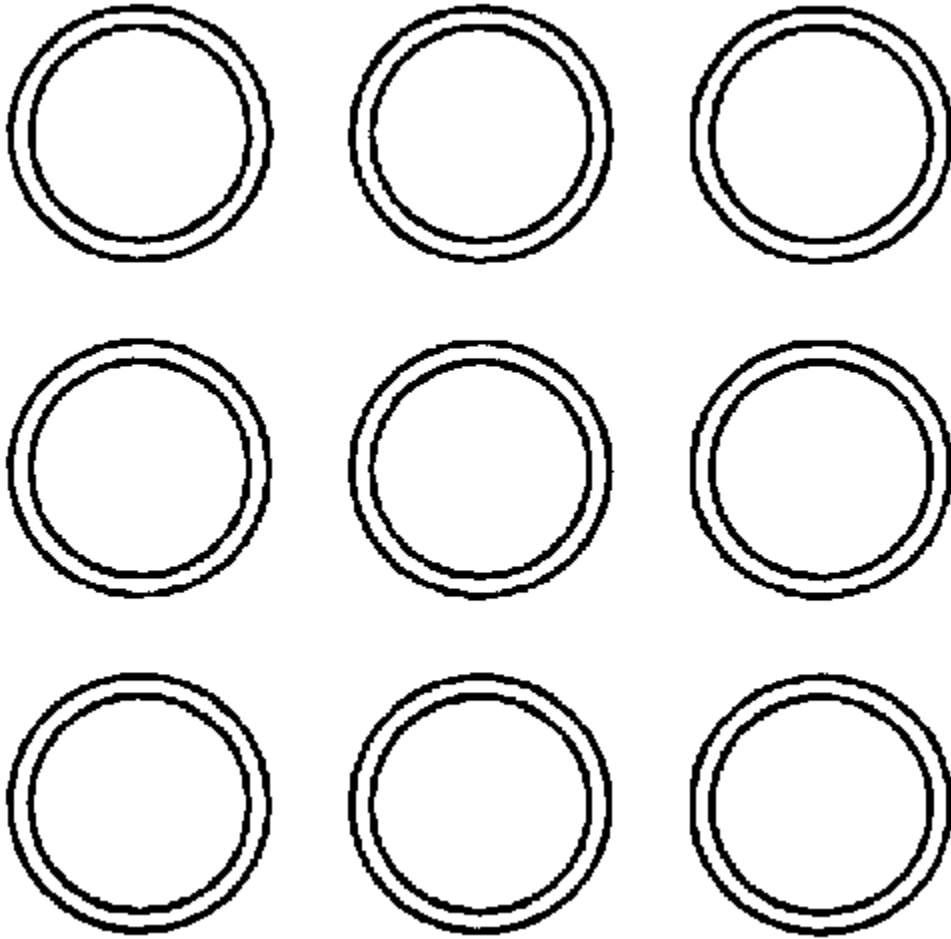


NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION  
BULLETIN NO. TCB 2-2000

NEMA GUIDELINES FOR THE SELECTION AND INSTALLATION  
OF UNDERGROUND NONMETALLIC DUCT



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## FOREWORD

This manual is intended to provide assistance as a guide to obtain the most appropriate and satisfactory installation of nonmetallic duct systems.

This manual is in no way intended to assume or replace any responsibilities of engineers, customer representatives, owners, or other persons in establishing engineering design practices and procedures best suited to individual job conditions.



## SCOPE

This manual covers recommendations for shipping, handling, storage, installation, and joining of underground single bore nonmetallic duct for power, lighting, signaling, and communications applications.

Although not specifically mentioned in this manual, variations of the products discussed may occasionally be specified. Users should follow installation recommendations of the manufacturer.

## NOMENCLATURE

Abbreviations for nonmetallic materials referenced in this document include the following:

HDPE	High Density Polyethylene
PE	Polyethylene
PVC	Polyvinyl Chloride
RTR	Reinforced Thermosetting Resin (fiberglass)

Other abbreviations include:

CCD	Corrugated Coilable Plastic Utility Duct
DB	Direct Burial—refers to duct buried without concrete encasement
DS	Duct Stiffness
EB	Encased Burial—refers to duct buried with concrete encasement
EPC 40	PVC Conduit (Schedule 40)
EPC 80	Extra Heavy Wall PVC Conduit (Schedule 80)
EPEC	Smooth Wall Coilable High Density Polyethylene Conduit
HW	Heavy Wall—refers to heavy-wall reinforced thermosetting resin conduit
PS	Pipe Stiffness
RTRC	Reinforced Thermosetting Resin Conduit (Fiberglass)
SW	Standard Wall—refers to standard-wall reinforced thermosetting resin conduit

## I. GENERAL INFORMATION

### A. TYPES OF DUCT

1. Duct Designed for Encasement in Concrete
  - a. PVC EB duct meeting the requirements of NEMA TC-6 & 8
  - b. RTRC SW and HW manufactured to NEMA TC-14
  - c. EPEC meeting NEMA TC-7
2. Duct Designed for Direct Burial
  - a. CCD meeting the requirements of NEMA TC-12; details on storage, handling, and installation are covered in NEMA Bulletin No. TCB-3
  - b. PVC DB duct meeting NEMA TC-6 & 8
  - c. Smooth-wall coilable PE duct meeting NEMA TC-7
  - d. RTRC SW (except 5 and 6 inch) and HW (all sizes) meeting NEMA TC-14
  - e. EPC-40 meeting NEMA TC-2
  - f. EPC-80 meeting NEMA TC-2
  - g. EPEC meeting NEMA TC-7
3. DB, RTRC-HW, HW, EPC-40, EPC-80, EPEC, and CCD duct may also be encased in concrete (either in trenches or in casings or borings) for extra heavy or high dynamic load applications such as under railroad beds. (See Appendix 2)

### B. DUCT STIFFNESS

1. Duct stiffness (DS), also known as pipe stiffness (PS), is a useful test value for evaluating the load bearing and deflection characteristics of the duct.
2. Duct stiffness is dependent upon two factors: the modulus of elasticity of the duct material and the moment of inertia of the duct (which is a function of the duct diameter and the geometry of the duct wall).
3. In the design of each duct system, consideration should be given to duct stiffness requirements to withstand the specific application loadings. (See Appendix 2)
4. ASTM D2412 is the generally accepted test method for determining pipe stiffness. Appendix X1 of D2412 gives a method of using pipe stiffness to calculate approximate deflections under earth loads.
5. Duct stiffness values are determined at a specified ID deflection of 5%. Values are expressed in pounds of force per inch of duct length per inch of deflection.

$$DS = PS = F/\Delta y$$

Where:

DS = duct stiffness in lbs/inch/inch

PS = pipe stiffness in lbs/inch/inch

F = load in pounds per inch of duct length that will deflect the duct ID 5%

$\Delta y$  = change in ID in inches due to the applied load F

6. Minimum duct stiffness requirements for EB, DB, SW, and HW are specified in the applicable NEMA standards.

### **C. DUCT SEPARATION**

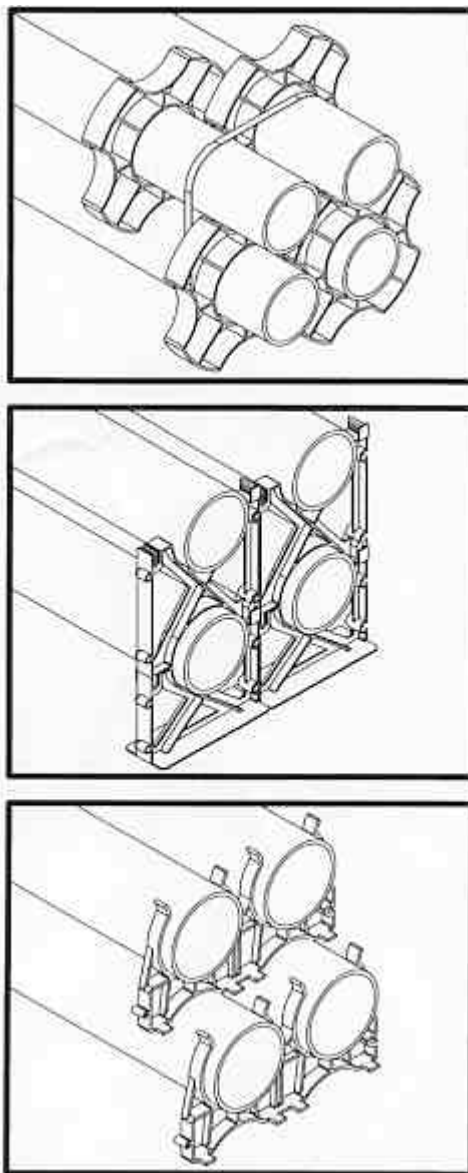
#### 1. Duct Spacers

There are many different configurations of commercially available spacers. See Figure 1 for examples.

- a. For encased burial, duct separation can be achieved by use of commercially available spacers.
- b. For direct burial, spacers shall meet certain conditions as specified by the design engineer:
  - (1) Spacers identified for such use
  - (2) Appropriate backfill material
  - (3) Proper compaction of backfill material

The use of duct spacers for direct burial may result in excessive point deflections unless proper design engineering is applied.

Blocking should not be used to bring the duct to grade.



**Figure 1—Types of Spacers**

2. Power Duct Banks

In power duct banks, individual ducts should be separated from one another for the following reasons:

- a. To provide adequate dissipation of the normal buildup of heat from cables within the duct
- b. To provide void space to allow the encasement material to fully surround each duct
- c. To physically separate ducts in the event of a fault

3. Communications Duct Banks

Since there is no appreciable build-up of heat in communications duct banks, separation is intended only to allow the encasement material to fully surround each duct.

4. Combined Power and Communications Duct

Many specifications require three inches or more of separation between power duct groups and communications duct groups. Since spacer manufacturers generally do not stock spacers for more than three-inch separations, use of a dummy spacer inserted horizontally between the power and communications duct groups will usually provide acceptable separation.

5. Considerations for Specifiers

Frequently the duct bank designer will specify center-to-center dimensions between ducts, leaving the contractor with the responsibility to calculate the clear dimensions. Specifiers should keep in mind that stock spacers are available to provide 1 1/2-inch, 2-inch, and 3-inch separation for power ducts. For 4-inch communications ducts, 1 1-inch separation is available. For any other separation, a custom-produced spacer will be required.

## II. HANDLING AND STORAGE

### A. TRANSPORTATION

1. Generally, duct is shipped on reels or in self-supporting framed units designed for mechanical unloading. Units should not be dropped from truck or beds.
2. Duct may also be shipped in vans, either loose or in bundles. Care should be taken to avoid damage during shipping. Prolonged storage of shipments of duct in closed vans should be avoided, since excessive weight and elevated temperature may cause ovality on the bottom ducts.
3. Abusive handling should be avoided. Care should be exercised when handling thermoplastic duct in temperatures below 32°F.



### B. STORAGE

The manufacturer's recommendations regarding storage should be followed. In general, the following are recommended:

1. Framed Units

Framed units should be stored on a level surface. The wood frames should line up, one on top of another, so that the load will be on the wood frames rather than on the duct. Standing height of stacked units should be limited to twelve feet.



2. Coils and Reels - Storage area should be of sufficient size to accommodate the duct and components, to allow room for handling equipment to get around them, and to have a relatively smooth level surface free of stones, debris, and other material that could damage the duct or components or interfere with handling.



3. Bulk Storage

The most desirable method of stacking loose duct is with all duct parallel. To avoid excessive ovality on the bottom row, the stacking height should be limited to four feet for EB, five feet for DB duct, and 10 feet for RTRC. The bottom row of duct should be laid on as level a surface as possible. Supports should not be placed under the duct, as excessive deflections and sagging could result.

4. Bends and Sweeps

Bends and sweeps can be stored outdoors on flat ground. The manufacturer should be consulted for other storage procedures.

5. Fittings, Spacers, and Accessories

When stored outdoors, fittings, spacers, and accessories in cartons should be under cover to protect cartons from the elements.

6. Cleaners, Primers, Cements, and Adhesives

All cleaners, primers, cements, and adhesives should be stored in a cool place except when actually in use at the job site. They should not be stored in freezing areas as this can cause premature gelation and loss of the cements. Some products have a limited shelf life when not stored in hermetically sealed containers. The product manufacturer should be consulted for specific recommendations on storage conditions and shelf life. In hermetically sealed containers, the normal shelf life of these products is approximately one to two years.

NOTE—Some products are flammable. Fumes can be harmful if adequate ventilation is not provided.

7. Inventories

It is recommended that inventories be rotated—first in, first out—to minimize possible loss from excessive storage time.

**C. HANDLING ON THE JOBSITE**

1. Duct

Abusive handling should be avoided. Care should be exercised when handling thermoplastic duct in temperatures below 32°F.

2. Coils and Reels

Appropriate unloading and handling equipment of adequate capacity must be used to unload the truck, and safe handling and operating procedures must be followed. Coils or reels must not be rolled or pushed off the truck. During cold weather, care should be taken not to drop the duct and to keep handling equipment and other objects from hitting duct.

3. Solvent Products

The handling of solvent products should be in accordance with ASTM F402 "Standard Recommended Practice for Safe Handling of Solvent Cements Used for Joining Thermoplastic Pipe and Fittings."

4. Inventories

It is recommended that inventories be rotated—first in, first out—to minimize possible loss from excessive storage time.

### III. INSTALLATION OF DUCT

#### A. PROPER INSTALLATION

1. A duct system is considered to be properly installed if the inside diameter of each duct is adequate to allow free passage of the specified deflection mandrel.
2. To limit deflection, special attention should be paid to trench bedding, duct separation, spacer intervals, type of backfill material, and amount of compaction.

#### B. TRENCH EXCAVATION

1. All federal, state, and local regulations should be followed, including those pertaining to:
  - a. Rights of way
  - b. Permits
  - c. Combined trenches
  - d. Excavation of open trenches
  - e. Shoring
  - f. Minimum cover over ducts
  - g. Safety
2. Routing of the duct should be coordinated with all utility companies who may have underground lines in the area of the proposed trenching layout.



3. The trench dimensions are determined as follows:
  - a. The depth is determined by the height of the duct bank, plus the minimum required cover over the bank.
  - b. The width of the trench is determined by the width of the duct bank to be installed plus a minimum three-inch space on each side to adequately place and compact the backfill material. If shoring is required, additional trench width may be necessary.
4. Trench Wall
  - a. Where unstable soil conditions are encountered in the trench wall, these conditions should be stabilized before laying the duct. The design engineer is responsible for providing methods to control such conditions. Well points or underdrains may be required to control excessive groundwater conditions.
  - b. Where required by regulations or by soil conditions, the trench walls should be adequately shored. Care should be taken that the duct installation is not disturbed by removal of shoring materials.
5. Trench Bottom
  - a. The trench bottom should be smooth and free of any debris that may be detrimental to the duct or impede the positioning of spacers.
  - b. Where the trench bottom is rocky, a four-inch layer of compactable bedding material is recommended.

- c. In direct burial applications, bedding must be uniformly graded to provide continuous support.
  - d. Under no circumstances should blocking or mounding be used to raise the duct to grade.
  - e. Where an unstable trench bottom is encountered, it must be stabilized before laying duct. Usually, this can be accomplished by over-excavating and providing a bedding of crushed stone or gravel to provide a stable base. This material should be suitably graded to act as an impervious mat through which the unstable soil will not penetrate.
  - f. Maximum particle size of the bedding material should be 1 inch. To aid in placement around small-diameter duct and to prevent damage to the duct wall, a smaller maximum size may be specified.
6. Care should be taken to prevent rocks, hard lumps, frozen clods, organic matter, and other foreign material from falling into the trench.

### **C. TRENCHLESS TECHNOLOGY**

#### 1. Plowing and Planting

Plowing and planting involve cutting a narrow trench and feeding the conduit into the trench through a shore or chute fitted just behind the trench cutting equipment.

#### 2. Horizontal Boring

Horizontal boring is usually performed to install a conduit line below existing roadways or structures where opening a trench may be impractical or undesirable. Typically, entry and exit pit excavations are required, and the bore is made by tunneling directly across and under the structure.

#### 3. Directional Boring

Directional boring uses directional drilling techniques and can be used to install long runs under rivers or lakes, or through congested underground infrastructure.

#### 4. Sliplining

Sliplining is insertion of new duct inside an existing duct for purposes of rehabilitation. Sliplining does reduce the bore of the rehabilitated conduit.

### **D. JOINING**

#### 1. Types of Joints

##### a. PVC Solvent Cement Joints

Solvent cement joining is used with PVC ducts. This method of joining is described in detail elsewhere in this installation manual.

All solvent cements should be examined prior to usage. If solvent cement exhibits an appreciable change from the original viscosity, or if a sign of gelation is apparent, it is

unsuitable for use and should be discarded. A gelation condition is indicated when the cement appears lumpy and stringy after thorough stirring.



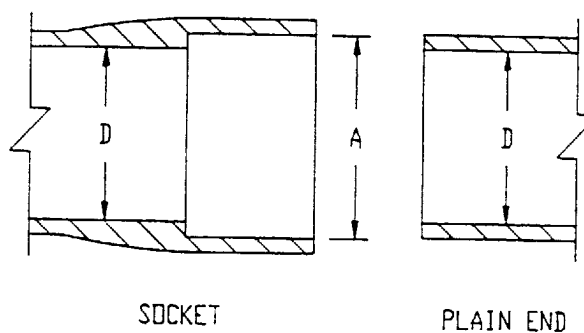


Partially used containers should be tightly closed to prevent solvent evaporation during short-term storage. The cement should be discarded if, when reopened, it does not re-stir to a smooth consistency and exhibits excessive thickening or signs of gelation.

The cements should not be thinned. Restoration of the original viscosity or removal of gelation by adding solvents or thinners is not acceptable.

Disposal of empty or partially used cement containers should be in accordance with local, state, and federal regulations. Do NOT incinerate as the solvents are flammable and could create explosive forces during incineration.

b. Fiberglass Adhesive Joints



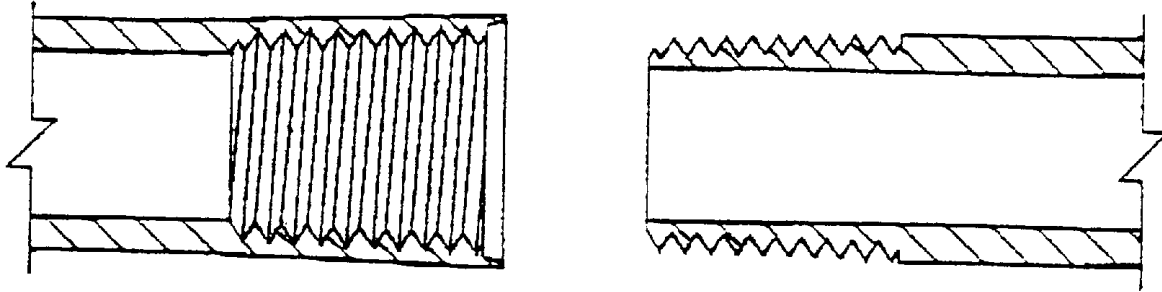
When using an adhesive type joint, the manufacturer's instructions should be followed.

(1) Adhesives for Fiberglass

Most adhesives for fiberglass conduit consist of two parts: resin and hardener. The two materials must be combined before they can be used. The two components

once mixed will harden (set up). The unused portion of the mixture is harmless after hardening.

c. Threaded Joints



- (1) When HDPE underground duct has threaded ends, it is joined with threaded couplings.

A threaded coupling with right- and left-hand threads, on each end respectively, may be used on unthreaded polyethylene conduit ends.

After installation of coupling, a heat shrink, cold shrink, or silicone tape should be applied to prevent moisture ingress.

- (2) Some fiberglass conduit is furnished with threaded bells and spigots as well as threaded couplings and adapters.
- (3) Underground duct is joined to threaded metallic and nonmetallic ducts by means of threaded terminal or female adapters.

d. Expansion-Contraction Fittings

Expansion-contraction couplings are used in applications where temperature fluctuations in the duct system require compensation. Examples are tunnels, bridge crossings, and other exposed applications. Buried duct banks do not require expansion fittings.

e. Heat Fusion Joints

Heat fusion joining is a process where mating surfaces are prepared for joining, heated until molten, joined together and cooled under pressure. All fusion procedures require appropriate surface preparation tools, alignment tools, and temperature controlled heating equipment.

Three methods are used for heat fusion joining of plain-ended HDPE duct. One method utilizes the butt fusion type joint; another utilizes socket-type couplings that are fused externally to the duct; the third method is electrofusion. This joining method is not ideally suited to HDPE with corrugated outer walls.

f. Heat Shrink Joints

These joints utilize a heat shrinkable polyethylene sleeve. This type of joining method is used to join polyethylene duct to other types of duct materials.

g. Adhesive Joints

There are adhesives available to provide watertight connections.

h. Gasketed Joints

There are a variety of gasketed joints available that utilize elastomeric seals to provide watertight connections.

i. Mechanical Joints

There are a variety of mechanical joints that utilize devices such as friction fits, compression joints, and bolt-on couplings.

2. Recommended Joining Procedures

a. General

(1) Cutting the Duct

Cut duct square with a hand saw, power saw, or rotary cutter. Remove the burrs left by sawing and the ridges left by the rotary cutter with a knife or file. Break all sharp edges on the OD and ID of the cut with a knife, file or other beveling tool to prevent possible damage to hands during handling and to prevent damage to cable coverings during subsequent cable pulls. Additionally, if the burrs and ridges are not removed, an inferior joint may result.



(2) Cleaning Joint Surfaces

Surfaces to be joined should be clean and free from dirt, foreign materials and moisture. Clean the outside surface of the duct spigot (for the depth of the socket), and the inside surface of the socket with a clean dry cloth.

b. Solvent Cement Joints

(1) Selection of Solvent Cement

Solvent cement specified by the manufacturer for use with PVC should be used.

(2) Handling Cement

THE SOLVENTS USED IN THESE CEMENTS ARE FLAMMABLE. THEIR FUMES CAN BE HARMFUL IF ADEQUATE VENTILATION IS NOT PROVIDED. When cementing joints or fittings in confined spaces such as unventilated underground vaults or in small, enclosed areas, forced ventilation systems should be provided and used. Because they are flammable, these cements must not be used where exposed to open flames, exposed heating elements, or sparks. Don't smoke when solvent cementing joints. READ AND OBSERVE THE WARNINGS AND CAUTIONS CLEARLY STATED ON THE LABELS OF SOLVENT CEMENT CONTAINERS AND THE MATERIAL SAFETY DATA SHEETS (MSDS).

(3) Selection of Brush

Cements should be applied with a natural bristle or nylon brush or applicator of appropriate size to easily and rapidly coat the surfaces to be joined. As a guide, a brush width at least half the nominal duct size is recommended.

(4) Application of Cement and Joining

Solvent cements are fast drying and should be applied as quickly as possible consistent with good workmanship.

Apply a heavy, even coating of cement to the duct spigot OD surface, equal to the length of the duct socket.

Immediately, while the spigot surface is still wet with cement, insert the duct spigot with a slight twisting motion into the socket until it bottoms home at the socket shoulder. Do not twist or turn the duct after it has bottomed on the shoulder. This slight twisting motion used during insertion helps to distribute the cement evenly, but if twisted after bottoming, the initial bond could be impaired.

(5) Precautions

Assembly of a cemented joint should be completed within 15 seconds after application of cement. Initial bonding begins immediately when the cement coated joint surfaces are in position.

If there is any sign of drying of the cement surfaces prior to assembly, recoat the duct spigot with a fresh coat of cement and immediately insert the duct spigot into the socket with a twisting motion.

After assembly, wipe excess cement from the duct at the end of the socket, both for good workmanship and to prevent excessive cement from dripping on and possibly weakening the lower ducts.

Cure times will be greatly affected by temperature and humidity conditions. Consult manufacturer's instructions for specific recommendations.

c. Threaded Joints

Threaded joints are made by screwing the mating threaded parts together, hand tight, and then tightening one additional turn using strap wrenches. If the joint is intended to be taken apart and reassembled several times during its service life, wrap the male threads with one layer of pipe thread tape. This allows easy disassembly and prevents possible thread galling when tightened. (For RTRC double lead threads, refer to Appendix 4.)

d. Heat Fusion Joints

Heat fusion joints should be made in accordance with manufacturer's recommended practice for heat joining of thermoplastic pipe and fitting ASTM D-2657.

e. Heat Shrink Joints

The procedure for making these heat shrinkable polyethylene sleeve joints is as follows:

- (1) Place the sleeve over the sections being joined. Keep the sleeve centered over the joint.
- (2) Using a hot air heat source and working from one end of the joint, move the heat source around the sleeve and towards the opposite end. Avoid concentrating the heat in one spot. Apply heat until sleeve shrinks snugly around joint assembly.
- (3) The coupling has left and right hand threads so it can thread onto both duct ends simultaneously. Note the orientation of the thread pattern. Apply a small amount of cable lubricant to the inside of the coupling. It is useful to make the thread cutting easier.

Bring both ends of the duct into the coupling. Forcing the duct ends toward one another, begin to rotate the coupling. Use wrenches to complete installation. Do not overtighten. It will result in a significant reduction of the pull-out resistance.

Be certain that the coupling is threading onto both ends of the duct. Both ends should meet in the center of the coupling. This is necessary to obtain the maximum resistance to pull out. If the coupling is not threading on equally, unscrew and restart the threading operation.

f. Adhesive Joints--See Appendix 3.

g. Gasketed Joining

Because of the variety of gasketed joint designs available, refer to manufacturer for specific assembly instructions.

h. Compression Joints

Remove the coupling's two PVC compression nuts and rubber compression glands from the coupling. Slide a nut and gland onto each section of duct at the joint. The nut may be a tight fit on the duct. In some instances it may be necessary to scrape clean the inside edge of the nut that contacts the duct. On some sizes of duct, it may be necessary to round the duct manually to aid in slipping the nut into place.

Take care to center the coupling before tightening. Tighten compression couplings with wrenches to assure a proper seal.

## **E. CONCRETE ENCASUREMENT OF NONMETALLIC DUCT**

### 1. Duct Laying

Care should be taken to prevent damage to the duct. Spacers should be placed in position as specified in the project plans.

#### a. Spacers

It is recommended that manufactured plastic spacers be used. The particular type and design of the manufactured spacer should be consistent with the owner/engineer specification to prevent excessive deflection from loading or buoyancy forces. Any spacer systems improvised in the field should be approved by the engineer. The use of bricks or wood is not recommended because these materials may deform the duct wall. The bottom spacer must provide sufficient clearance off the trench floor to permit the specified thickness of concrete to gather at the bottom.

There are a number of commercially manufactured duct spacers available for assembling duct banks. These products maintain the desired separation between ducts and provide the required support during assembly and concrete encasement.

The placement of these spacers varies in accordance with the conduit material and installation specification. Typically, spacers are placed 5 to 8 feet apart.

#### b. Sequence of Laying

Starting at the manhole location, the first lengths of duct are joined to the manhole terminators or end bells. (See Section II for the proper joining procedure for the duct material.) Staggering of joints of adjacent ducts is often specified.

When all ducts in the bottom tier are terminated to the manhole, the second tier of ducts should be terminated in the same manner. This procedure is followed until the top tier of the duct bank has been terminated. Then the hold down assembly should be installed in accordance with the spacer manufacturer's recommendations.

The next lengths of ducts are then joined to the first lengths, following the same procedures described above.

#### c. Closure of a Run Between Manholes

As the duct run approaches the next manhole, it is recommended that a complete set of full length ducts be terminated at the second manhole. Then lengths of duct should be cut to fill in the difference. Before installing the cut lengths, a sleeve coupling should be slipped onto each duct in the main duct bank run. The cut lengths should then be joined to the lengths that have already been terminated to second manhole. After each cut length has been connected, the sleeves should be used to join the cut lengths to the main duct bank run.



## 2. Temperature

All nonmetallic duct and fittings to be joined should be exposed to the same temperature conditions before assembly.

Nonmetallic ducts will expand or contract the following distances per 100 feet for every temperature change of 10°F: about 3/8" for PVC materials, 1" per every 100 feet for every 10 degree F temperature change if it is not restrained for PE materials and 1/8" for RTRC materials. To minimize length adjustment at the manholes, backfilling should always proceed from one manhole or vault toward the other end of the duct run. Where large differences between the temperature of the air and soil exist, consideration should be given to making tie-ins at both manholes after the duct bank has been covered a few hours.

## 3. Anchoring

An important consideration is to make sure that the entire duct bank is run as straight as possible from manhole to manhole. Once the duct bank is straight, it is necessary to anchor it to prevent movement when the concrete is poured. Movement may be caused by: buoyancy, concrete churning and vibration. Various manufactured spacers provide for different ways of anchoring the duct. Recommended methods incorporate reinforcing rods which are driven into the trench floor to secure the duct bank and to prevent movement during the concrete pour. In areas where soil conditions make it impossible to drive a rod deep enough to gain an effective anchor, it is recommended that a trench jack be firmly placed directly over the spacer location and adjustable wedges be used to wedge down the duct bank. Methods of anchoring that are improvised in the field should be approved by an engineer.

4. Concrete Pour

Typically, a concrete pour begins at a manhole and works down the duct bank towards the next manhole. The concrete used should have a compression strength and slump as specified by the engineer. Typically, slump is specified to be 7 to 9 inches to assure proper distribution of the concrete around the ducts. Higher slumps, or more fluid concrete, may create adverse flotation or buoyancy forces. The recognized maximum aggregate size should be one-half the minimum clear space between the ducts. Care should be taken to limit the fall of the concrete to a minimum *height* from the chute to the top tier of ducts to minimize flotation effects.





5. Backfilling

The trench can be backfilled after the concrete has set. The first 12 inches of fill should be free of large stones, broken pavement, etc., that might damage the duct structure. The backfill should be thoroughly tamped using lightweight equipment, such as pneumatic or vibrating tampers.

On warm sunny days where the duct structure has been encased, if the first 12 inches of backfill cannot be placed and tamped immediately following the concrete work, one or two inches of sand or other granular material should be placed over the concrete immediately after leveling to prevent rapid evaporation of water from the surface of the concrete.

**F. DIRECT BURIAL OF NONMETALLIC DUCT**

1. Duct Laying

Duct should be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power ducts, to provide for heat dissipation. A separation of 1 inch both vertically and horizontally between ducts is a recommended minimum to provide room for heat dissipation and for good compaction of backfill. If spacing is less than 1-1/2 inches, it is difficult to achieve the compaction necessary for proper conduit support. Other spacing may be required for different applications in which case the engineer's or owner's specifications should be followed.

For direct burial, spacers shall meet certain conditions as specified by the design engineer:

- a. Spacers identified for such use
- b. Appropriate backfill material
- c. Proper compaction of backfill material

The use of duct spacers for direct burial may result in excessive point deflections unless the duct installation complies with the design engineer's specifications.

The duct formation may be built up layer by layer. After each layer is placed, the selected backfill should be placed over it to a minimum depth of 1-inches. This fill should be spread evenly and compacted to provide continuous support for the next tier of ducts. Any temporary spacers used should be removed from each layer of duct as soon as backfill is completed in that layer.

To maintain clearance between ducts, joints for adjacent ducts should be offset about 6 inches both horizontally and vertically.

2. Temperature

As stated previously under "Concrete Encasement of Nonmetallic Duct," all duct and fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.

3. Bends or Grade Changes

When short radius bends or abrupt grade changes are encountered, the thermoplastic ducts are often encased in concrete to protect against possible winch line cutting.

4. Duct Embedment and Final Backfill

The embedment zone of a duct trench is that portion of the trench from approximately four inches below the bottom of the first row of ducts to approximately six inches above the top of the final row of ducts.

The external loading capacity of flexible ducts is largely dependent upon the type of embedment material chosen and the quality of the installation of the material in the embedment zone.

The best materials for use in the embedment zone are coarse grained materials such as crushed stone, sand, and pea gravel. Coarse grained soils mixed with silts or clays can also be satisfactory provided the mix is compactible and stable. Soils not recommended in the embedment zone are the highly organic materials and the highly plastic clays. The maximum particle size in the embedment zone should be limited to one inch in diameter.

The final backfill zone of the duct trench is that portion of the trench extending from the top of the embedment zone to the top of the trench.

The final backfill is not critical for duct performance, but can be important for providing a proper foundation for a road or other structure, which may be constructed over the duct trench.

Selection of the final backfill materials is not critical for the duct; all types of soils are acceptable provided they do not contain particles that can damage the duct. However, since most duct installations have structures built over them, the final backfill material is often of a select nature much like the embedment zone.

The project engineer is responsible for the selection of the embedment and final backfill materials.

5.        **Compaction**

Proper compaction of the embedment zone is important for limiting the deflection of the ducts. After compaction, the soil should completely encase each duct, providing support entirely around the diameter and along the length of each duct. The soil should be consolidated and free of voids. The density of the soil after compaction is specified by the project engineer and is typically in the range of 85-95% proctor density.

Compaction of the final backfill material is not critical for duct performance, but is important for providing a stable foundation for structures that may be built over the trench.

The type of compaction method chosen depends on the type of backfill materials used. For coarse-grained, non-cohesive soils such as crushed stone, pea gravel, and sand, vibratory compactors work well. Static compaction devices, which utilize their own weight to compact the soil, can also be used on non-cohesive soils. For cohesive soils, such as the finer-grained clays, impacting compactors are the most effective devices.

When mechanical compaction equipment is used, care must be exercised to prevent damage to the ducts. Hand-held, unpowered compaction equipment should be used when there is little soil covering the ducts. This can include shovels, two-by-fours, and other hand-held devices. When using small mechanical compactors, the ducts should be covered by at least six inches of soil. For larger mechanical compaction equipment, 30 inches of cover or more may be necessary depending on the influence area of the device. The project engineer is responsible for determining the appropriate compaction method to be used for a given installation.

Water compaction (sometimes called "jetting") can be effective for soils that are not expansive and will flow when wetted, such as sand. In such soils, water compaction can achieve desired soil densities without risk of damage to the ducts. However, the duct banks should be restrained from flotation if water compaction is used.

Compaction is best done in layers, or "lifts" of soil of between 6 inches and 12 inches in thickness. A lift of backfill is placed, then compacted before the next lift is placed. Each row of duct is embedded in a lift before the next row is placed. It may be possible to use greater thicknesses of lifts when water compacting.

**G.        FIELD BENDING**

The natural flexibility of most nonmetallic duct makes field bending, to form curves and to avoid obstacles, a relatively simple operation. Of course, as with all installation practices there are some techniques that make field bending easier and faster and produce a better duct run. See Appendix 1 for field bending instructions for PVC and RTRC duct and conduit. For field bending instructions for PE duct and conduit, consult manufacturer. Consult manufacturer for minimum field bend radii.

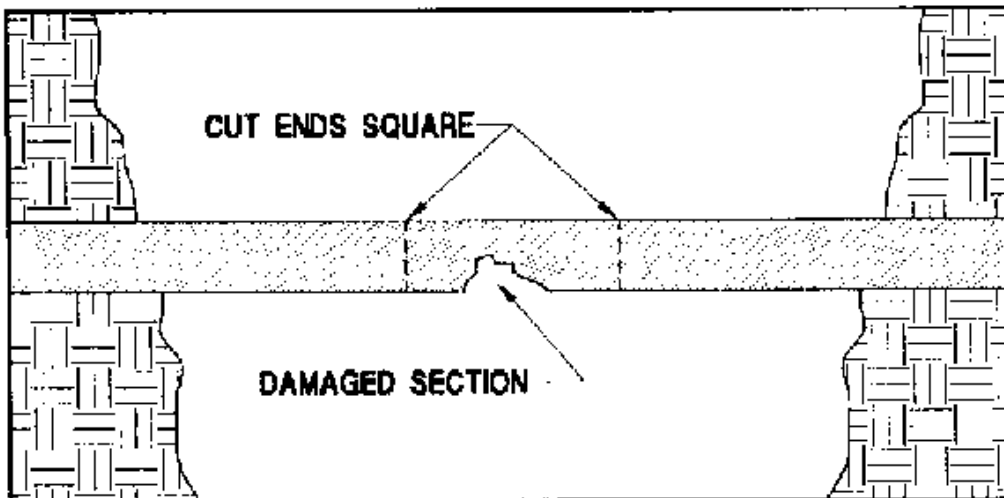
**H.        SHORT-RADIUS BENDS**

1.        For the purpose of this guideline, a short-radius bend is a bend having a radius of five feet or less.
2.        It is recommended that short-radius thermoplastic bends be encased in concrete.
3.        Unless otherwise specified, it is recommended that the bend radius used in duct installation be a minimum of twelve times the diameter of the largest cable to be installed. The cable manufacturer's recommendations should be followed.

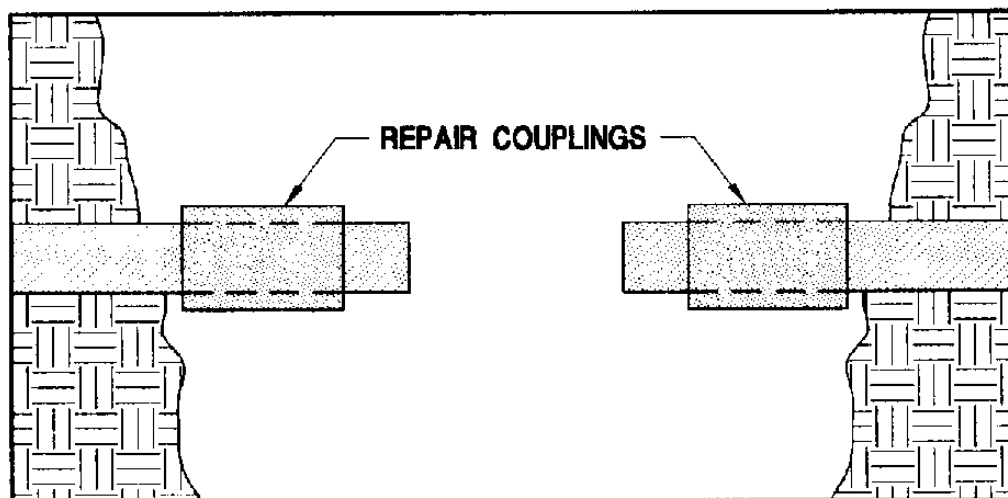
4. All concrete-encased bends should be independently supported by duct spacers of such type to maintain the designed separation between adjacent ducts, both horizontally and vertically.
5. When selecting short radius bends, consideration must be given to pulling tension and duct sidewall pressure.

#### I. DUCT REPAIRS (PVC & RTRC)

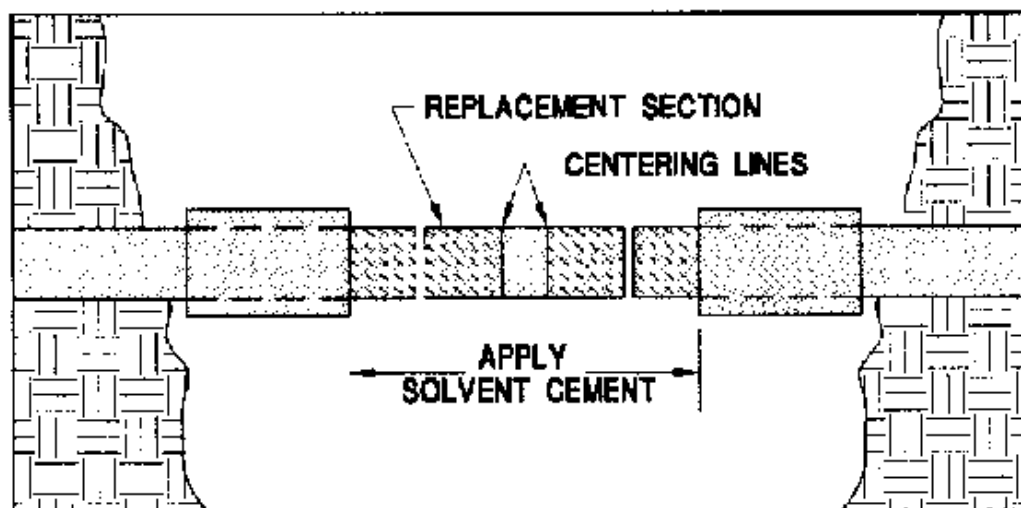
1. PVC and RTRC
  - a. Remove a sufficient amount of the concrete and/or backfill material to completely expose all of the damaged duct or ducts and also provide adequate working space in the trench. The damaged ducts should be exposed back to a point at least one foot on both sides of the damaged area.
  - b. Cut out the damaged portions of the ducts. The cut should be made as square as possible. Deburr and chamfer the edges of the fixed duct.



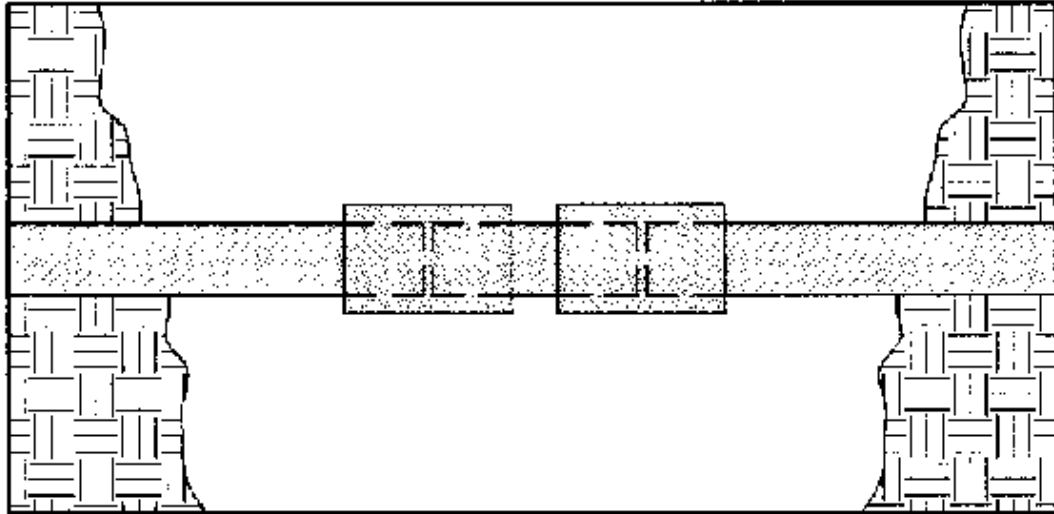
- c. Cut the replacement section from a piece of duct with the same outside diameter and wall thickness. The replacement section should be cut approximately 1/8 inch shorter than the gap in the fixed duct. Deburr and chamfer the edges.
    - d. Thoroughly clean the exposed ends of the fixed duct and both ends of the replacement section.



- e. Slide the repair (or sleeve-type) couplings over the ends of the fixed duct. Mark lines around the ends of the replacement section, one half the length of the repair coupling away from the ends, in order to center the repair couplings.
- f. Apply solvent cement or adhesive on both ends of the replacement section and on the exposed ends of the fixed duct, provided solvent cementing is an approved method for joining the duct material being repaired. Otherwise, use a gasketed repair coupling.



- g. Place the repair section into the duct line and center the repair couplings over the joints to the lines marked on the replacement section. Rotate the couplings approximately one-quarter turn to distribute the cement or adhesive.



- h. If more than one duct line is damaged at the same location, repair them one at a time starting at the bottom of the duct structure and working to the top, replacing duct spacers as work progresses.
  - i. After completion of the duct repair, replace the concrete and/or backfill material.
2. PE

Methods of repairing PE duct include the use of couplings and/or a splice.

A splice consists of an oversized piece of duct placed over the repair area and sealed using heat or cold shrink tubing.

#### **J. CONNECTIONS TO OTHER DUCT SYSTEMS OF OTHER MATERIALS**

Because of the wide variety of adapters available for connecting to different duct systems, the manufacturer's recommendations should be closely followed.

#### **K. DUCT RODDING (Fishing)**

One of the many advantages of nonmetallic duct is the ease and low cost of pneumatic rodding. Several types of projectiles and air sources can be utilized to propel the fishline through the nonmetallic duct. Rodding machines or duct rods can also be used to manually insert pulling lines through the duct should pneumatic equipment not be available. Typical pneumatic rodding takes 15 - 50 psi. Consult manufacturer for recommended pressures.

#### **L. MANDRELLING**

After the duct has been concrete encased and/or backfilled, but before any surface construction begins, it is common practice to check duct deflection by pulling a mandrel through the ducts.

Mandrels function as "go/no go" gauges. They are sized to be smaller than the ID of the duct so that some deflection of the ducts is allowable (and completely normal). The mandrels are pulled through the ducts by means of a rope or cable. If the mandrel can be pulled through the tested section, then the section is considered acceptable. If the mandrel cannot be pulled through the duct, there are a few possibilities as to the reason. First, the duct may have deflected beyond what

the mandrel will allow. Second, the mandrel may have caught in a fitting, perhaps due to a tight radius. Third, debris may be blocking the path of the mandrel. The cause of the mandrel blockage should always be ascertained.

It is recommended that the mandrels be shaped such that the maximum mandrel OD occurs over a very short distance (<1 inch) so that the mandrel can travel through sweeps without bridging. Ball-shaped mandrels are therefore commonly used, but there are many configurations possible.

Mandrels are not generally used for ducts less than 2 inches nominal diameter.

The following chart provides suggested mandrel ODs for various conduits and ducts:

	<b>Size (inches)</b>	<b>Mandrel OD (inches)</b>	
NEMA TC-2 Conduit:	2	1.80	
	2-1/2	2.17	
	3	2.71	
	3-1/2	3.20	
	4	3.58	
	5	4.52	
	6	5.41	
NEMA TC-6&8 Duct:	2	2.11	
	3	3.05	
	3-1/2	3.72	
	4	3.97	
	5	4.92	
	6	5.86	
NEMA TC-14A Conduit:  Standard Wall        Heavy Wall	2	2.09	
	3	3.15	
	4	4.10	
	5	5.11	
	6	6.06	
	8	7.93	
	4	4.10	
	5	5.11	
	6	6.06	
	8	7.93	
	NEMA TC-14B Conduit:  Standard Wall        Heavy Wall	2	1.88
		2-1/2	2.36
		3	2.83
		3-1/2	3.31
4		3.78	
5		4.73	
6		5.68	
4		3.78	
5		4.73	
6		5.68	



## APPENDIX 1

### A. FIELD BENDING FOR PVC AND RTRC DUCT AND CONDUIT

The example which follows (Figure 2) is based on installations up to four ducts high by four ducts wide using 4" Type EB duct with a duct stiffness ( $F/\Delta y$ ) of approximately 35 lbs./inch/inch. These procedures are applicable to bends of approximately a 150 foot radius to a 35 foot radius. Bends of less than a 35 foot radius can be accomplished by using factory bends, bends greater than a 150 foot radius or greater than the manufacturers minimum bending radius.

Consult manufacturers for typical examples of other duct materials or wall thicknesses.

### B. JOINING

The joining procedure detailed in paragraph D, page 11, should be followed:

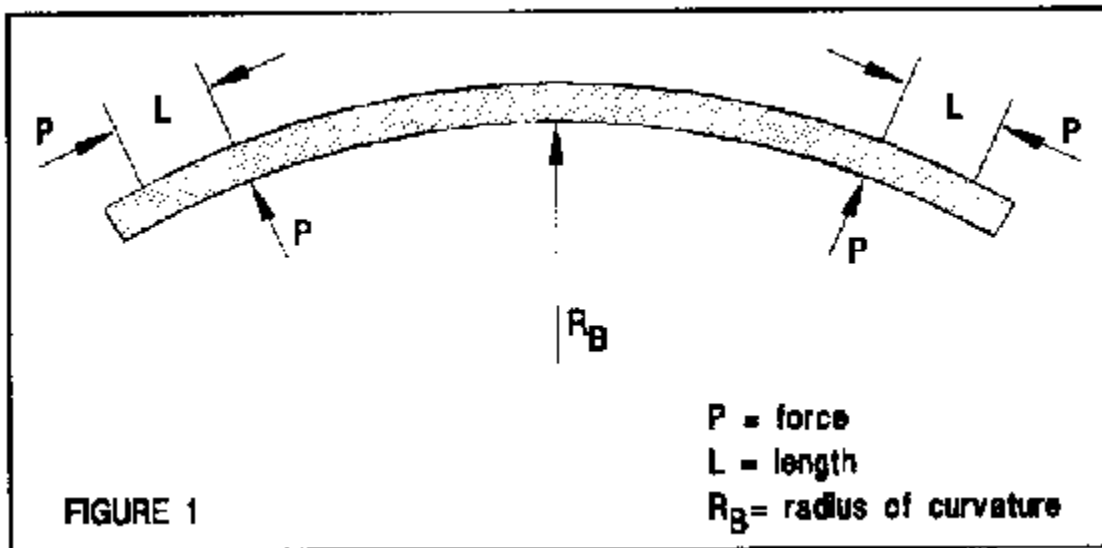


Figure 1 above illustrates the forces on a length of duct when bent. By looking at the drawing, it is evident that the side of the conduit away from the center of curvature is elongated, or under tension; the side toward the center of curvature is shortened and under compression. Direct joints which fall within the radius of the curve are subjected to the same forces. To prevent the tension side of the joint from failing, caution must be taken in allowing sufficient drying time for all joints in the radius of the bend. Approximately two hours curing time is considered adequate at 70°F. Shorter times may be adequate in hot weather and longer times may be required in cold weather.

Basically, the usual joining procedure outlined is recommended. For bends where the running length of duct required, including tangents, is 150 feet or less, the bending operation is simplified if the entire length is pre-assembled and allowed to cure the requisite time prior to bending operation. This applies particularly in installations where the radius of curvature is small, for example, less than 80 feet.

Where it is not possible or convenient to preassemble the entire length to be bent, it may be necessary to relieve the trench wall at the end of the first section laid to permit straight alignment of the joint for the curing period while the next lengths are assembled.

### C. TRENCHES AND SPACINGS

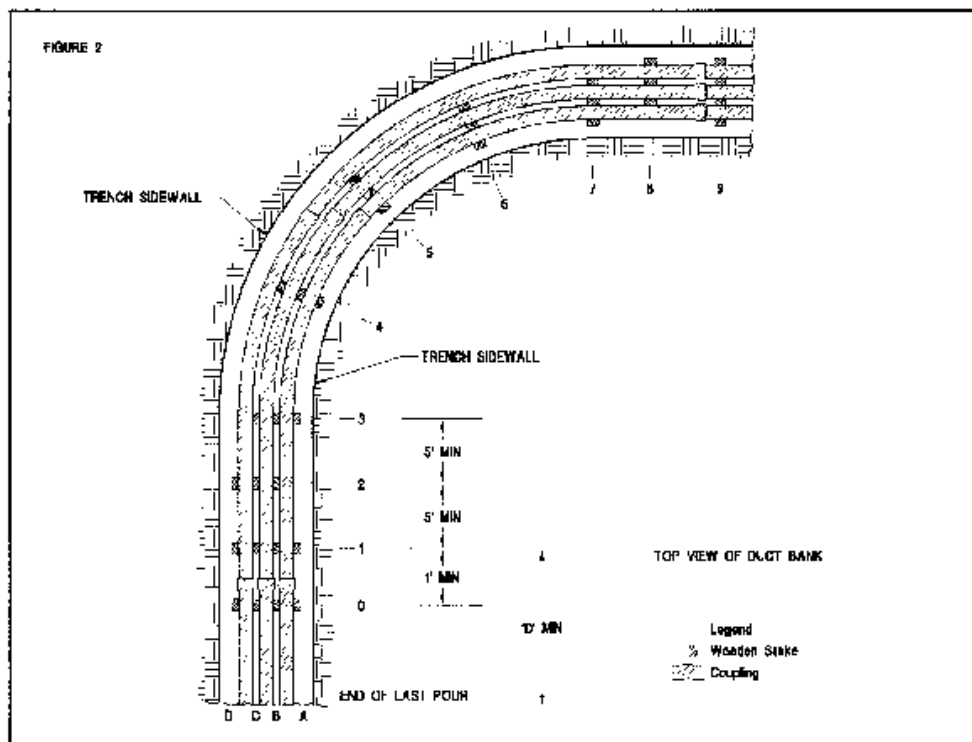
Trenches for all duct runs should be constructed to provide proper clearance. It is recommended that a 3" clearance be maintained between trench bottom, trench walls and ducts. The bottom clearance may be maintained by the use of a base spacer of the specified dimension placed on the trench bottom at horizontal intervals of 4 feet to 6 feet. The method of obtaining side wall clearance will vary depending upon the method of installation chosen, however, a minimum of three inches should be maintained.

### D. PROCEDURES FOR INSTALLATION OF DUCTS FOR FIELD BENDS

Temporary stakes may be used to hold the formation in place until the spacers are adequately anchored. Reinforcing rods are generally used to permanently hold the spacers in place until the trench is backfilled with concrete.

The temporary stakes may be either formed steel or wood. Steel stakes are preferable for added dimensional stability and to facilitate driving. Steel stakes should have 1" minimum bearing surface on the ducts and have an effective thickness of 1" minimum to provide adequate space between ducts. Wooden stakes may be 2 x 2 construction lumber.

Figure 2 is a schematic diagram of the field bend annotated so the sequence of operations may be followed. The numbered stations are points of restraint, or spacings, and the lettered designations indicate spaces between the vertical tiers of ducts.



Vertical duct tiers are indicated as the combination of the two spacers on either side thereof, e.g., AB, BC, etc. Using Figure 2 as a reference, the steps in temporarily staking field bends are:

1. If the last coupling of the last duct is close to the start of the bend, the first point of restraint (anchored spacer or temporary stake) may be at the coupling. If that is not the case, proceed to step 2.

2. Stakes should be driven at positions B-1 and A-3 through A7, prior to joining the length of duct AB that will start the bend. All the A position stakes may be braced to the trench wall if conditions require.
3. Duct A-B may then be joined and formed to the bend, with restraining stakes driven at positions B-9 and A-9. If A-B is a vertical tier of ducts, the remaining lengths can be joined and spaced as required. If the stake at position B-9 proves to be inadequate to hold the vertical tier in proper alignment, multiple stakes may be employed at that position or a temporary crossbrace may be used to brace the top of the stake to the outside trench wall.
4. Stakes may then be driven at positions C-1, B-3 through B-7, and another restraining stake at C-9.

The vertical tier of ducts C-B may then be joined and formed from the bottom up as was the B-A tier. If a temporary crossbrace was required for stake B-9, it may be removed, shortened, and applied to C-9.

5. After the placement of stakes D-1, C-3 and C-7, and D-9, and the bracing of D-1 and D-9 to the outside trench wall, the next vertical tier D-C is formed in the same fashion as the previous tiers.

At this stage in the construction, the alignment of the ducts between stations 7 and 9, as well as 1 and 3, may not be exactly parallel to the line of the trench. This situation may be improved by the placement of stakes driven at positions 2-B, 2-C, 2-D, 8-B, 8-C, and 8-D. Stakes 2-D and 8-D may then be barred or wedged to produce alignment and braced to the outside trench wall, and all the above stakes may be driven until commercial spacers are inserted adjacent to each stake location and firmly held in proper position using re-bars. The temporary stakes are to be removed before backfilling.

It is suggested that after the bending operation is completed, the installation be checked to ascertain that excessive deflection has not resulted to the duct due to the loads imposed at the points of restraint. Ducts subject to the greatest crushing loads are the upper tier on the inside of the bend at stations 3 and 7. The difference between horizontal and vertical OD should not exceed  $\frac{1}{4}$ ". If deflection greater than this has occurred, it may be corrected by driving stakes or using spacers between positions 3-4, or 6-7, or by easing the degree of bracing to the trench wall at positions A-3 and/or A-7.

One possible source of difficulty in forming bends by this method is obtaining sufficient force at positions 1 and 9 to produce the requisite coupling or bending movement prior to completion of the bend. This difficulty is more likely under the combination of poor trench bottom conditions with wide and/or high formations and on bends with the minimum radius of curvature.

Such difficulties, if they occur, may be reduced or eliminated by several modifications to the above suggested method, including employing greater than the minimum distance between conditions 1 and 3 or 7 and 9 and/or using two sets of spacers at each of the stations 1 and 9.

1. A stake should be driven at position A-1.
2. Spacers (a number equal to the number of ducts high) are placed against the inside trench wall at positions 3, 4, 5, 6, and 7.
3. Lower duct of vertical tier A-B is joined and formed to the bend and restrained with temporary stakes and spacers at positions 1-9 and B-9.
4. The remaining ducts in vertical tiers A-B are then positioned.

5. Spacers are then placed at positions 1, 2, 8, and 9 to complete the restraints on the inside trench wall.
6. Spacers are then connected at all stations, thus completely enclosing the ducts in vertical tiers A-B.
7. Stakes are then driven at positions C-0 or C-1 and at C-9, and the tier C-B is placed in the same fashion, and spacers are placed on the outside thereof at the same stations as in the case of the tier A-B.
8. Tier D-C is then placed in similar fashion, and spacers are applied to the outside of the bend at stations 1 through 9.

Alignment of the ducts at the beginning and at the end of the bend may then be adjusted by bracing the spacers last assembled at stations 1, 2, 8, and 9 to the outside trench wall. After placement of cross braces on top of the duct on 5' maximum spacing to prevent flotation, the installation is ready to pour. When forming horizontal rows in sequence, all of the general considerations previously outlined pertain.

In formations less than three high and containing six ducts or less, no special procedures are usually required, providing spacers and reinforcing rods or stakes are used for hold down and alignment. The bottom spacers are laid at positions 1 through 9, rods driven, and the first horizontal row of ducts joined and laid. Spacers are then placed and the operation repeated. After placement of top spacers, the rods may be bent, and, if the bend remains in alignment, it is ready to pour.

In larger or higher formations, particularly in poor soil conditions, the rods may not adequately hold the formation in alignment during the entire bending operation. This problem may be reduced or eliminated by driving stakes and bracing to the trench wall at positions 1-D, 2-D, 3-A, 7-A, 8-D, and 9-D. These stakes may usually be applied any time prior to laying the third horizontal row of ducts or whenever their need becomes apparent. Normally bracing of this type will not be required at stations 4 through 6, as the forces at these locations are significantly less.

## APPENDIX 2

### CONDUIT-IN-CASING

When it is necessary to place power or communications cables under a railroad, highway, or runway without disruption to either traffic or the roadbed, conduit-in-casing is the construction method of choice. Simplified, the conduit-in-casing construction procedure is as follows:

1. Dig a hole on both sides of the roadbed.
2. Bore under the roadbed connecting the vertical holes, and install a steel casing.
3. Place conduits in the steel casing.
4. Inject grout into the area between the conduits and steel casing.
5. Allow the grout to cure.
6. Pull power and/or communications cables through the conduits.

The steel casing is usually pushed into place with hydraulic jacks while the earth ahead of the casing is removed by hand or with special boring machines. The most common steel casings used for conduit-in-casing installations are shown in Table I below.

**Table I**  
**Common Steel Casings used for Conduit-in-Casing Installations**

Casing OD (Inches)	Casing Wall Thickness (Inches)	
	Under Highway	Under Railroad
16	.250	.312
18	.250	.312
20	.250	.375
24	.250	.375
30	.312 & .375	.375 & .469
36	.375 & .500	.500 & .531
42	.500 & .750	.625
48	.500 & .750	.688

Since wall thickness requirements vary with each location, it is important to consider soil conditions and to get casing approval from the applicable railroad, airport, or roadway authorities.

Normally the conduit used within the steel casing is EPC40 (Schedule 40) PVC per NEMA TCB-2. On occasion, DB120 PVC conduit per NEMA TC 6 & 8, heavy wall epoxy reinforced fiberglass conduit per NEMA TC-14, or heavy wall HDPE conduit have been successfully used. These are all fairly heavy wall conduits that hold up to the hydraulic pressure normally encountered when injecting grout. They also hold up to the loads presented by the bands that are used to hold the conduits and bore spacers together.

Manufactured spacers are available that are shaped to fit in a round steel casing. Some of the typical features incorporated in bore spacers are:

1. Provisions for mounting rollers to aid in installation
2. Holes for wire ropes, which when held taut prevent the corkscrewing of the duct bank when pulled through the casing

3. Float-stops to prevent the conduit from being deformed by the upward load created by the duct bank floating when the grout is injected
4. Flow holes and a contoured perimeter to allow the grout to pass through easily
5. Bore spacers are usually manufactured from a nonmetallic material

The bore spacers should be spaced 5 feet apart for the full length of the casing. Bands, normally steel, should be secured around the duct bank near each spacer, locking them into position. The most common separation between conduit-in-casing conduits is:

Communications	1"
Power	1 1/2" or 2" (3" on occasion)
Between Power & Communications	2" or 3"
Fiber Optics	0"

The space between the OD of the conduits and the casing ID is normally grouted for the following reasons:

(Reasons 1-3 are applicable to both power and communications applications. Reasons 4 & 5 are applicable only to power applications.)

1. To eliminate the possibility of a duct bank collapse due to the force put on the duct bank when cable is being pulled into place.
2. To eliminate the possibility of duct bank collapse due to the weight of the cables.
3. To eliminate the possibility of duct bank rotation due to cable weight causing an out of balance rotational torque.
4. To reduce the possibility of a duct bank meltdown when there is a cable fault. The grout will tend to contain the fault to a single duct.
5. Grout is normally required for power applications to transfer the heat generated by the power cables to the surrounding ground.

The grout used is an important consideration as it must fill the void completely, but the pumping pressure must be kept low enough so as to not collapse or deform the conduits.

There are a number of grout mix designs that have worked very well for conduit-in-casing installations. Cement grout mix designs that are highly cementitious (high in cement and fly ash) and have a slump of approximately seven to eight inches perform well for power applications.

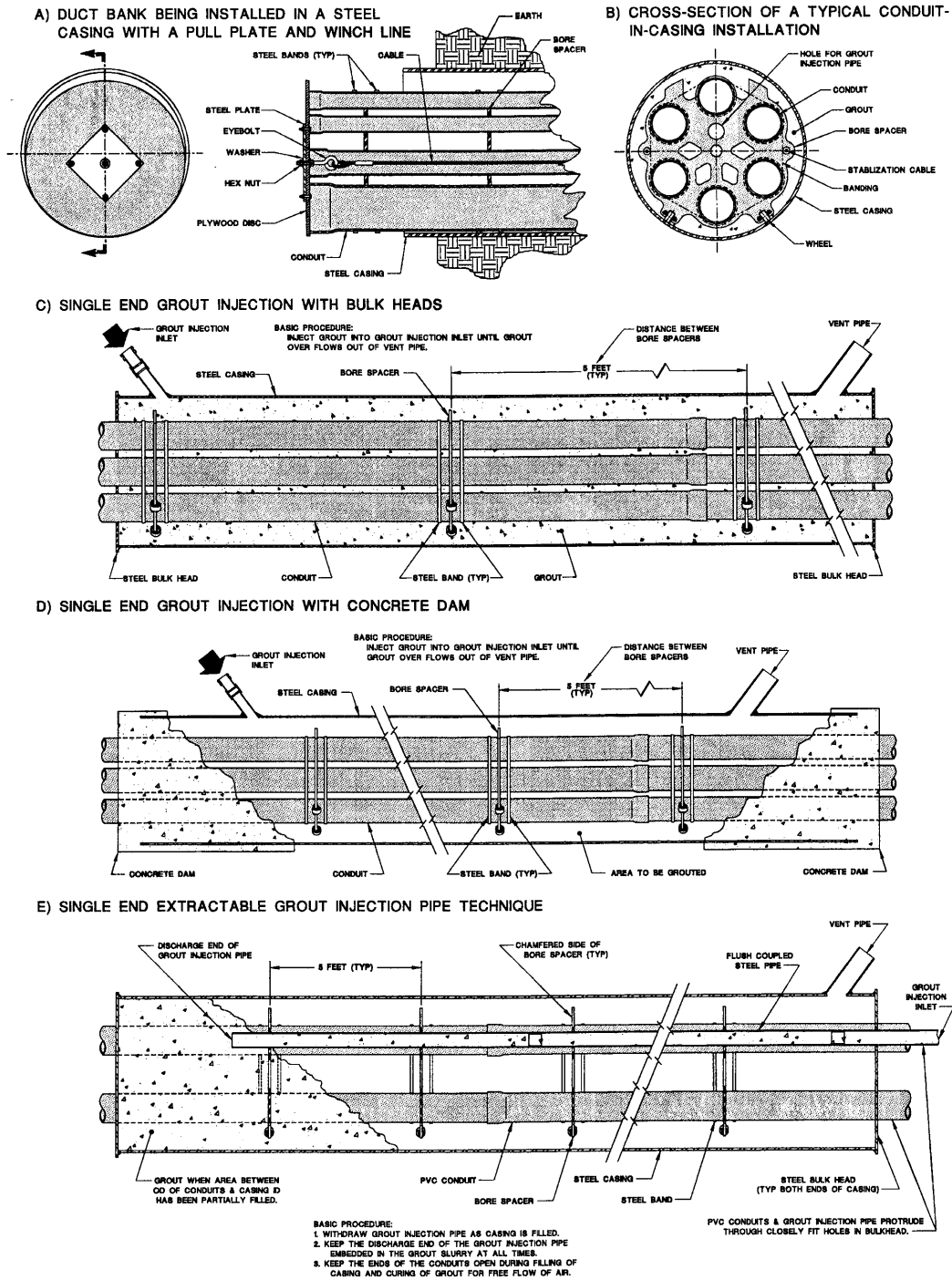
Grout with special additives (such as "Elastizell" or "Mearicrete"), which reduce the grout density to about 75 lbs./cu. ft. and increase fluidity so it is similar to that of an 11" slump, also work well, but since they have lower thermal conductivity, they are normally restricted to communication applications.

There are a number of different grout injection techniques and variations. The drawings at the end of this appendix show a few of these techniques.

There are applications where it is advantageous not to fill the area between the conduit and the casing. When approaching a no-grout application, be sure to allow for duct bank expansion and contraction due to

temperature change, and be sure that the bore spacers are of sufficient strength and close enough together to properly support the cables.

On rare occasions, sand is blown into the area between the conduits and the casing ID. Since sand will not dissipate the heat generated by power cables as quickly as cement grout, it may be necessary to de-rate the power cables.





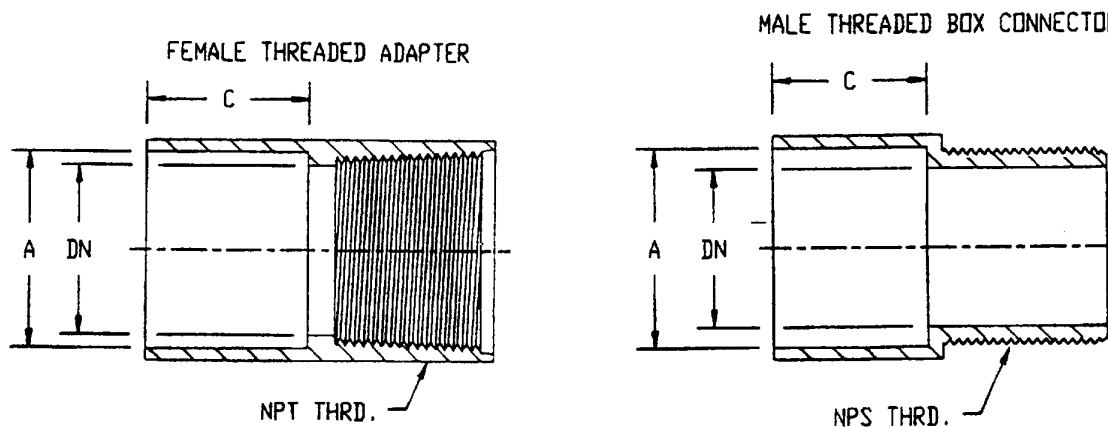
### APPENDIX 3

## INSTALLATION INSTRUCTIONS FOR RTRC JOINTS

### A. JOINING METHODS

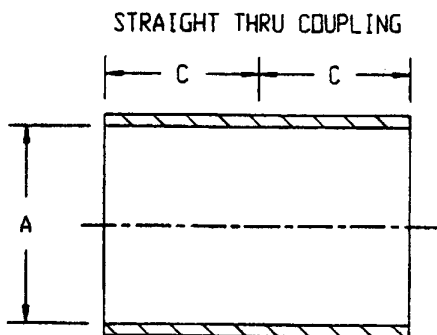
#### 1. Double or Single Lead Threaded Joint

With a mechanical joining system featuring tapered, double or single lead sealing threads on both the male and female ends, installation is fast and easy. The threads lock with only a few turns.



The threads are applied in the factory. Conduit is shipped ready to install. Double or single lead threaded joints are reusable. They have excellent pull-out resistance over the entire temperature rating range of the conduit. As a user option, this system can be made into a permanent joint with the application of epoxy adhesive during assembly.

#### 2. Straight Socket Joint



For field repairs, attachment of adapters or other fittings that are situated such that a factory length of conduit must be cut; a straight socket epoxy adhesive joint is recommended.

**B. DOUBLE OR SINGLE LEAD THREADED AND SOCKET JOINT INSTALLATION INSTRUCTIONS (with or without adhesive)**

Remove the protective caps from the conduit ends, if so supplied, just prior to joint make-up (for adhesive bonded joint; see "Joint Cleaning and Adhesive Mixing" instructions). After cleaning the joint and mixing the adhesive, completely coat the male thread and brush adhesive on female threads applying a THIN uniform coating to the first one inch of the female connection. Excess adhesive can result in restrictions in the conduit I.D. Align the male and female threads and screw the conduit together.

1. Cutting the Conduit

Cutting is relatively easily done. It can be accomplished with a circular saw using a reinforced abrasive blade, satire-saw with a fine-toothed metal cutting or tungsten carbide blade, or a hacksaw (32 teeth/inch blade).

2. Adhesive Bonded Joints

After the conduit is cut to the desired length, remove the resin gloss two inches back from the cut edge or to the manufacturer's specific length if different.

After sanding, follow the "Joint Cleaning and Adhesive Mixing" instructions. After mixing adhesive, brush a uniform coat on both the bell and spigot bonding surfaces, applying adhesive to only the first one inch of the female connection.

Then, using a stab and twist motion, joint the bell and spigot. The joint should not be disturbed until adhesive has cured. Excess adhesive can result in a restriction in the conduit.

3. Joint Cleaning and Adhesive Mixing

Bonding surface must be factory fresh in appearance.

- a. Joint Cleaning: Use sufficient joint cleaner and clean paper towels as provided in adhesive kit. If additional cleaner is needed, consult manufacturer for recommended solvents.

- (1) Clean all of the bonding surfaces to remove oil, grease, mud, fingerprints, etc.
- (2) Once cleaned, do not touch the bonding surfaces or allow them to be contaminated. Allow cleaner to evaporate before applying adhesive.

- b. Adhesive Mixing: Thoroughly mix the adhesive. Complete information is packed with each adhesive kit.

- (1) When the weather is cool or the adhesive has been stored in a cool environment, pre-warm the adhesive kits following the manufacturer's specifications.
- (2) Empty the hardener into the base adhesive.
- (3) Mix all of the adhesive with all of the hardener. NEVER ATTEMPT TO SPLIT A KIT. Do not split hardener during the mixing process. Cut through the adhesive with the edge of the mixing stick to assist in mixing the two components.
- (4) Mix until the adhesive has a consistent texture and/or color.

c. Adhesive Work Life: Working life or pot life is the time it takes for the adhesive to harden in the mixing can. This is measured from the time the hardener and adhesive are first mixed. It is shorter at temperatures above 70°F and becomes longer as the temperature drops below 70°F. Working life is affected by the quantity of adhesive as well as temperature. The following suggestions can be used to increase the pot life of adhesives:

- (1) Make it cooler by wrapping the can with rags or paper towels; then keep the wrappings wet with water or joint cleaner. Cut off the bottom two inches of the carton in which the adhesive kit is furnished. Line the inside with rags or paper towels and wet the rags or towels with joint cleaner. Nest the can in the prepared carton. DO NOT contaminate the adhesive with water or joint cleaner.
- (2) Working life in hot weather can also be extended by spreading the adhesive out into a film. Empty the adhesive mix out of the can and spread it out on a clean piece of foil.

4. Adhesive Curing Time

Cure time is the time required for the adhesive in the assembled joint to harden. Cure time is dependent on the ambient temperature.

