



## **NEMA Standards Publication TCB 2-2017**

### *Guidelines for the Selection and Installation of Underground Nonmetallic Raceways*

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## Foreword

These guidelines are intended to assist in obtaining the most appropriate and satisfactory installation of rigid nonmetallic conduit (RNC) or raceway systems.

These guidelines are 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.



### Typical Installation Using Spacers

NEMA TCB 2 was approved by the NEMA Polymer Raceway Products Section. Approval does not necessarily imply that all members of the Section voted for its approval. At the time of approval, the Section consisted of the following members:

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The NEMA Polymer Raceway Products Section will periodically review this standard and revise it as necessary.

Proposed or recommended revisions can be submitted to:

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## CONTENTS

1	Scope .....	1
2	Nomenclature .....	1
3	Reference Publications .....	1
4	Selection of Conduit and Duct.....	2
4.1	Types of Raceway.....	2
4.1.1	Raceway Designed for Encased Burial (EB) in Concrete.....	2
4.1.2	Raceway Designed for Direct Burial (DB).....	2
4.2	Pipe Stiffness .....	3
5	Handling and Storage of Conduit and Duct.....	3
5.1	Handling .....	3
5.2	Storage.....	4
5.2.1	Framed Units.....	4
5.2.2	Coils and Reels .....	4
5.2.3	Bulk Storage.....	5
5.2.4	Elbows and Sweeps.....	5
5.2.5	Fittings, Spacers, and Accessories.....	5
5.2.6	Cleaners, Primers, Cements, and Adhesives .....	5
5.2.7	Inventories.....	5
5.3	Handling on the Jobsite.....	5
5.3.1	Conduit and Duct .....	5
5.3.2	Coils and Reels .....	5
5.3.3	Solvent Products .....	5
6	Installation of Conduit and Duct .....	6
6.1	Proper Installation .....	6
6.2	Trench Excavation .....	6
6.2.4	Trench Wall .....	7
6.2.5	Trench Bottom.....	7
6.3	Conduit and Duct Separation .....	7
6.3.1	Raceway Supports .....	7
6.3.2	Power Duct Banks.....	8
6.3.3	Communication Duct Banks.....	9
6.3.4	Combined Power and Communication Duct Banks .....	9
6.3.5	Spacer Specifications.....	9
6.4	Joining of Raceway .....	9
6.5	Encased Burial (EB) of Rigid Nonmetallic Conduit (RNC) .....	9
	Example of Concrete Encasement.....	9
6.5.1	Conduit and Duct Laying.....	10
6.5.2	Spacers .....	10
6.5.3	Sequence of Laying .....	10
6.5.4	Closure of a Run between Manholes .....	10
6.5.5	Temperature.....	10
6.5.6	Anchoring .....	11
6.5.7	Concrete Pour .....	11
6.5.8	Backfilling .....	11
6.6	Direct Burial (DB) of Rigid Nonmetallic Conduit (RNC) .....	12
6.6.1	Conduit and Duct Laying.....	12
6.6.2	Temperature.....	12
6.6.3	Elbows or Bends for Grade Changes.....	12
6.6.4	Raceway Embedment and Final Backfill.....	12
6.6.5	Compaction .....	13
6.7	Expansion Fittings.....	13
6.8	Field Bending .....	14
6.9	Short-Radius Elbows.....	14
6.10	Conduit and Duct Repairs .....	14
6.10.1	Conductors and Cabling.....	14



6.10.2	PVC Raceway and RTRC (Cables de-energized and removed) .....	14
	.....	18
6.10.4	High Density Polyethylene (HDPE).....	18
6.11	Connections to Conduit Systems of Other Materials .....	18
6.12	Conduit Rodding (Fishing) .....	18
6.13	Mandrelling.....	18
ANNEX A	Field Bending Procedures For Pvc Conduit.....	21
A.1	Joining .....	21
A.2	Trench Preparation .....	22
A.3	Procedures for Installation of Conduits for Field Bends.....	22
ANNEX B	Joining of RTRC .....	25
B.1	General Recommended Joining Procedures .....	25
B.1.1	Cutting the Conduit .....	25
B.1.2	Cleaning Joint Surfaces .....	25
B.2	Specific Joining Types and Procedures.....	25
B.2.1	RTRC Adhesive Joints .....	25
B.2.2	RTRC Gasket Joints .....	25
B.2.3	RTRC inside Tapered Bell and Spigot Joint Installation (with or without Adhesive).....	26
B.2.4	RTRC Adhesive Straight Bell and Spigot Joint Installation.....	26
B.3	Joint Cleaning and Adhesive Instructions .....	27
B.3.1	Joint Cleaning.....	27
B.3.4	Adhesive Work Life .....	28
B.3.5	Adhesive Curing Time.....	29
B.4	RTRC Coupling Joints.....	29



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## 1 Scope

This guideline covers recommendations for the selection, handling and installation of underground single bore rigid nonmetallic conduit (RNC) or raceway for power, lighting, signaling, and communications applications. For this guideline, RNC refers to PE, PVC or RTRC conduit and duct. Corrugated coilable utility duct is not covered in this guideline; details on storage, handling, and installation are covered in NEMA TCB 3.

Guidelines for HDPE conduit are covered in NEMA TCB 4.

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

## 2 Nomenclature

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

EPEC	Electrical Polyethylene Conduit
HDPE	High-Density Polyethylene
PVC	Polyvinyl Chloride
RTRC	Reinforced Thermosetting Resin Conduit (fiberglass)

Abbreviations for burial type include:

DB	Direct burial—refers to duct buried without concrete encasement
EB	Encased burial—refers to duct buried with concrete encasement

Abbreviations for stiffness include:

DS	Duct stiffness
PS	Pipe stiffness

Abbreviations for conduit type include:

EPC 40	PVC conduit (Schedule 40)
EPC 80	PVC conduit (Schedule 80)
RNC	Rigid nonmetallic conduit

Abbreviations for wall type include:

HW	Heavy wall—refers to HW RTRC
TW	Thin wall—refers to TW RTRC
SW	Standard wall—refers to SW RTRC
XW	Extra heavy wall—refers to XW RTRC

## 3 Reference Publications

ASTM D2412 *Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*

ASTM D2564 *Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems*

ASTM D2657 *Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings*

ASTM D2855 *Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings*

*ASTM F402 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings*

*ASTM F656 Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings*

*ASTM F2160 Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)*

*NEMA FB 2.40 Selection and Installation Guidelines for Expansion, Expansion-Deflection and Deflection Fittings*

*NEMA TC 2 Electrical Polyvinyl Chloride (PVC) Conduit*

*NEMA TC 6 & 8 Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations*

*NEMA TC 7 Smooth-Wall Coilable Electrical Polyethylene Conduit*

*NEMA TC 14.BG, TC 14.AG, TC 14.XW Reinforced Thermosetting Resin Conduit (RTRC) and Fittings*

*NEMA TCB 4 Guidelines for the Selection and Installation of Smooth-Wall Coilable High-Density Polyethylene (HDPE) Conduit*

*NEMA PRP 1 Guidelines for Conduit-in-Casing Construction*

*NEMA PRP 2 Guidelines for Solvent-Cementing Joints for PVC Rigid Nonmetallic Conduit, Duct, and Fittings*

*NEMA PRP 3 Expansion Epoxy-Based Fittings for RTRC Rigid Nonmetallic Conduit*

*NEMA PRP 4 Expansion Fittings for PVC Rigid Nonmetallic Conduit*

## **4 Selection of Conduit and Duct**

### **4.1 Types of Raceway**

#### **4.1.1 Raceway Designed for Encased Burial (EB) in Concrete**

PVC encased burial (EB) duct meeting the requirements of NEMA TC 6 & 8, EPEC meeting NEMA TC 7, and RTRC EB, TW, SW, and HW manufactured to NEMA TC 14.BG are designed for use in underground concrete encasement in trenches or forms.

#### **4.1.2 Raceway Designed for Direct Burial (DB)**

PVC DB duct meeting NEMA TC 6 & 8, which has a heavier wall, is designed for underground DB in soils. Additionally, the following raceways may be used in DB applications:

- a. EPC 40 meeting NEMA TC 2;
- b. EPC 80 meeting NEMA TC 2;
- c. EPEC meeting NEMA TC 7;
- d. RTRC SW and HW.

DB PVC duct, RTRC, EPC 40, EPC 80 and EPEC is also permitted to 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 NEMA PRP 1).



## 4.2 Pipe Stiffness

Pipe stiffness (PS), also known as duct stiffness (DS), is a useful test value for evaluating the load bearing and deflection characteristics of the raceway. Pipe stiffness is dependent upon two factors: the modulus of elasticity of the raceway material, and the moment of inertia of the raceway (which is a function of the raceway diameter and wall thickness). In the design of each raceway system, consideration should be given to pipe stiffness requirements to withstand the specific application loadings.

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. Pipe stiffness values are determined at a specified inside diameter (ID) deflection of 5%. Values are expressed in pounds of force per inch of raceway length per inch of deflection (kPa).

$$PS = F/\Delta y$$

Where:

PS = pipe stiffness in lbs./inch/inch (kPa);

F = load in pounds (kg) per inch (mm) of raceway length that deflects the ID 5%;

$\Delta y$  = change in ID in inches (mm) due to the applied load F.

Minimum pipe stiffness requirements for EB PVC duct, DB PVC duct, SW RTRC, EPEC duct, and HW RTRC are specified in the applicable NEMA standards.

## 5 Handling and Storage of Conduit and Duct

### 5.1 Handling

Polymer raceways are shipped on reels or in self-supporting framed units designed for mechanical unloading. Avoid abusive handling and do not drop units shall from trucks or beds. Raceways 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 raceways in closed vans should be avoided, since excessive weight and elevated temperature may cause ovality on the bottom raceways. Care should be exercised in particular when handling thermoplastic raceways in temperatures below 32°F (0°C), and when handling RTRC in temperatures below -40°F (-40°C). Additional instructions from the conduit manufacturer shall be followed.



**Properly Handled Raceways on Flat Bed Truck**

## 5.2 Storage

Recommendations for storage of raceways below, in addition to those from the manufacturer, should be followed.

### 5.2.1 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 is on the wood frames rather than on the raceway. Standing height of stacked units should be limited to 12 ft. (3.6 m).



**Properly Stacked Rigid PVC Conduit**

### 5.2.2 Coils and Reels

The storage area should be of sufficient size to accommodate the raceway 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 raceway or components, or interfere with handling.



**Proper Storage of Coils and Reels**

### **5.2.3 Bulk Storage**

Loose raceways should be stacked in a parallel manner. To avoid excessive ovality on the bottom row, the stacking height should be limited to 4 ft. (1.2 m) for EB duct and 5 ft. (1.5 m) for DB duct. The bottom row of raceway should be laid on as level a surface as possible. Supports should not be placed under the raceway, as excessive deflection and sagging could result.

### **5.2.4 Elbows and Sweeps**

Elbows and sweeps may be stored outdoors on flat ground.

### **5.2.5 Fittings, Spacers, and Accessories**

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

### **5.2.6 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.

### **5.2.7 Inventories**

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

## **5.3 Handling on the Jobsite**

### **5.3.1 Conduit and Duct**

Avoid abusive handling at all times. Exercise care shall when handling thermoplastic raceways in temperatures below 32°F (0°C), and when handling RTRC in temperatures below -40°F (-40°C).

### **5.3.2 Coils and Reels**

Use of appropriate unloading and handling equipment of adequate capacity is required to unload the truck. Safe handling and operating procedures are required to be followed. Coils or reels are not to be rolled or pushed off the truck. During cold weather, care should be taken not to drop the raceway and to keep handling equipment and other objects from hitting the raceway.

### **5.3.3 Solvent Products**

The handling of solvent products shall be in accordance with ASTM F402 *Standard Recommended Practice for Safe Handling of Solvent Cements Used for Joining Thermoplastic Pipe and Fittings*, or according to the manufacturer's instructions.

## **6 Installation of Conduit and Duct**

### **6.1 Proper Installation**

A raceway system is considered to be properly installed if the inside diameter of each raceway is adequate to allow free passage of the deflection mandrel specified in Table 1.

To limit deflection, special attention should be paid to trench bedding, raceway separation, distance between supports, joining of raceways, type of backfill material, and amount of compaction.

### **6.2 Trench Excavation**

#### **6.2.1 Regulatory Considerations**

All federal, state, and local regulations shall 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 raceways;
- g. Safety.

#### **6.2.2 Routing**

Routing of the raceway should be coordinated with all utility companies who may have underground lines in the area of the proposed trenching layout.



**Routing of Raceway in Trench**



### **6.2.3 Trench Dimensions**

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 3-in. (76-mm) space on each side to adequately place and compact the backfill material. If shoring is required, additional trench width may be necessary.

### **6.2.4 Trench Wall**

Any unstable soil conditions encountered in the trench wall shall be stabilized before laying the raceway. The design engineer is responsible for providing methods to control such conditions. Well points or under drains may be required to control excessive groundwater conditions.

Where required by regulations or by soil conditions, the trench walls shall be adequately shored. Care should be taken that the raceway installation is not disturbed by removal of shoring materials.

### **6.2.5 Trench Bottom**

The trench bottom should be smooth and free of any debris that may be detrimental to the raceway or impede the positioning of spacers or supports. Where the trench bottom is rocky, a 4-in. (103-mm) layer of compactable bedding material is recommended. In DB applications, bedding should be uniformly graded to provide continuous support. Under no circumstances should blocking or mounding be used to raise the raceway to grade. An unstable trench bottom, where encountered, should be stabilized before laying raceway. 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 does not penetrate. The maximum aggregate size of the bedding material should be 1 in. (25 mm). To aid in placement around small diameter raceway and to prevent damage to the raceway wall, a smaller maximum aggregate size may be specified.

Care should be taken to prevent rocks, hard lumps, frozen clods, organic matter, and other foreign material from falling into the trench.

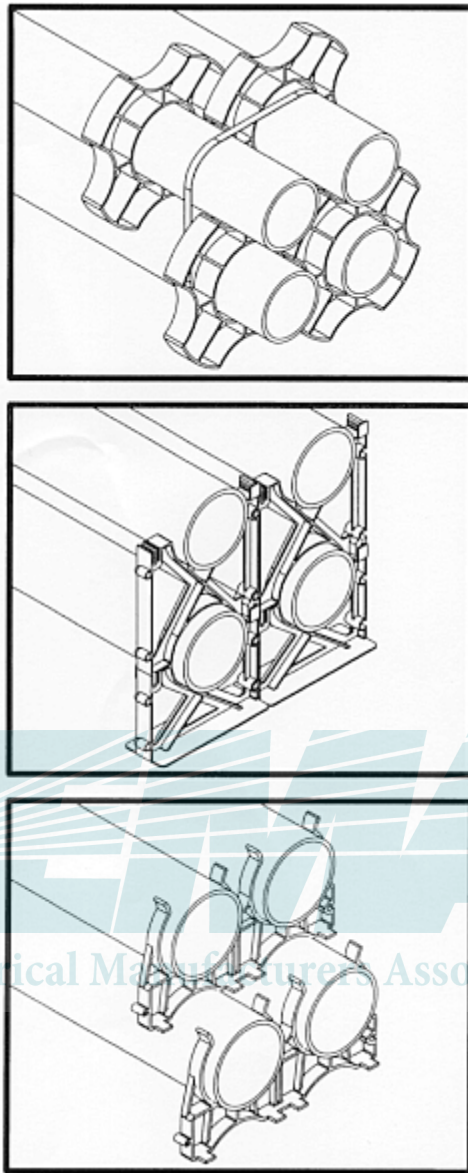
## **6.3 Conduit and Duct Separation**

### **6.3.1 Raceway Supports**

For EB, raceway separation can be achieved by use of spacers. There are many different configurations of commercially available spacers; see Figure 1 for examples.

For DB, supports need to meet the conditions specified by the design engineer.

Conduit and duct spacers are not designed for DB applications since the use of spacers in a DB application may result in backfill voids and excessive deflection points on the raceways.



**Figure 1**  
**Types of Spacers**

### **6.3.2 Power Duct Banks**

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

- a. To provide adequate dissipation of the normal build-up of heat from cables within the raceway;
- b. To provide void space to allow the encasement material to fully surround each raceway;
- c. To physically separate raceways in the event of a cable fault.

### 6.3.3 Communication Duct Banks

Since there is no appreciable build-up of heat or risk of a cable fault in communication duct banks, separation is intended only to allow the encasement material to fully surround each raceway.

### 6.3.4 Combined Power and Communication Duct Banks

Many design specifications require 3 in. (76 mm) or more of separation between power and communication raceways. Since spacer manufacturers generally do not manufacture spacers with a separation of greater than 3 in. (76 mm), the use of dummy spacers inserted between the power and communication raceways usually provide acceptable separation. Custom spacers for separations of greater than 3 in. (76 mm) may be available; consult NEMA-member spacer manufacturers.

### 6.3.5 Spacer Specifications

For power and communication raceways, duct bank designers should consider that stock spacers are available to provide separations of 1 in. (25 mm), 1½ in. (38 mm), 2 in. (51 mm) and 3 in. (76 mm). Custom spacers for other separations may be available; consult NEMA-member spacer manufacturers.

## 6.4 Joining of Raceway

See NEMA PRP 2 for the solvent cementing procedures for PVC raceways. See Annex B for joining procedures for RTRC.

The joining procedures for PE conduit should follow the recommendations for HDPE conduit as described in NEMA TCB 4.

## 6.5 Encased Burial (EB) of Rigid Nonmetallic Conduit (RNC)



Example of Concrete Encasement

### **6.5.1 Conduit and Duct Laying**

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

### **6.5.2 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. Bricks or wood should not be used because these materials may deform the conduit wall. The bottom spacer is to 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 conduit spacers available for assembling duct banks. These products maintain the desired separation between raceways and provide the required support during assembly and concrete encasement.

The placement of these spacers varies in accordance with the raceway material and installation specification. Typically, spacers are placed 5 ft. (1.5 m) to 8 ft. (2.4 m) apart.

### **6.5.3 Sequence of Laying**

Starting at the manhole location, the first lengths of raceway are joined to the manhole terminators, end bells, or radius bell ends. When all raceways in the bottom tier are terminated to the manhole, the second tier of raceways should be terminated in the same manner. This procedure is followed until the top tier of the duct bank has been terminated. See the spacer manufacturer's recommendations to prevent duct bank flotation.

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

### **6.5.4 Closure of a Run between Manholes**

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

### **6.5.5 Temperature**

All raceway and fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.

Raceways, when not restrained, expand or contract the following approximate distances per 100 ft. (30.5 m) for every temperature change of 10°F (5.6°C) for the following materials:

- a. PVC: 3/8 in. (9.5 mm);
- b. RTRC: 1/8 in. (3.2 mm).

To minimize length adjustment at the manholes, backfilling should always proceed from one manhole or vault toward the other end of the raceway 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.

### 6.5.6 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 raceway. 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.

### 6.5.7 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 specified by the engineer.

Note: Typically, slump is specified to be 7 in. (177.8 mm) to 9 in. (228.6 mm) to assure proper distribution of the concrete around the raceways. Higher slumps, or more fluid concrete, may create adverse flotation or buoyancy forces.

The recognized maximum aggregate size should be one-half or less of the minimum clear space between the raceways. Care should be taken to limit the fall of the concrete to a minimum height from the chute to the top tier of raceways to minimize flotation effects.

### 6.5.8 Backfilling



**Backfilling of Trench**

The trench can be backfilled after the concrete has set. The first 12 in. (304.8 mm) of fill should be free of large stones, broken pavement, etc., that might damage the raceway structure. The backfill should be thoroughly tamped using lightweight equipment, such as pneumatic or vibrating tampers.

On warm, sunny days where the raceway structure has been encased, if the first 12 in. (304.8 mm) of backfill cannot be placed and tamped immediately following the concrete work, 1 in. (25.4 mm) or 2 in. (50.8 mm) 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.

## **6.6 Direct Burial (DB) of Rigid Nonmetallic Conduit (RNC)**

### **6.6.1 Conduit and Duct Laying**

Raceways should be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power raceways, to provide for heat dissipation. A separation, both vertically and horizontally, between raceways is needed to provide room for heat dissipation and good compaction of backfill. If the spacing between raceways is less than 1-1/2 in. (38 mm), it is difficult to achieve the compaction necessary for proper raceway 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 (DB), supports need to meet the conditions specified by the design engineer.

Conduit and duct spacers are not designed for **direct burial (DB)** applications. The use of spacers in a **direct burial** application may result in backfill voids and excessive deflection points on the raceways.

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

To maintain clearance between conduits, joints for adjacent conduits should be offset about 6 in. (152.4 mm) both horizontally and vertically.

### **6.6.2 Temperature**

All raceways and fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.

### **6.6.3 Elbows or Bends for Grade Changes**

When short-radius bends or abrupt grade changes are encountered, thermoplastic raceways are often encased in concrete to protect against possible winch line cutting, however, metal elbows or bends or RTRC elbows can also be used with the thermoplastic raceways for this purpose. Consult the local authority having jurisdiction to verify that this installation practice is permitted.

### **6.6.4 Raceway Embedment and Final Backfill**

The embedment zone of a raceway trench is that portion of the trench from approximately 4 in. (101.6 mm) below the bottom of the first row of raceways to approximately 6 in. (152.4 mm) above the top of the final row of raceways.

The external loading capacity of the raceways 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 used, provided the mix is compactable and stable. Soils not recommended in the embedment zone are highly organic materials and highly plastic clays. The maximum aggregate size in the embedment zone should be limited to one inch (25.4 mm) in diameter.

The final backfill zone of the raceway 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 raceway performance but can be important for providing a proper foundation for a road or other structure that may be constructed over the raceway trench.

Selection of the final backfill materials is not critical for the raceway; all types of soils are acceptable provided they do not contain particles that can damage the raceway. When raceway installations have structures built over them, the final backfill material should be similar to the material in the embedment zone.

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

### **6.6.5 Compaction**

Proper compaction of the embedment zone is important for limiting the deflection of the raceways. After compaction, the soil should completely encase each raceway, providing support around the diameter and along the length of each raceway. 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 raceway 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 is to be exercised to prevent damage to the raceways. Hand-held unpowered compaction equipment should be used when there is little soil covering the conduits. This can include shovels, two-by-fours, and other hand-held devices. When using small mechanical compactors, the raceways should be covered by at least 6 in. (152 mm) of soil. For larger mechanical compaction equipment, 30 in. (762 mm) 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 flow when wetted, such as sand. In such soils, water compaction can achieve desired soil densities without risk of damage to the raceways. However, the duct bank should be restrained from flotation if water compaction is used.

Compaction is best done in layers or "lifts" of soil of between 6 in. (152 mm) and 12 in. (305 mm) in thickness. A lift of backfill is placed, and then compacted before the next lift is placed. Each row of raceway is embedded in a lift before the next row is placed. It may be possible to use greater thicknesses of lifts when water compacting.

### **6.7 Expansion Fittings**

Expansion fittings are used in applications where temperature fluctuations in the raceway system require compensation. Examples are tunnels, bridge crossings, and other exposed applications. Encased or buried raceways do not require expansion fittings. For additional information, see NEMA PRP 4 *Expansion Fittings for PVC Rigid Nonmetallic Conduit*, NEMA PRP-3 *Expansion Epoxy-Based Fittings for RTRC Rigid Nonmetallic Conduit*, and NEMA FB 2.40 *Selection and Installation Guidelines for Expansion, Expansion-Deflection, and Deflection Fittings*.

## **6.8 Field Bending**

The natural flexibility of most RNC makes field bending, to form curves and to avoid obstacles, a relatively simple operation. As with all installation practices, there are some techniques that make field bending easier and faster and produce a better raceway run. See Appendix A for field bending instructions for PVC raceway and RTRC. Consult the manufacturer for field bending instructions for EPEC.

## **6.9 Short-Radius Elbows**

For the purpose of this guideline, a short-radius elbow is an elbow having a radius of 5 ft. (1.52 m) or less.

Pulling tension and raceway sidewall pressure need to be considered when selecting short-radius elbows. It is recommended that short-radius thermoplastic elbows be encased in concrete or replaced with metal or RTRC elbows. All concrete-encased elbows should be independently supported to maintain the designed separation between adjacent conduits, both horizontally and vertically.

Unless otherwise specified, it is recommended that the elbow radius used in a raceway installation be a minimum of twelve times the diameter of the largest cable to be installed. The cable manufacturer's recommendations should be followed.

## **6.10 Conduit and Duct Repairs**

Remove a sufficient amount of the concrete and/or backfill material to completely expose all of the damaged raceways and to provide adequate working space in the trench. The damaged raceways should be exposed back to a point at least 1 ft. (0.3 m) on both sides of the damaged area.

There are a number of methods for repairing damaged raceways. One method, shown is Clause 6.10.2, requires the de-energizing and removal of cables and conductors prior to repair. Another method shown below in Clause 6.10.3, using split duct, does not require the removal of cables and conductors.

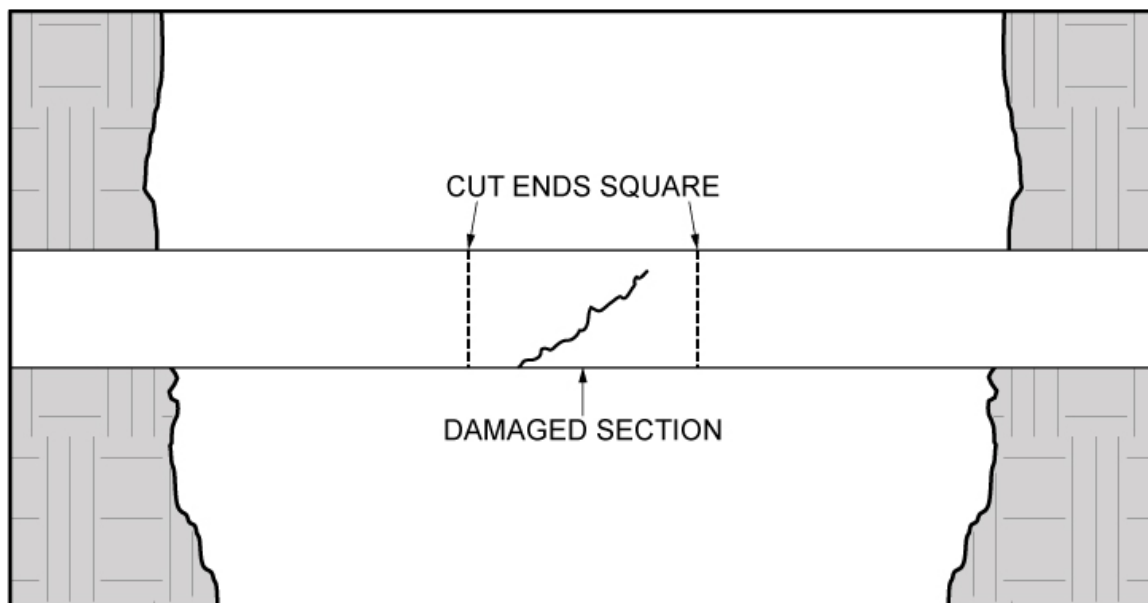
### **6.10.1 Conductors and Cabling**

Conductors and cabling should be de-energized and removed from the raceway prior to any repair operations.

### **6.10.2 PVC Raceway and RTRC (Cables de-energized and removed)**

Cut out the damaged portions of the raceways. The cut should be made as square as possible, as shown in Figure 2.





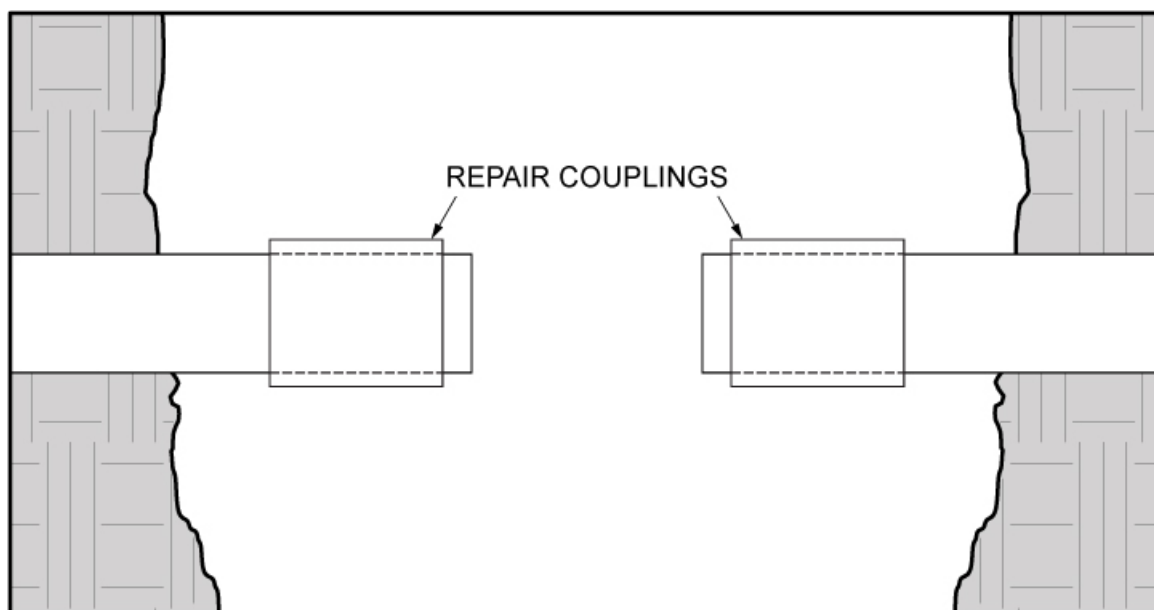
**Figure 2**  
**Cutting Damaged Portion of Raceway**

Deburr and chamfer the edges of the remaining raceway.

Cut the replacement section from a piece of raceway with the same outside diameter and wall thickness. The replacement section should be cut approximately 1/8 in. (3.2 mm) shorter than the gap in the remaining raceway. Deburr and chamfer the edges of the replacement section.

Thoroughly clean the exposed ends of the remaining raceway and both ends of the replacement section.

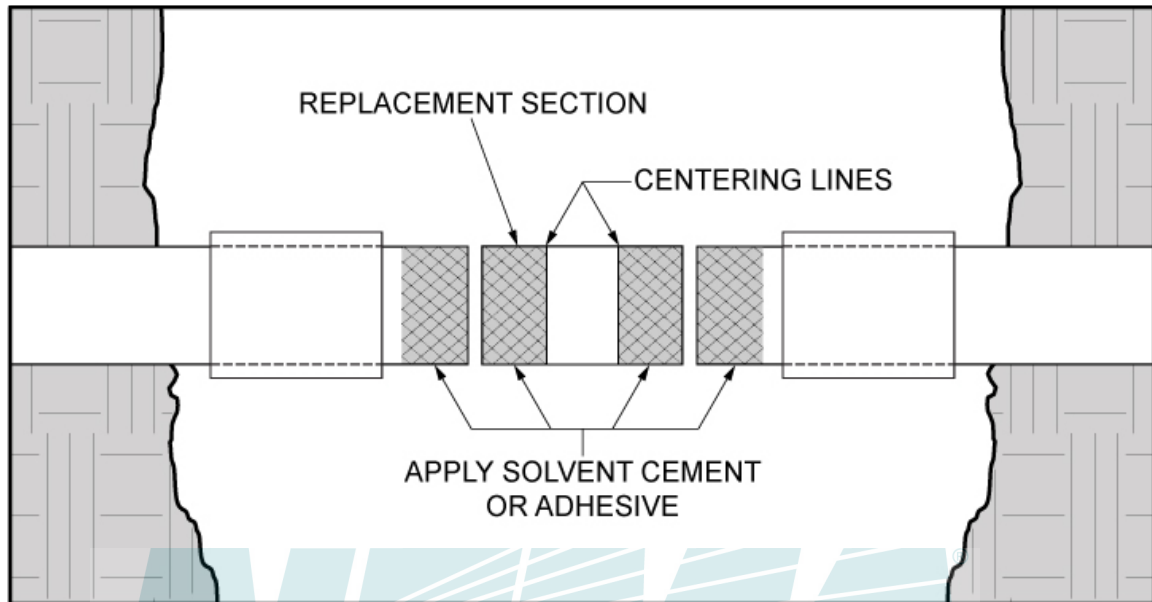
Slide the repair (sleeve type) fittings over the ends of the remaining raceway as shown in Figure 3.



**Figure 3**  
**Repair Couplings Slid Over Remaining Raceway**

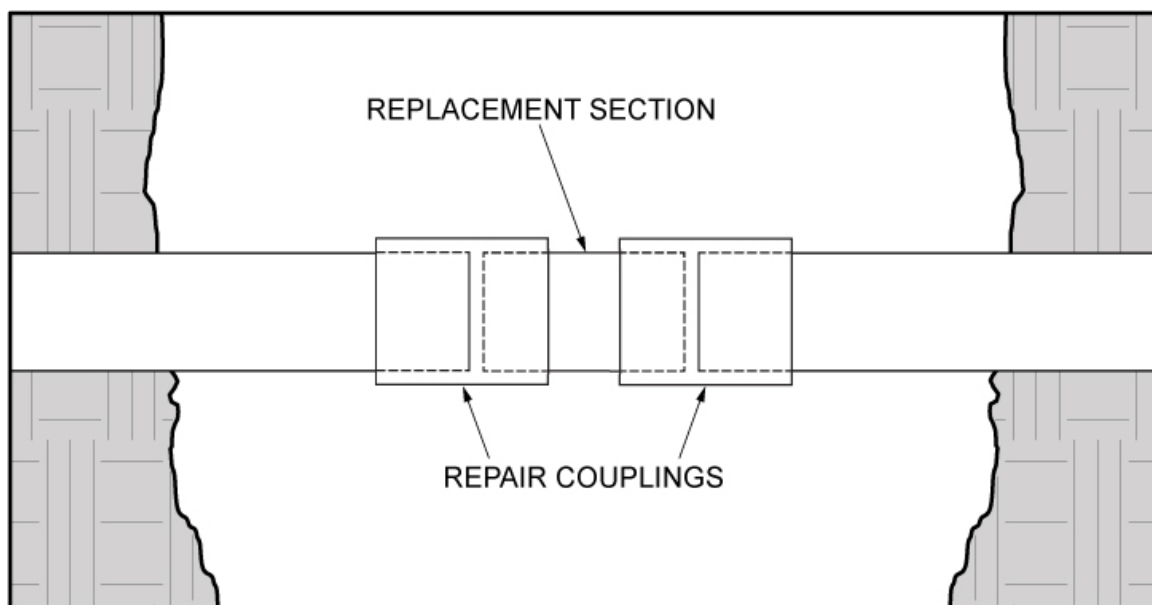
Mark lines around the ends of the replacement section, half the length of the repair fitting away from the ends, in order to center the repair fittings as shown in Figure 4.

Apply solvent cement (for PVC) or adhesive (for RTRC) on both ends of the replacement section and on the exposed ends of the remaining raceway as shown in Figure 4.



**Figure 4**  
**Solvent Cement or Adhesive Applied to Replacement Section and Remaining Raceway**

Place the repair section into the raceway line and center the repair fittings over the joints to the lines marked on the replacement section as shown in Figure 5. Rotate the fitting approximately one-quarter turn to distribute the cement or adhesive.



**Figure 5**  
**Completed Raceway Repair**

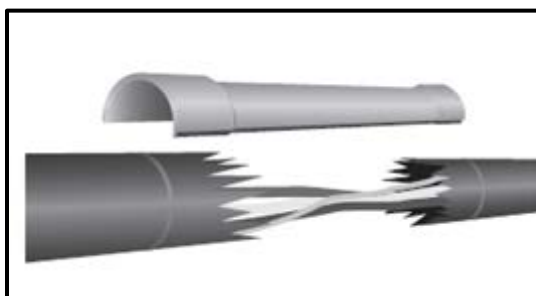
If more than one raceway line is damaged at the same location, repair them one at a time starting at the bottom of the raceway structure and working to the top, replacing spacers if necessary as work progresses.

After completing the raceway repair, replace the concrete and/or backfill material.

### 6.10.3 PVC Raceway and RTRC (Conductors and Cables de-energized and not removed)

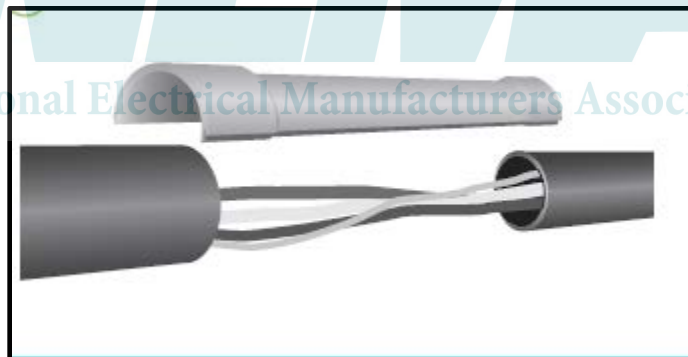
All conductors and cables shall be de-energized before repairing the conduit.

Place one half of the split-duct centered over the broken conduit section. Mark the damaged area to be cut.



**Figure 6**  
**Mark the Pipe**

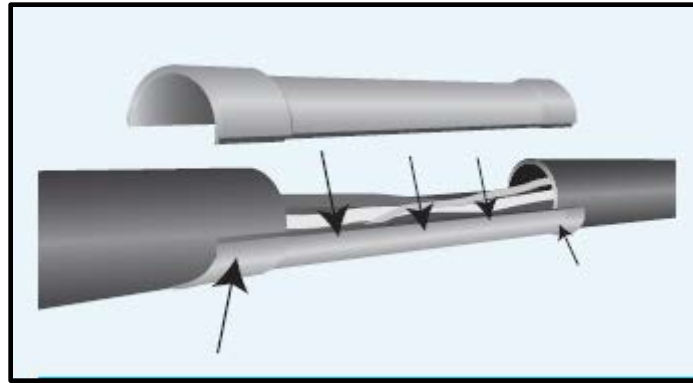
Cut marked pipe and remove damaged pipe. Clean and smooth the ends. Do not cut into electrical conductors and cabling when removing damaged pipe, death or serious injury may occur.



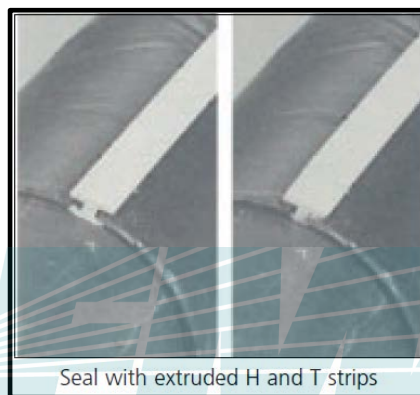
**Figure 7**  
**Cut on Marks**

Test fit the split-duct before applying solvent cement or adhesive. Make any adjustments to damaged pipe and test fit split-duct until you have a proper fit.

Take one half of the split-duct, clean, adhere and hold until secure. Adhere rigid PVC raceway using solvent cement. Adhere RTRC using T or H strips and adhesive.



**Figure 8**  
**Join Two-Half Sections**



**Figure 9**  
**Seal with Extruded H and T Strips**

#### **6.10.4 High Density Polyethylene (HDPE)**

Methods of repairing HDPE conduit include the use of couplings and/or a splice. A splice consists of an oversized piece of conduit placed over the repair area and sealed using heat or cold-shrink tubing.

#### **6.11 Connections to Conduit Systems of Other Materials**

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

#### **6.12 Conduit Rodding (Fishing)**

One of the many advantages of RNC 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 conduit. Rodding machines or duct rods can also be used to manually insert pulling lines through the conduit should pneumatic equipment not be available. Typical pneumatic rodding takes between 15 psi (103.4 kPa) and 50 psi (344.7 kPa). Consult manufacturer for recommended pressures.

#### **6.13 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 conduit so that some deflection of the conduit is allowable (and completely normal). The mandrels are pulled through the conduits 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 conduit, there are a few possible reasons. First, the conduit may have deflected beyond what the mandrel allows. Second, the mandrel may have been caught in a fitting, perhaps due to a tight radius. Third, debris may be blocking the path of the mandrel. Always determine the cause of any mandrel blockage.

It is recommended that the mandrels be shaped such that the maximum mandrel OD occurs over a very short distance (less than 1 inch [25.4 mm]) so that the mandrel can travel through sweeps without bridging. Ball-shaped mandrels are therefore commonly used, but there are many configurations possible.

Table 1 shows suggested mandrel ODs for various conduit and ducts and are being provided for information purposes only; users should consult with the mandrel manufacturer for specific guidance. Mandrels are not generally used for ducts less than 2 in. (50.8 mm) nominal diameter.



**Table 1**  
**Suggested Mandrel ODs for Various Conduits and Ducts**

Conduit Type	Conduit Size		Mandrel OD	
	inches	mm	inches	mm
<b>NEMA TC 2 Schedule 40 Conduit and NEMA TC 6 &amp; 8 Conduit</b>	2	53	1.71	43.5
	2-1/2	63	2.05	52.0
	3	78	2.55	64.7
	3-1/2	91	2.92	74.2
	4	103	3.35	85.2
	5	129	4.21	107.0
	6	155	5.07	128.8
	8	205	6.68	169.7
<b>NEMA TC 14.AG/TC 14.BG IPS Conduit Dimensions</b>	2	53	1.88	47.8
	2-1/2	63	2.33	59.2
	3	78	2.84	72.1
	4	103	3.67	93.2
	5	129	4.56	115.8
	6	155	5.42	137.7
	8	205	7.12	180.8
<b>NEMA TC 14.AG/TC 14.BG ID Conduit Dimensions</b>	2	53	1.68	42.7
	2-1/2	63	2.11	53.6
	3	78	2.53	64.3
	3-1/2	91	2.96	75.2
	4	103	3.38	85.9
	4-1/2	116	3.81	96.8
	5	129	4.22	107.2
	6	155	5.07	128.8

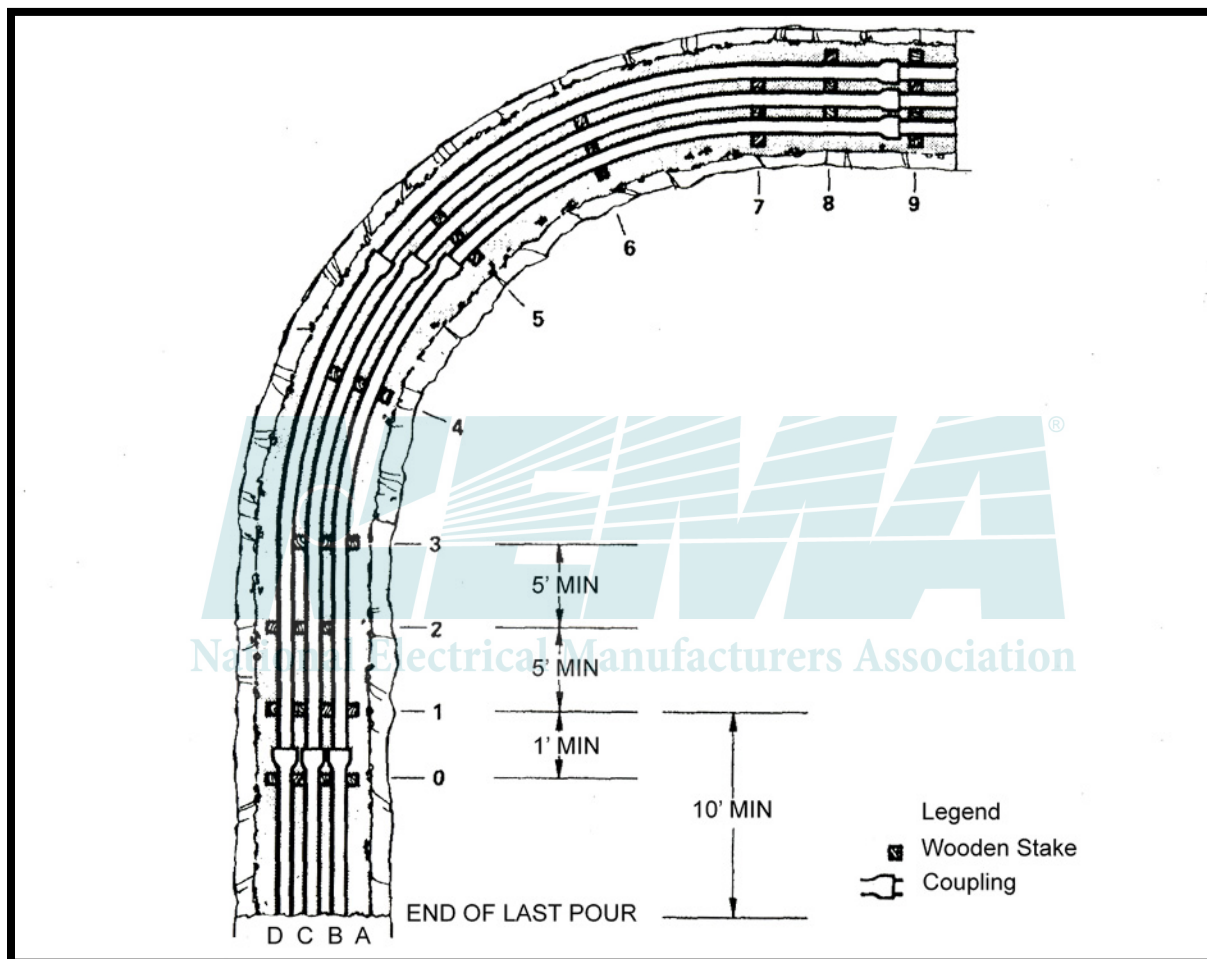


## Annex A

### Field Bending Procedures for PVC Conduit

These procedures are applicable to radius bends from approximately 35 ft. (10.7 m) to 150 ft. (45.7 m). Bends tighter than a 35-foot (10.7-m) radius can be accomplished by using factory elbows.

The example that follows (Figure A-1) is based on installations up to four ducts high by four ducts wide using 4-in. (103-mm) Type EB duct with a duct stiffness ( $F/\Delta y$ ) of approximately 35 lbs./inch/inch (246.4 kPa).

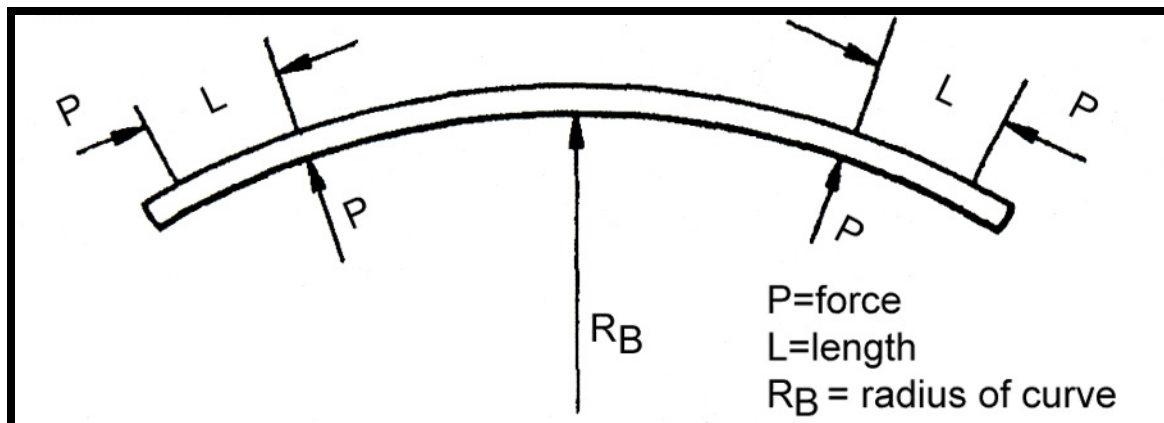


**Figure A-1**  
**Radius Bend Example**

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

#### A.1 Joining

The joining procedure detailed in the section "Joining of Conduits" should be followed.



**Figure A-2**  
**Forces on Bent Duct**

Figure A-2 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 needs to 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 (21°C). Shorter times may be adequate in hot weather and longer times may be required in cold weather.

For bends where the running length of conduit required, including tangents is 150 ft. (45.7 m) or less, the bending operation is simplified if the entire length is pre-assembled and allowed to cure the requisite time. This applies particularly in installations where the radius of curvature is less than 80 ft. (24.4 m).

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.

## **A.2 Trench Preparation**

Trenches should be constructed to provide proper clearance between the trench bottom, trench walls and conduits. The method of obtaining side wall clearance varies depending upon the method of installation chosen, however, a minimum of 3 in. (76.2 mm) should be maintained.

## **A.3 Procedures for Installation of Conduits 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 in. (25.4 mm) minimum bearing surface on the conduits and have an effective thickness of 1 in. (25.4 mm) minimum to provide adequate space between conduits. Wooden stakes may be 2" x 2" construction lumber.

Figure A-1 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 conduits.

Vertical conduit tiers are indicated as the combination of the two spacers on either side thereof, e.g., A-B, B-C, etc. Using Figure A-1 as a reference, the steps in temporarily staking field bends are:

- a. If the last coupling of the last conduit 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.
- b. Stakes should be driven at positions B-1, and A-3 through A-7 prior to joining the length of conduit A-B that starts the bend. All the A position stakes may be braced to the trench wall if conditions require.
- c. Conduit 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 conduits, 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 cross-brace may be used to brace the top of the stake to the outside trench wall.
- d. 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 conduits C-B may then be joined and formed from the bottom up as was the B-A tier. If a temporary cross-brace was required for stake B-9, it may be removed, shortened and applied to C-9.
- e. 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 conduits 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, and 8-B, 8-C, 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 driven until commercial spacers are inserted adjacent to each stake location and firmly held in proper position using re-bars. The temporary stakes are then 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 conduit due to the loads imposed at the points of restraint. Conduits 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  $\frac{1}{4}$ " (6.35 mm). 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 need the minimum radius of curvature.

Such difficulties, if they occur, can 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.

- a. A stake should be driven at position A-1.
- b. Spacers (a number equal to the number of conduits high) are placed against the inside trench wall at positions 3, 4, 5, 6, and 7.
- c. Lower conduit of vertical tier A-B is joined and formed to the bend, and restrained with temporary stakes and spacers at positions A-9 and B-9.
- d. The remaining ducts in vertical tiers A-B are then positioned.
- e. Spacers are then placed at positions 1, 2, 8, and 9 to complete the restraints on the inside trench wall.

- f. Spacers are then connected at all stations, thus completely enclosing the ducts in vertical tiers A-B.
- g. Stakes are then driven at positions C-0 or C-1 and at C-9 and the tier C-B is placed on the same fashion, and spacers placed on the outside thereof at the same stations as in the case of the tier A-B.
- h. 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 conduits 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' (1.5 m) 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 conduits 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 conduits 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 conduits, or whenever their need becomes apparent. Normally bracing of this type is not required at stations 4 through 6, as the forces at these locations are significantly less.

  
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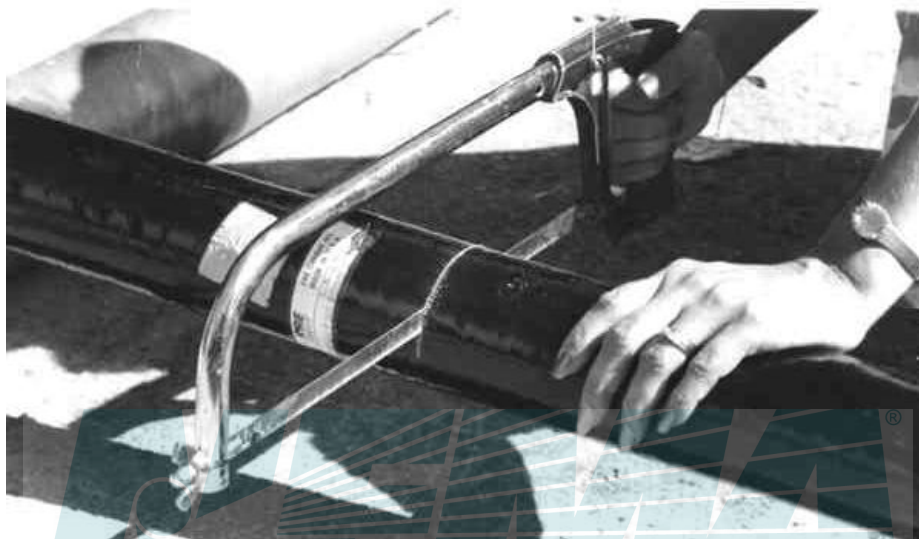
## **Annex B**

### **Joining of RTRC**

#### **B.1 General Recommended Joining Procedures**

##### **B.1.1 Cutting the Conduit**

Cutting is easily accomplished with a circular saw using a reinforced abrasive blade, sabre saw with a fine-toothed metal cutting or tungsten carbide blade, or a hacksaw (32 teeth per inch blade).



##### **B.1.2 Cleaning Joint Surfaces**

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

#### **B.2 Specific Joining Types and Procedures**

##### **B.2.1 RTRC Adhesive Joints**

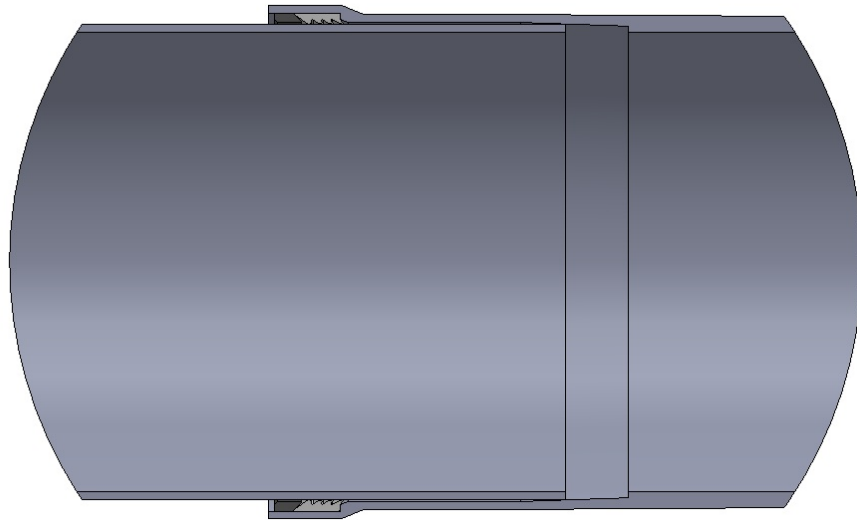
When using an adhesive type joint, the manufacturer's instructions should be followed.

Most adhesives for RTRC fiberglass conduit consist of two parts: resin and hardener. The two materials need to be mixed before they can be used. The two components harden once mixed (set up). The unused portion of the mixture is harmless after hardening.

##### **B.2.2 RTRC Gasket Joints**

There are a variety of gasketed joints available that utilize elastomeric seals to provide mechanically strong watertight connections (see Figure B-1 for an example). Because of the variety of gasketed joint designs available, refer to manufacturer for specific assembly instructions.

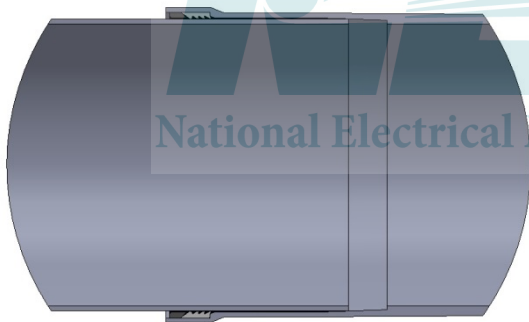




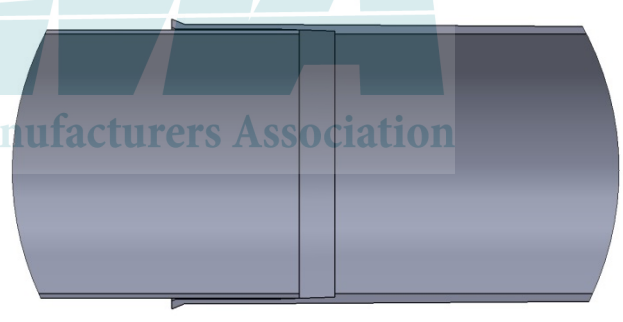
**Figure B-1**  
**RTRC Gasketed Inside Tapered Bell and Spigot Joint**

### **B.2.3 RTRC inside Tapered Bell and Spigot Joint Installation (with or without Adhesive)**

Installation is fast and easy with a mechanical joining system featuring tapered bell and spigot ends, See Figures B-2 and B-3.



**Figure B-2**  
**RTRC Adhesive Inside Tapered Gasketed Bell and Spigot Joint**



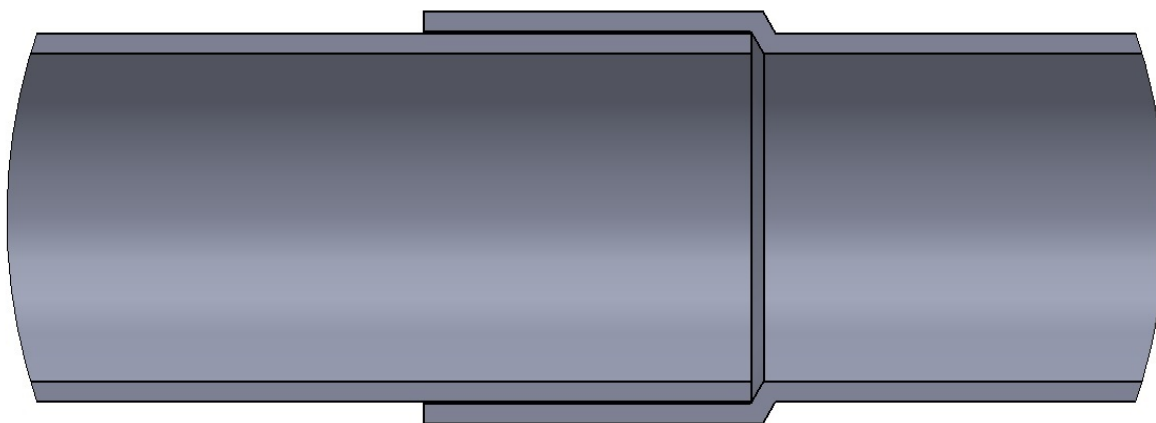
**Figure B-3**  
**RTRC Adhesive Inside Tapered Bell and Spigot Joint**

The user can opt to make this system a permanent water tight joint with the application of epoxy adhesive during assembly.

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, apply a thin layer of adhesive to the spigot end. Excess adhesive applied can result in restrictions in the conduit I.D. Align the male and female threads and screw the conduit together.

### **B.2.4 RTRC Adhesive Straight Bell and Spigot Joint Installation**

See Figure B-4. After the conduit is cut to the desired length, remove the resin gloss 4 in. back from the cut edge or to the manufacturer's specific socket length if different.



**Figure B-4**  
**RTRC Adhesive Straight Bell and Spigot Joint**

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

### **B.3 Joint Cleaning and Adhesive Instructions**

#### **B.3.1 Joint Cleaning**

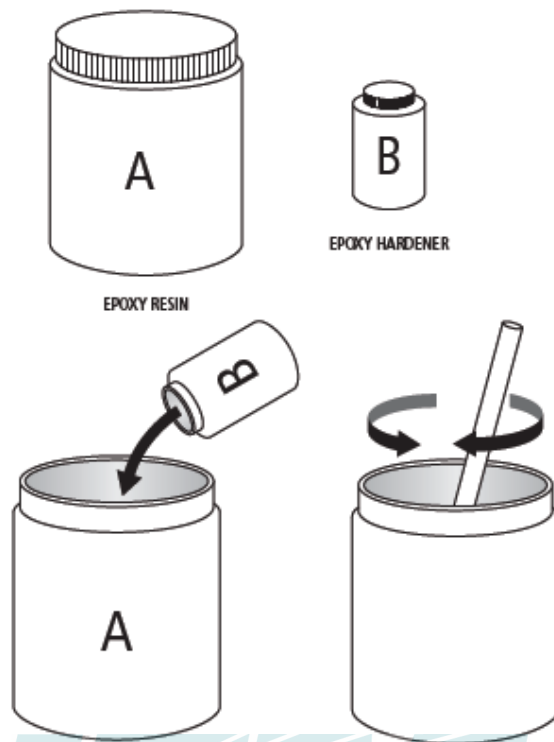
Use sufficient joint cleaner and clean paper towels, which are provided in the adhesive kit. If additional cleaner is needed, consult the conduit manufacturer for recommended solvents.

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

#### **B.3.2 Adhesive Mixing**

See Figure B-5. Thoroughly mix the adhesive. Complete information is packaged with each adhesive kit.

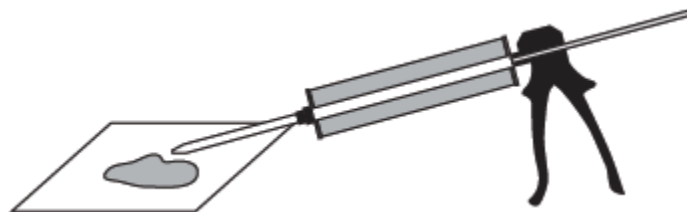
- a. When the weather is cool or the adhesive has been stored in a cool environment, pre-warm the adhesive kits following the adhesive manufacturer's specifications.
- b. Empty the hardener into the base adhesive.
- c. Mix the entire adhesive with all of the hardener. NEVER ATTEMPT TO SPLIT A KIT. Do 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.
- d. Mix until the adhesive has a consistent texture and/or color.



**Figure B-5**  
**Adhesive Kit**

### **B.3.3 Adhesive with Dual Cartridge**

- a. Install the adhesive dual cartridge in the applicator and then insert the static mixer fully.
- b. Squeeze the handle until adhesive comes out. Deposit adhesive on cardboard (see Figure B-6) or, if space permits, apply it directly to the spigot end. Please note that the mix inside the static mixer may harden due to the specific adhesive used and/or the ambient temperature. Please consult the conduit manufacturer.



**Figure B-6**  
**ADHESIVE DUAL CARTRIDGE**

### **B.3.4 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 (21.1° C) and becomes longer as the temperature drops below 70°F (21.1° C). Working life is affected by the quantity of adhesive as well as temperature.

The pot life of adhesives can be increased 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

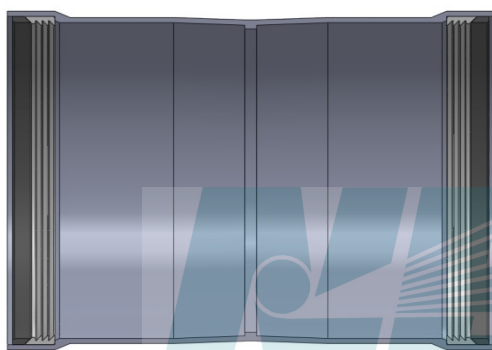
adhesive kit is furnished. Line the inside with rags or paper towels and wet the rags or towels with joint cleaner. Nest the can in the prepared carton. Do NOT contaminate the adhesive with water or joint cleaner.

### **B.3.5 Adhesive Curing Time**

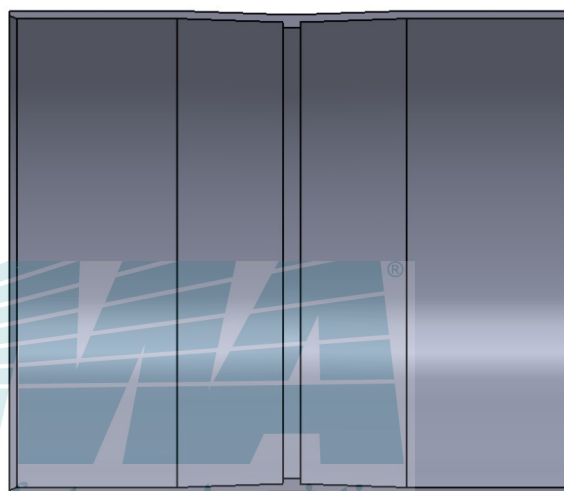
Cure time is the time required for the adhesive in the assembled joint to harden. Cure time is dependent on the ambient temperature. Epoxy adhesives are well known to provide mechanically stronger and quicker joints when heat cured.

### **B.4 RTRC Coupling Joints**

Couplings are available in different styles, such as a double bell coupling with or without gaskets. See examples in Figures B-7 and B-8.



**Figure B-7**  
**RTRC Double Bell Coupling With**  
**Gasket**



**Figure B-8**  
**RTRC Double Bell Coupling Without Gasket**

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