TABLE 2
Maximum Particle Size vs. Pipe Size

Nominal Pipe Size (in.)	Maximum Particle Size (in.)
2 to 4	½
6 to 8	¾
10 to 15	1
16 and larger	1 ½

Migration

When the pipe is located beneath the ground water level, consideration must be given to the possibility of loss of side support through soil migration (the conveying by ground water of finer particle soils into void spaces of coarser soils). Generally, migration can occur where the void spaces in the embedment material are sufficiently large to allow the intrusion of eroded fines from the trench side walls.

For migration to occur, the in-situ soil must be erodible. Normally, erodible soils are fine sand and silts and special clays known as dispersive clays. (Most clays have good resistance to dispersion.) This situation is exacerbated where a significant gradient exists in the ground water from outside of the trench toward the inside of the trench; i. e. , the trench must act as a drain. (Seasonal fluctuations of the ground water level normally do not create this condition.)

For such anticipated conditions, it is desirable when using granular materials (Class I and II) to specify that they be angular and graded to minimize migration. Rounded particles have a tendency to flow when a considerable amount of water exists and material with a high void content provides "room" for migrating particles. The Army Corps of Engineers developed the following particle size requirements for properly grading adjacent materials to minimize migration:

(1) $D_{15}^{E} < 5D_{85}^{A}$

(2) $D_{50}^{E} \geq 25D_{85}^{A}$

Where the D_{15}, D_{50} and D_{85} are the particle sizes from a particle size distribution plot at 15%, 50% and 85%, respectively, finer by weight and where D^E is the embedment soil and D^A is the adjacent in-situ soil.

Another approach to preventing migration is to use geotextile separation fabrics. The fabric is sized to allow water to flow but to hold embedment materials around the pipe. Figure 4 shows a typical installation.

which could damage the pipe when dropped into the trench or create concentrated pipe loading. The final backfill may be placed in the trench by machines.

There should be at least one foot of cover over the pipe before compaction of the final backfill by the use of self-powered compactors. Construction vehicles should not be driven over the pipe until a three foot cover of properly compacted material is placed over the pile.

When backfilling on slopes, the final backfill should be well compacted if there is any risk of the newly backfilled trench becoming a "french drain." Greater compaction may be achieved by tamping the final backfill in 4 inch layers all the way from the top of the initial backfill to the ground or surface line of the trench. To prevent water from undercutting the underside of the pipe, concrete collars keyed into the trench sides and foundation may be poured around the pipe or a polyethylene waterstop can be fabricated onto the pipe.

Proper Burial of HDPE Fabricated Fittings

A common question is "Does the installation of heat fused polyethylene solid wall pipe and fittings need thrust blocks?" The simple answer to this question is that heat fused HDPE pipe and fittings are a monolithic structure which does not require thrust blocks to restrain the longitudinal loads resulting from pipe pressurization.

Since fittings are part of the monolithic structure no thrust blocks are needed to keep the fittings from separating from the HDPE pipe. Bell and spigot piping systems must have thrust blocks or restrained joints to prevent separation of pipe from fittings when there is a change of direction.

Pipe movement due to elastic deformation, thermal expansion/contraction, etc. is not detrimental to HDPE pipe, but pipe movement or the attachment of valves or other appurtenances used with HDPE pipe systems can cause excessive loads. Proper backfill prevents excessive loads in most situations.

Common fittings, elbows and equal tees normally require the same backfill as specified for the pipe. When service connections are made from HDPE water mains, no special compaction is required. When service connections are made under an active roadway, 95% Standard Proctor density is normally required around the pipe and the service connection.

In water systems and fire protection piping systems, reducing tees are frequently used to connect from the main to valves and hydrants. The attached drawing shows the use of concrete support pads, thrust blocks on hydrants, self restrained HDPE MJ adapters and sand stabilized with cement around the reducing tee. While no true thrust blocks are on the HDPE pipe or fittings in this arrangement, the sand stabilized with cement provides proper support for the reducing tee. Compaction of

Inspection

One principal function of the inspector is to insure that the pipe meets the acceptance deflection specified by the engineer. Besides seeing that the installation practice of the contractor meets the specification, the inspector should periodically make deflection measurements of the pipe. Where the pipe can be accessed, inspection can be as simple as going through the pipe and taking diameter measurements. For smaller pipe, a mandrel or deflection measuring device can be pulled through the pipe.

Good installation practice consists of frequent deflection checks at the beginning of the project or anywhere there is a significant change in the installation procedure, soil formation, or materials. A prudent contractor will check deflection every 100 or 200 feet under these circumstances. After the contractor is confident in the procedure, the frequency of inspection can be relaxed.

Typically, acceptance deflection is measured after the pipe has been installed for at least 30 days. This gives the soil time to settle and stabilize. Where pipe exceeds its acceptance limit, it should be uncovered and the embedment material should be replaced and compacted.

References

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Appendix 1

Simplified Installation Guidelines for Pressure Pipe

(Small diameter pressure pipes usually have adequate stiffness and are usually installed in such shallow depths that it is unnecessary to make an internal inspection of the pipe for deflection.)

A quality job can be achieved for most installations following the simple steps that are listed below. These guidelines apply where the following conditions are met:

1. Pipe Diameter of 24-inch or less
2. SDR equal to or less than 26
3. Depth of Cover between 2. 5 feet and 16 feet
4. Groundwater elevation never higher than 2 feet below the surface
5. The route of the pipeline is through stable soil

Stable soil is an arbitrary definition referring to soil that can be cut vertically or nearly vertically without significant sloughing, or soil that is granular but dry (or de-watered) that can stand vertical to at least the height of the pipe. These soils must also possess good bearing strength. (Quantitatively, good bearing capacity is defined as a minimum unconfined compressive strength of 1000 psf for cohesive soils or a minimum standard penetration resistance of 10 blows per ft for coarse grained soils.) Examples of soils that normally do not possess adequate stability for this method are mucky, organic, or loose and wet soils.

Where the above conditions are met, the specifier can write installation specifications from the following steps. The specifier should insure that all OSHA, state and local safety regulations are met.

The following are general guidelines for the installation of PE pipe. Other satisfactory methods or specifications may be available. This information should not be substituted for the judgment of a professional engineer in achieving specific requirements.

Simplfied Step-by-Step Installation

Trenching

Trench collapses can occur in any soil and account for a large number of worker deaths each year. In unbraced or unsupported excavations, proper attention should be paid to sloping the trench wall to a safe angle. Consult the local codes. All trench shoring and bracing must be kept above the pipe. (If this is not possible, consult the more detailed installation recommendations.) The length of open trench required for fused pipe sections should be such that bending and lowering the pipe into the ditch does not exceed the manufacturer's minimum recommended bend radius and result in kinking. The trench width at pipe grade should be equal to the pipe outer diameter (O. D.) plus 12 inches.

De-watering

For safe and proper construction the groundwater level in the trench should be kept below the pipe invert. This can be accomplished by deep wells, well points or sump pumps placed in the trench.

Bedding

Where the trench bottom soil can be cut and graded without difficulty, pressure pipe may be installed directly on the prepared trench bottom. For pressure pipe, the trench bottom may undulate, but must support the pipe smoothly and be free of ridges, hollows, and lumps. In other situations, and for gravity drain or sewer pipe, bedding may be prepared from the excavated material if it is rock free and well broken up during excavation. For gravity flow systems, the trench bottom

should be graded evenly. The trench bottom should be relatively smooth and free of rock. When rocks, boulders, or large stones are encountered which may cause point loading on the pipe, they should be removed and the trench bottom padded with 4 to 6 inches of tamped bedding material. Bedding should consist of free-flowing material such as gravel, sand, silty sand, or clayey sand that is free of stones or hard particles larger than
one-half inch.

Pipe Embedment

Figure 1 shows trench construction and terminology. Haunching and initial backfill are considered trench embedment materials. The embedment material should be a coarse grained soil, such as gravel or sand, or a coarse grained soil containing fines, such as a silty sand or clayey sand. The particle size should not exceed one-half inch for 2 to 4-inch pipe, three-quarter inch for 6 to 8-inch pipe and one inch for all other sizes. Where the embedment is angular, crushed stone may be placed around the pipe by dumping and slicing with a shovel. Where the embedment is naturally occurring gravels, sands and mixtures with fines, the embedment should be placed in lifts, not exceeding 6 inches in thickness, and then tamped. Tamping should be accomplished by using a mechanical tamper. Compact to at least 85 percent Standard Proctor density as defined in ASTM D-698. Under streets and roads, increase compaction to 95 percent Standard Proctor density.

Pressure Testing

If a pressure test is required, it should be conducted after the embedment material is placed.

Trench Backfill

The final backfill may consist of the excavated material, provided it is free from unsuitable matter such as large lumps of clay, organic material, boulders or stones larger than 8 inches, or construction debris. Where the pipe is located beneath a road, place the final backfill in lifts as mentioned earlier and compact to 95 percent Standard Proctor Density.

Appendix 2

Guidelines for Preparing an Installation Specification General Requirements

General Requirements

Subsurface conditions should be adequately investigated and defined prior to establishing final project specifications. Subsurface investigations are necessary