in the gasket groove.
- (vi) Pipe is not damaged during assembly.
- (vii) Pressure testing is conducted, if specified.
- (viii) Additionally for steel cylinder concrete pressure pipe, the inspector must verify that—
  - Joints are completely sealed with bituminous mastic.
  - Concrete is clean and, if specified by manufacturer, primed before installing mastic.
  - Mastic is covered with metal or fabric bands.
  - Fabric bands are added over metal bands if specified.
  - Bands are secured tightly around the joint.

F. Embedment and Backfill

(1) After the pipes have been joined and the joints inspected, verify that the pipe is at the specified grade and alignment before beginning the embedment operation. Unless the pipe is embedded in a full concrete cradle that extends up to the springline of the pipe, some soil will have to be compacted under the haunches of the pipe as seen in figure 15-26.

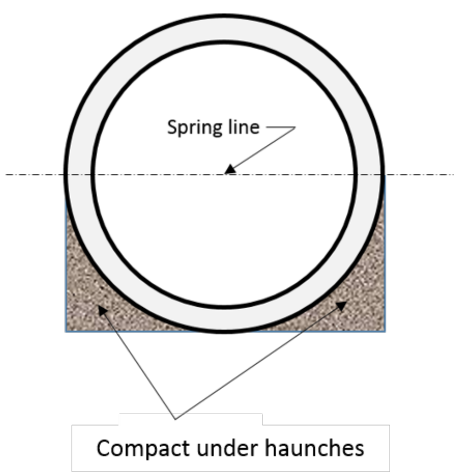

Figure 15-26: Compacted soil under the haunches

(2) When compacting material under the haunches, care must be taken to avoid moving the pipe. Compaction of soil under each side of the pipe should be done concurrently so as not to push the pipe to one side. It may also be necessary to fill the pipe with water or place a load on the top of the pipe to resist raising it when compacting under the haunches.

(3) Embedment material (figure 15-27) must not contain rock or hard soil clods in excess of the specified maximum size. Care must be taken in placing and compacting material near and above the pipe. Embedment must be placed to the minimum specified height before backfill can be placed to complete the filling of the trench.

Backfill material may contain larger rock or soil clods or may be the same type of material as the embedment.

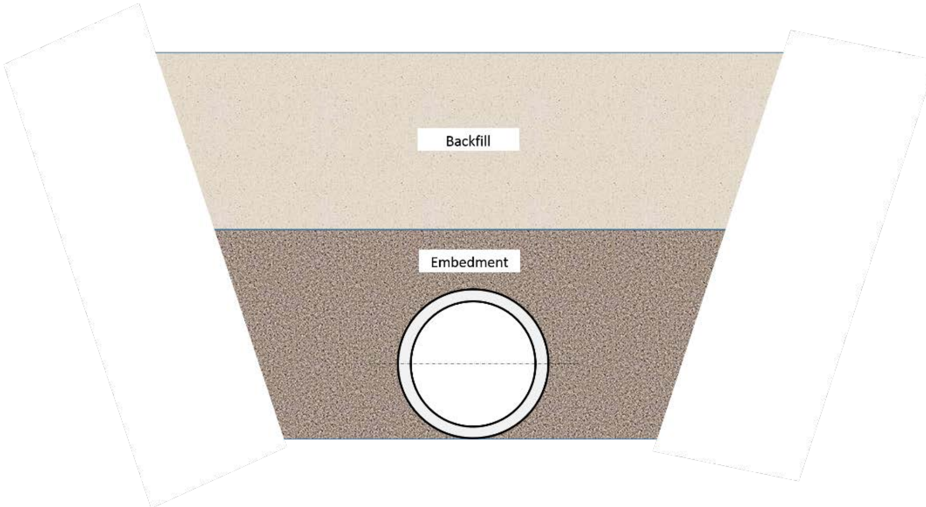

Figure 15-27: Embedment and backfill

(4) The embedment and backfill must be compacted to the specified density, but compacting material immediately above the pipe should be avoided. Unless otherwise specified, heavy construction equipment must not operate within 2 feet of the pipe or be allowed to cross over the pipe until it has been covered by at least 2 feet of fill. If the function of the installation is contingent on having a strong or dense material immediately above the pipe, it may be best to encase the pipe in concrete or flowable fill.

(5) The inspector's responsibilities related to embedment and backfill include verifying that—

(i) Pipe is at the specified grade and alignment before beginning the embedment operation.

(ii) Embedment material does not contain rocks or soil clods in excess of the specified maximum size.

(iii) Embedment material completely fills the haunch area and is compacted to the specified density under the haunches.

(iv) Pipe is not displaced when compacting under the haunches.

(v) Care is taken when placing and compacting embedment material to avoid damage to the pipe.

(vi) Embedment is placed and compacted to the minimum specified height.

(vii) There is no compaction immediately above the pipe.

(viii) Heavy equipment is not operated within 2 feet of the pipe or within the specified distance from the pipe.

645.1503 Sampling and Testing

A. Sampling and testing related to pipe installation includes sampling and testing pipe foundation, bedding, embedment, and backfill materials and, if required, testing the pipe for leakage.

B. Pipe foundation, bedding, embedment, and backfill must be compacted to a specified density. If the density is specified as a percentage of standard or modified Proctor maximum density, the materials must be sampled and tested in accordance with ASTM D698 or ASTM D1557 to determine the maximum density. Sand density may be specified as a percentage of relative density or as a percentage of the density obtained by compacting dry sand with the standard or modified compaction effort. There are several field tests to determine in-place density of the compacted material. Refer to Title 210, National Engineering Handbook, Part 645, Chapter 8, for detailed information concerning compaction and testing that may be necessary to verify specification compliance.

C. Leak testing may be specified for pipe that has fixed or articulating joints. Generally speaking, leak testing is not required for solid joints. When specified, leak testing must be done at the specified pressure (head) and the amount of leakage must be determined to be within the maximum allowable leakage rate. Open pipe ends are sealed and a standpipe is installed so that when the pipeline is completely filled with water the water can be elevated to the specified elevation corresponding to the specified head for testing. If there are leaks, the water surface elevation will drop. Changes in water surface elevation is monitored over time. The quantity of leakage at any point in time can be computed by multiplying the amount of the drop in the standpipe water elevation by the cross-sectional area of the inside of the standpipe. The leakage rate is then computed by dividing the quantity of leakage by the time it took for the leakage to occur.

645.1504 Records and Reports

The daily diary is used to record information related to pipe installation. There are no worksheets dedicated to pipe installation or testing. All pipeline material submittals and approvals should be recorded in the "Material Submittal Record" in the diary. Daily diary entries should report when the material is delivered and provide verification that the material complies with the specifications and has been approved for incorporating into the work. Report all operations related to pipeline installation including checks on line and grade, verification that gaskets remain in position when pipe is pushed home, and any pertinent comments on foundation, bedding, joining, pressure testing, embedment, and backfill. A sample diary entry related to pipe installation is included in appendix C.

645.1505 Technical References

Howard, A. (1996). "Pipeline Installation." Relativity Publishing, Lakewood, CO.

Howard, A. (2015). "Pipeline Installation 2.0." Relativity Publishing, Lakewood, CO.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2015. Specifications for Construction Contracts. National Engineering Handbook, Part 642. Washington, DC.