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FOREWORD

This guideline is intended to provide assistance as a guide to obtain the most appropriate and satisfactory installation of rigid nonmetallic conduit (RNC) or raceway systems.

This guideline 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.

NEMA Polymer Raceway Products Section

Anamet Electrical, Inc. Mattoon, IL
AFC Cable Systems, a part of Atkore International New Bedford, MA
Allied Tube and Conduit, a part of Atkore International Harvey, IL
Champion Fiberglass, Inc. Spring, TX
FRE Composites St. André-d'Argenteuil, PQ, Canada
Hubbell Incorporated Shelton, CT
IPEX Electrical Inc. Mississauga, ON, Canada
Legrand North America West Hartford, CT
Panduit Corporation Tinley Park, IL
Royal Pipe Systems Shelby Township, MI
Southern Pipe, Inc. New London, NC
Thomas & Betts Corporation Memphis, TN
Underground Devices, Inc. Northbrook, IL
United Fiberglass of America Springfield, OH

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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 the purposes of this guideline, Rigid nonmetallic conduit (RNC) or raceway refers to HDPE, 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.

Although not specifically mentioned in this guideline, 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 guideline include the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>RTRC</td>
<td>Reinforced Thermosetting Resin Conduit (fiberglass)</td>
</tr>
</tbody>
</table>

Abbreviations for burial type include:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB</td>
<td>Direct burial – refers to duct buried without concrete encasement</td>
</tr>
<tr>
<td>EB</td>
<td>Encased burial – refers to duct buried with concrete encasement</td>
</tr>
</tbody>
</table>

Abbreviations for stiffness include:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>DS</td>
<td>Duct stiffness</td>
</tr>
<tr>
<td>PS</td>
<td>Pipe stiffness</td>
</tr>
</tbody>
</table>

Abbreviations for conduit type include:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPC 40</td>
<td>PVC conduit (Schedule 40)</td>
</tr>
<tr>
<td>EPC 80</td>
<td>Extra heavy wall PVC conduit (Schedule 80)</td>
</tr>
<tr>
<td>EPEC</td>
<td>Smooth wall coilable high density polyethylene conduit</td>
</tr>
<tr>
<td>RNC</td>
<td>Rigid nonmetallic conduit</td>
</tr>
</tbody>
</table>

Abbreviations for wall type include:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW</td>
<td>Heavy wall – refers to HW RTRC</td>
</tr>
<tr>
<td>SW</td>
<td>Standard wall – refers to SW RTRC</td>
</tr>
<tr>
<td>XW</td>
<td>Extra heavy wall – refers to XW RTRC</td>
</tr>
</tbody>
</table>

STANDARDS AND GUIDELINES REFERENCES

ASTM D 2412 Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading


ASTM D 2657 Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings

ASTM D 2855 Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM F 402 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and 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 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
Selection of Conduit and Duct

TYPES OF RACEWAY

Raceway Designed for Encased Burial (EB) in Concrete

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

Raceway Designed for Direct Burial (DB)

PVC DB duct meeting NEMA TC6 & 8, which has a heavier wall, is designed for underground direct burial in soils. Additionally, the following raceways may be used in direct burial applications:

- Smooth-wall coilable HDPE conduit meeting NEMA TC 7;
- EPC-40 meeting NEMA TC 2;
- EPC-80 meeting NEMA TC 2;
- EPEC meeting NEMA TC 7;
- RTRC SW and HW.

DB PVC duct, RTRC, EPC-40, EPC-80 and EPEC 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 B).

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 D 2412 is the generally accepted test method for determining pipe stiffness. Appendix X1 of D 2412 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).

$$PS = \frac{F}{\Delta y}$$

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, and HW RTRC are specified in the applicable NEMA standards.
Handling and Storage of Conduit and Duct

HANDLING

Generally, raceways are shipped on reels or in self-supporting framed units designed for mechanical unloading. Abusive handling should be avoided. Units should not be dropped from truck 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 when handling thermoplastic raceways in temperatures below 32°F (0°C), and when handling RTRC in temperatures below -40°F (-40°C).

STORAGE

Recommendations for storage of raceways are given below. Additional recommendations from the manufacturer should also be followed.

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 feet (3.6 m).
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.

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 four feet (1.2 m) for EB duct and five feet (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.
Elbows and Sweeps

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

Fittings, Spacers, and Accessories

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

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.

Handling on the Jobsite

Conduit and Duct

Abusive handling should be avoided at all times. Care should be exercised when handling thermoplastic raceways in temperatures below 32°F (0°C), and when handling RTRC in temperatures below -40°F (-40°C).

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.

Solvent Products

The handling of solvent products should be in accordance with ASTM F 402 Standard Recommended Practice for Safe Handling of Solvent Cements Used for Joining Thermoplastic Pipe and Fittings.

Inventories

It is recommended that inventories be rotated first in, first out to minimize possible product deterioration from excessive storage time.
Installation of Conduit and Duct

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 specified deflection mandrel.

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.

TRENCH EXCAVATION

All federal, state, and local regulations should be followed, including those pertaining to:

- Rights of way;
- Permits;
- Combined trenches;
- Excavation of open trenches;
- Shoring;
- Minimum cover over raceways;
- Safety.

Routing of the raceway should be coordinated with all utility companies who may have underground lines in the area of the proposed trenching layout.
The trench dimensions are determined as follows:

- The depth is determined by the height of the duct bank, plus the minimum required cover over the bank;
- The width of the trench is determined by the width of the duct bank to be installed plus a minimum three-inch (76-mm) space on each side to adequately place and compact the backfill material. If shoring is required, additional trench width may be necessary.

**Trench Wall**

Where unstable soil conditions are encountered in the trench wall, these conditions should 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 should be adequately shored. Care should be taken that the raceway installation is not disturbed by removal of shoring materials.

**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 four-inch (103-mm) layer of compactable bedding material is recommended. In direct burial applications, bedding is to 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, is to 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. Maximum particle size of the bedding material should be 1 inch (25 mm). To aid in placement around small diameter raceway and to prevent damage to the raceway wall, a smaller maximum 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.

**CONDUIT AND DUCT SEPARATION**

**Raceway Supports**

For encased burial (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 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.
Power Duct Banks

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

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

Combined Power and Communication Duct Banks

Many specifications require three inches (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 three inches (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 three inches (76 mm) may be available; consult NEMA member spacer manufacturers.

Considerations for Specifiers

Duct bank designers should specify raceway separations around commercially available spacers. Frequently the duct bank designer specifies center-to-center dimensions between raceways, leaving the contractor with the responsibility to calculate the clear dimensions. For power and communication raceways, specifiers should keep in mind that stock spacers are available to provide separations of 1 inch (25 mm), 1 1/2 inches (38 mm), 2 inches (51 mm), and 3 inches (76 mm). Custom spacers for other separations may be available; consult NEMA-member spacer manufacturers.

JOINING OF RACEWAY

See Appendix C for the solvent cementing procedures for PVC raceways. See Appendix D for joining procedures for RTRC. See Appendix E for joining procedures for HDPE raceway.
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.

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 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 feet (1.5 m) to 8 feet (2.4 m) apart.

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.
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 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.

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 feet (30.5 m) for every temperature change of 10° F (5.6° C) for the following materials:

- PVC: 3/8 inches (9.5 mm)
- HDPE: 1 inch (25.4 mm)
- RTRC: 1/8 inches (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.

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.

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. Typically, slump is specified to be seven inches (177.8 mm) to nine inches (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 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.
Backfilling

The trench can be backfilled after the concrete has set. The first 12 inches (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 inches (304.8 mm) of backfill cannot be placed and tamped immediately following the concrete work, one inch (25.4 mm) or two inches (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.

DIRECT BURIAL (DB) OF RIGID NONMETALLIC CONDUIT (RNC)

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 for good compaction of backfill. If spacing between raceways is less than 1-1/2 inches (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 six inches (152.4 mm) both horizontally and vertically.

Temperature

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

Bends or Grade Changes

When short-radius bends or abrupt grade changes are encountered, the thermoplastic raceways are often encased in concrete to protect against possible winch line cutting. Metal or RTRC elbows or bends can also be used with the thermoplastic raceways to protect against possible winch line cutting.

Raceway Embedment and Final Backfill

The embedment zone of a raceway trench is that portion of the trench from approximately four inches (101.6 mm) below the bottom of the first row of raceways to approximately six inches (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 satisfactory provided the mix is compactable and stable. Soils not recommended in the embedment zone are highly organic materials and highly plastic clays. Maximum particle 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 of a select nature similar to the material in the embedment zone.

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

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 six inches (152 mm) of soil. For larger mechanical compaction equipment, 30 inches (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 inches (152 mm) and 12 inches (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.

**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 Joints for PVC Rigid Nonmetallic Conduit and NEMA PRP-3 Expansion Fittings for RTRC Rigid Nonmetallic Conduit.

**FIELD BENDING**

The natural flexibility of most Rigid Nonmetallic Conduit (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 HDPE conduit.

**SHORT-RADIUS ELBOWS**

For the purpose of this guideline, a short-radius elbow is an elbow having a radius of five feet (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.

CONDUIT AND DUCT REPAIRS

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

PVC Raceway and RTRC

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

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 inch (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.
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.

PE

Methods of repaired PE 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.

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.

CONDUIT RODDING (Fishing)

One of the many advantages of rigid nonmetallic conduit (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.

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 possibilities as to the reason. First, the conduit may have deflected beyond what the mandrel allows. 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 (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 inches (50.8 mm) nominal diameter.

| Table 1 |
| SUGGESTED MANDREL ODS FOR VARIOUS CONDUITS AND DUCTS |

<table>
<thead>
<tr>
<th>Conduit Type</th>
<th>Conduit Size</th>
<th>Mandrel OD</th>
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<tbody>
<tr>
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<td>inches</td>
<td>mm</td>
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<td>53</td>
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<tr>
<td></td>
<td>3-1/2</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<tr>
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<td>3-1/2</td>
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<tr>
<td></td>
<td>4</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>129</td>
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<tr>
<td></td>
<td>6</td>
<td>155</td>
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<tr>
<td></td>
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<tr>
<td>NEMA TC 6 &amp; 8 Conduit</td>
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<td>53</td>
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<tr>
<td></td>
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<td>129</td>
</tr>
<tr>
<td></td>
<td>6</td>
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<tr>
<td>NEMA TC 14 AG/TC 14 BG IPS Conduit Dimensions</td>
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<td>78</td>
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<tr>
<td>NEMA TC 14 AG/TC 14 BG ID Conduit Dimensions</td>
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<tr>
<td></td>
<td>6</td>
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</tr>
</tbody>
</table>
Appendix A
Field Bending Procedures for PVC Conduit

These procedures are applicable to radius bends from approximately 35 feet (10.7 m) to 150 feet (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-inch (103-mm) Type EB duct with a duct stiffness (F/Δy) 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.

JOINING

The joining procedure detailed in the section “Joining of Conduits” should be followed.
Figure A-2 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 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 feet (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 feet (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.

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 three inches (76.2 mm) should be maintained.

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 inch (25.4 mm) minimum bearing surface on the conduits and have an effective thickness of 1 inch (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:
1. 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.

2. 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.

3. 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.

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 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.

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 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 ¼” (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, 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 conduits high) are placed against the inside trench wall at positions 3, 4, 5, 6, and 7.

3. 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.

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 on the same fashion, and spacers 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 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.
Appendix B
Conduit-In-Casing Construction

Invention

I've done it, I've done it!
Guess what I've done!
Invented a light that plugs into the sun.
The sun is bright enough,
The bulb is strong enough,
But, oh, there's only one thing wrong…

The cord ain't long enough.

The poem, “Invention”\(^1\) illustrates the never-ending quest of the power and communication industries to “get the cord long enough.” Conduit-in-casing construction is one method that helps make the cord long enough to get from the communication or power source to the consumer. If you can’t go over it and can’t go around it and, therefore, need to go under it, conduit-in-casing is often the construction method of choice.

WHAT IS CONDUIT-IN-CASING CONSTRUCTION?

The conduit-in-casing construction procedure is a solution to the problem of laying power/communication cables under a surface obstruction (highway, runway, rail bed, river, etc.) without disrupting traffic roadbed, rail bed or riverbed. The basic procedure is to:

1. Excavate and shore pits on both sides of the surface obstruction;
2. Bore under the surface obstruction connecting the excavated pits 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 communication cables through the conduits.

The steel casing is usually pushed into place with hydraulic jacks while the earth ahead of the casing is removed with special boring machines or by hand.

WHY USE CONDUIT-IN-CASING CONSTRUCTION?

**Organization:** Conduit-in-Casing construction keeps the conduits organized within the steel casing. The advantage of this method is the precise placement of the casing within the earth. Such precision helps avoid existing underground pipes, cables and obstructions. The organization also keeps to a minimum underground clutter that may hinder future construction projects. The casing is easily located and avoided by those doing future underground work.

**Protection:** Conduit-in-casing is the obvious choice when maximum cable protection is a priority. The casing protects mission critical cables, such as airport cables, from being severed by a natural disaster or construction accident.

**Longevity:** Conduit-in-casing construction provides the ultimate in longevity. Further, it is normally possible to replace cables by simply pulling out the old cables and pulling in new ones.

CASING TYPES AND SIZES

The most common methods used for conduit-in-casing installations utilize steel casings. Typical steel casing sizes are shown in Table B-1. Steel casings above 12 inch (304,8 mm) in diameter should always be specified by both OD and wall thickness. Unless there is a specific reason to the contrary, casings between 14 inch (355,6 mm) and 48 inch (1219,2 mm) should have one of the OD’s shown in Table B-1. The selection of casing OD’s that do not conform to this table may require specialized boring equipment, causing higher installation costs. Casing wall thicknesses that do not conform to Table B-1 are often used and normally do not pose any installation problems.
Table B-1
COMMON STEEL CASINGS USED FOR CONDUIT-IN-CASING INSTALLATIONS

<table>
<thead>
<tr>
<th>Casing OD</th>
<th>Casing Wall Thickness</th>
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<tr>
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<td>Nominal</td>
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<tr>
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<tr>
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<tr>
<td>48</td>
<td>1219.20</td>
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</tbody>
</table>

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

CONDUIT NORMALLY USED

Normally the conduits used within the steel casing are EPC-40 (Schedule 40) PVC per NEMA TC 2, EPC-80 (Schedule 80) PVC per NEMA TC 2, DB120 PVC conduit per NEMA TC 6&8, RTRC conduit per NEMA TC 14.BG, and/or HDPE conduit per NEMA TC 7. These are all fairly heavy wall conduits that hold up to the hydraulic pressure and temperature 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.

WHAT SUPPORTS THE CONDUITS?

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. Provisions to 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.

It is a common practice to place the bore spacers five feet apart and secure the conduits to the bore spacers with steel bands or split stop rings, see Figures B-1 through B-7.

The most common separation between conduit-in-casing conduits is shown in Table B-2:
### Table B-2
COMMON CONDUIT SEPARATION REQUIREMENTS

<table>
<thead>
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<th>Duct Bank Application</th>
<th>Common Separations</th>
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</tr>
<tr>
<td>Fiber Optics</td>
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### TYPICAL BORE SPACER EXAMPLES

Some typical conduit-in-casing configurations are shown in Figures B-1 through B-7 below:

**Figure B-1**
HYBRID TYPE BORE SPACER
(2 Ea. 6" Conduits, 2.000" Separation between Conduits, 20.000" OD x .375" Wall Steel Casing)

**Figure B-2**
SPIDER TYPE BORE SPACER
(6 Ea. 6" Conduits, .750" Separation between Conduits, 24.000" OD x .375" Wall Steel Casing)

**Figure B-3**
DOUBLE WALL, FULL COMPLEMENT BORE SPACER
(8 Ea. 6" & 1 Ea. 4" Conduits, 4.930" Separation between 4" & 6" Conduits, 4.000" Separation between 6" Conduits, 47.700" OD x 1.690" Wall Centrifugal Cast Fiberglass Casing)

**Figure B-4**
DOUBLE WALL, HYBRID TYPE BORE SPACER FOR DIRECTIONAL BORE
(4 Ea. 6" & 2 Ea. 4" Conduits, 2.000" Separation between 4" & 6" Conduits, 5.424" Separation between 6" Conduits, 38.300" OD x 1.824" Wall DR21 [DIPS] HDPE Casing)
Figure B-5
DOUBLE WALL, SPIDER TYPE BORE SPACER
FOR DIRECTIONAL BORE
(4 Ea. 6" & 2 Ea. 4" Conduits,
1.020" Separation between 6" Conduits,
Casingless Installation [20.615" OD Duct Bundle])

Figure B-6
DOUBLE WALL, FULL COMPLEMENT BORE SPACER
(30 Ea. 4" Conduits,
2.000" Separation between Conduits,
48.000" OD x .688" Wall Steel Casing)

Figure B-7
DOUBLE WALL, FULL COMPLEMENT BORE SPACER
(16 Ea. 8" Conduits,
3.500" Conduit Separation,
73.500" OD x 7.750" Wall Concrete Casing)
GROUT AND REASONS TO GROUT

The space between the OD of the conduits and the casing ID is normally grouted for the following reasons (shown in no order of importance):

1. To eliminate the possibility of a duct bank collapse due to the force put on the duct bank when power and/or communications cables are being pulled into place.

2. To eliminate the possibility of duct bank collapse due to the weight of the power and/or communications cables.

3. To eliminate the possibility of duct bank rotation due to power and/or communications cable weight causing an out of balance rotational torque.

4. To reduce the possibility of a duct bank meltdown when there is a power cable fault. The grout tends to contain the fault to a single duct.

5. To transfer the heat generated by the power cables to the surrounding ground.

It is important to select a proper grout recipe for the injection process. Not all installations are identical. Therefore, a cement grout vendor or specialist should be consulted for the proper grout mix and injection method for an installation. An ideal grout fills the casing void completely, while maintaining a pumping pressure low enough not to crush the conduits and a curing temperature low enough not to deform or collapse the conduits.

“NO GROUT” AND “BLOWN SAND” APPLICATIONS

There are applications where it is advantageous not to fill the area between the conduit and casing with grout. 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 conduits and cables.

On rare occasions dry sand is blown into the area between the conduit and the casing. Since sand does not dissipate the heat generated by power cables as quickly as cement grout, it may be necessary to de-rate the power cables. If kiln dried sand is used, the installer needs to ensure that the sand is cool; hot sand can cause the conduit to deform or collapse.
TYPICAL BORE SPACER CROSS-SECTIONS

Figure B-8
DUCT BANK BEING INSTALLED IN A STEEL CASING WITH A PULL PLATE AND WINCH LINE

Figure B-9
CROSS-SECTION OF A TYPICAL CONDUIT-IN-CASING INSTALLATION
GROUT INJECTION TECHNIQUES

There are a number of different grout injection techniques and variations. Figures B-10 through B-12 show a few of these techniques.

**Figure B-10**
SINGLE END GROUT INJECTION WITH BULK HEADS

**BASIC PROCEDURE:**
INJECT GROUT INTO GROUT INJECTION INLET UNTIL GROUT FLOWS OUT OF THE VENT PIPE

**Figure B-11**
SINGLE END EXTRACTABLE GROUT INJECTION PIPE TECHNIQUE

**BASIC PROCEDURE:**
1. WITHDRAW GROUT INJECTION PIPE AS CASING IS FILLED.
2. KEEP THE DISCHARGE END OF THE GROUT INJECTION PIPE EMBEDDED IN THE GROUT SLURRY AT ALL TIMES.
3. KEEP THE ENDS OF THE CONDUITS OPEN DURING FILLING OF CASING AND CURING OF GROUT FOR FREE FLOW OF AIR.
OTHER METHODS AND PRACTICES

The foregoing is a general overview of the common conduit-in-casing practice that utilizes a straight steel casing and nonmetallic conduits. Other methods of installing power and communication duct banks under surface obstructions that are beyond the scope of this bulletin include, but are not limited to, the following:

- HDPE casing containing a nonmetallic duct bank that is pulled into a directionally drilled hole.

- Casingless duct bank that utilizes nonmetallic conduits, bore spacers and bands that is pulled into a directionally drilled hole.

- Reinforced thermosetting resin fiberglass casing containing nonmetallic conduits that is placed in a dredged trench and backfilled with marine grade concrete.

- Casingless duct bank that utilizes bore spacers and bands that is pulled into a dredged trench and is then backfilled with marine grade concrete.

- Concrete pipe casing and nonmetallic conduit.

- Centrifugally Cast Fiberglass Reinforced Polymer Mortar (CCFRPM) pipe and nonmetallic conduit.
Appendix C
Solvent-Cementing Joints for PVC Rigid Nonmetallic Conduit, Duct, and Fittings

Most forms of PVC conduit, duct, and fittings are meant to be assembled or joined by means of solvent-cementing of the integral bells or PVC couplings. Solvent cements contain chemicals which dissolve the surface of the PVC, softening it. As the chemicals evaporate, they leave a PVC resin behind which fuses the mating surfaces.

TO PRIME OR NOT TO PRIME

Primers are a form of chemical cleaner that may be used to remove surface impurities, soften, and dissolve the joining surfaces in order to better prepare them for solvent-cementing.

The National Electrical Code (NEC®) does not require PVC primer to be used in the joining of PVC conduit. However, under certain conditions, primer can aid in the ease of assembly and enhance the quality of the joints. Primer should always be considered for use in extreme cold weather and whenever the conduit spigot exterior or bell interior have foreign material on them that is not easily removed by wiping with a clean, dry cloth.

When using PVC primer wear proper clothing, gloves and eye protection. Never use PVC primer in the presence of sparks or flames. Avoid breathing of fumes and provide proper ventilation at all times.


SELECTION OF SOLVENT CEMENT

Solvent cements intended for use with PVC conduit and duct should meet all the applicable requirements of ASTM D 2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems. Since they are available in a wide range of viscosities and wet film thicknesses, the nature of the particular project needs to be considered when trying to decide between regular, medium, or heavy-bonded cement.

Environmental conditions (temperature and humidity), type of joining fit (interference or clearance fit between the bell and spigot) and Trade Size of conduit need to be taken into consideration when selecting the type of solvent cement.

CUTTING CONDUIT OR DUCT

Cut conduit or duct square with its longitudinal axis using a saw or other suitable tool as shown in Figure C-1. Ensure that all burrs or ridges are removed from the conduit of duct end as a result of cutting. A knife, file, pipe reamer or abrasive paper can be used to remove burrs and apply a slight chamfer to the cut end. Failure to remove ridges or burrs could result in the cement being scraped from the socket surface and cause the joint to fail. Ridges or burrs could also damage the conductors or cables being installed.
CLEANING

Ensure that surfaces to be joined are free from dirt, moisture, oil and other foreign material. Wipe surfaces with a clean dry cloth. If the surfaces require further cleaning, a chemical or mechanical cleaner needs to be used. Mechanical cleaners include fine abrasive paper or cloth (180 grit or finer) or clean, oil-free steel wool. Chemical cleaners include those recommended by the conduit, duct, fittings, or cement manufacturer or a primer meant for use with PVC.

APPLICATION PROCEDURE

1. Test dry fit of the joint to ensure that the conduit or duct and fitting can be joined. Interference fits do not bottom out when dry fitted with the coupling (1/2 to 2/3 insertion is normal for interference fit joints). After solvent cement is applied the spigot of an interference fit bottoms out in the coupling.

2. If using primer, apply it to the inside socket surface. Use a scrubbing motion to ensure penetration. Then apply primer to the male end to the depth of the fitting socket. Finally, apply primer again to the inside socket surface. Do not allow the primer to "puddle" inside the bell of the conduit or duct.

3. Without delay, apply cement lightly but uniformly to the inside socket surface. Take care to keep excess cement out of the socket or bell-to-pipe transition area. Apply cement to the outer surface of the male end.

4. Immediately after applying the cement to the conduit or duct, while both the joining surfaces are soft and wet with solvent cement, forcefully bottom the male end of the pipe in the socket turning 1/4 turn. This distributes the cement evenly.

5. After assembly, wipe excess cement from the conduit or duct at the end of the fitting socket. A properly made joint normally shows a bead around its entire circumference.

6. Until the cement is set in the joint, the conduit or duct may back out of the fitting socket if not held in place for approximately 1 to 2 minutes after assembly. Care should be taken during assembly not to disturb or apply any force to joints previously made.

ASSEMBLY PRECAUTIONS

PVC solvent cement is fast drying and needs to be applied as quickly as possible. Assembly should be made within 20 seconds after the last application of cement. If there is any sign of drying of the cemented surfaces, they should be recoated. Hold the assembly in place for approximately 1 minute to prevent the conduit or duct from backing out of the fitting socket. Care should be taken not to disturb or apply any force to newly assembled joints.
The integrity of joints can be compromised by early handling. Recommended set time is related to temperature as follows:

- 30 minutes minimum at 60° to 100°F
- 1 hour minimum at 40° to 60°F
- 2 hours minimum at 20° to 40°F
- 4 hours minimum at 0° to 20°F

**ATMOSPHERIC CONSIDERATIONS**

Under conditions of high humidity, quick application of solvent cement is important to minimize condensation of moisture from the air on the cement surface. Temperatures of the mating surfaces should not exceed 110°F at the time of assembly. The temperature may be reduced by swabbing the surface to be cemented with a wet rag provided the conduit or duct is thoroughly dry before cement is applied.

At temperatures below freezing, solvent cements penetrate and soften PVC slower than in warmer weather. As solvent cements and primers are highly flammable, do not use open flame or electric heaters to warm them. Care should be taken to remove moisture such as ice and snow from pipe and fitting surfaces before applying cements and primers. In cold weather, use primers to soften joining surfaces before applying cement.

Appendix D
Joining of RTRC

GENERAL RECOMMENDED JOINING PROCEDURES

Cutting the Conduit

Cutting is 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 even a hacksaw (32 teeth/inch blade).

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.

SPECIFIC JOINING TYPES AND PROCEDURES

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.

RTRC Gasket Joints

There are a variety of gasketed joints available that utilize elastomeric seals to provide mechanically strong watertight connections (see Figure D-1 for an example). Because of the variety of gasketed joint designs available, refer to manufacturer for specific assembly instructions.
RTRC Inside Tapered Bell and Spigot Joint Installation (with or without Adhesive)

With a mechanical joining system featuring tapered bell and spigot ends, installation is fast and easy. See Figures D-2 and D-3.

As a user option, this system can be made into 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.

RTRC Adhesive Straight Bell and Spigot Joint Installation

See Figure D-4. After the conduit is cut to the desired length, remove the resin gloss four 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. 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.

**JOINT CLEANING AND ADHESIVE INSTRUCTIONS**

The bonding surface is to be factory fresh in appearance.

**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.

**A) Adhesive Mixing**

See Figure D-5. 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 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.

4. Mix until the adhesive has a consistent texture and/or color.
B) Adhesive with Dual Cartridge

1. Install the adhesive dual cartridge in the applicator and then insert the static mixer fully.

2. Squeeze the handle until adhesive comes out. Deposit adhesive on cardboard see Figure D-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.

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 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.

**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.

**RTRC COUPLING JOINTS**

For field repairs, attachment of adapters or other fittings that are situated such that a factory length of conduit needs to be cut; the use of a coupling is recommended. These couplings are available in different styles, such as a double bell coupling with or without gaskets. Consult the examples in Figures D-7 and D-8.

The socket depth of the coupling shall be consistent with the socket depth of the integral conduit belled end.

For additional information on specific coupling types, or for assistance in selecting the appropriate coupling for your application, please consult the conduit manufacturer.
Appendix E
Joining Procedures for HDPE Raceway

INTRODUCTION

PE conduit can be joined by a variety of thermal and mechanical methods. Since PE conduit does not experience any long-term internal pressure and acts only as a pathway for power or other cables, the owner of the system may be tempted to neglect the importance of specifying effective couplings. However, an integral part of any PE conduit system is the type and quality of joining method used. Proper engineering design of a system will consider the type and effectiveness of these joining techniques.

The owner of the PE conduit system should be aware that there are joint performance considerations that affect the system's reliability well beyond initial installation. Some of those might include the following.

**Pull out resistance** both at installation and over time due to thermal contraction/expansion, must be considered. This is critical for "blow-in" cable installations, which will exert an outward force at joints, less so for pulling installations, which will tend to exert the opposite force.

**Pressure leak rates** for "blow-in" installations at pressures of 125 to 150 psig. Consideration must be given to how much leakage can be tolerated without reducing the distance the cable can consistently be moved through the PE conduit.

**Infiltration leakage** allowing water and/or silt to enter the PE conduit over time, can create obstacles for cable installation and repair or cause water freeze compression of fiber optic cables.

**Corrosion resistance** is important as PE conduit systems are often buried in soils exposed to and containing alkali, fertilizers, and ice-thawing chemicals, insecticides, herbicides and acids.

**Cold temperature brittleness resistance** is required to avoid problems with installation and long-term performance in colder climates.

GENERAL PROVISIONS

PE-to-PE joints may be made using heat fusion, electrofusion or mechanical fittings. However, mechanical couplings are often preferred over fusion joints, due to the internal bead of a butt fusion joint, which can interfere with cable installation. PE conduit may be joined to other materials in junction boxes or other hardware utilized by communication and electrical industries, by using mechanical fittings, flanges, or other types of qualified transition fittings. The user may choose from many available types and styles of joining methods, each with its own particular advantages and limitations for any joining situation encountered. Contact with the various manufacturers is advisable for guidance in proper applications and styles available for joining as described in this section.

MECHANICAL FITTINGS

PE conduit can be joined by a variety of available styles of mechanical fittings, each with its own particular advantages and limitations in any given application. This section will not address these advantages or limitations but will only offer general descriptions of many of these fitting types and how they might be utilized. ASTM F 2176 “Standard Specification for Mechanical Couplings Used on Polyethylene Conduit, Duct and Innerduct,” establishes performance requirements for material, workmanship, and testing of 2-inch and smaller mechanical fittings for PE conduit. PPI recommends that the user be well informed about the manufacturer’s recommended joining procedure, as well as any performance limitations, for the particular mechanical connector being used.
BARBED MECHANICAL FITTINGS

Barbed fittings are available in various materials and configurations for joining PE conduit sizes 2 inch and smaller. None of these fittings are offered with sealing capabilities. Installation involves pressing the fitting over ends of the PE conduit to be joined using a special tool. The inside of these fittings contain sharp, inward-facing barbs which allow the PE conduit to be pressed in, yet dig into the PE conduit and resist removal when pulled.

THREADED MECHANICAL FITTINGS

Threaded mechanical fittings are available in various materials and configurations for PE conduit sizes 2 inches and smaller. Some are designed with sealing capabilities while others are not. Internal thread designs of these fittings are typically tapered similar to pipe threads, with a left-hand thread on one end and a right-hand thread on the other to cut thread paths on the PE conduit’s outer surface. This thread design allows the operator to thread the fitting onto the ends of both PE conduit sections simultaneously. Some variations of threaded fittings may also be pressed on the PE conduit ends and used as barbed fittings. The user should consult the fitting manufacturer to determine if this alternate installation method is recommended.

COMPRESSION FITTINGS

As with the other mechanical fittings, compression fittings are also available in numerous designs—some designs for PE conduit as large as 8 inch and others for only 2 inch and below. While compression fittings used in PE pressure piping industries, such as water or gas, require internal stiffeners, PE conduit systems typically do not, because stiffeners may create obstacles for cable being blown through the PE conduit. For any fitting style being considered, consult the fitting manufacturer for available sizes and written instructions for use.

EXPANSION JOINTS

Expansion joints are designed primarily for aerial PE conduit installations. The primary purpose of this fitting design is to absorb thermal expansion and contraction in the PE conduit system created by ambient temperature changes, which can be extreme in these above ground installations. System designers should determine the number of expansion joints required based on the expansion length provided by the fitting and a calculation of the pipe’s overall thermal expansion factor for the overall length of above ground installation.

HEAT FUSION

The principle of heat fusion is to heat two surfaces to a designated temperature and fuse them together by application of a force sufficient to cause the materials to flow together and mix. When fused in accordance with the manufacturer’s recommended procedure and allowed to cool to nearly ambient temperatures, the joint becomes as strong or stronger than the PE conduit itself in both tensile and pressure properties. Three primary heat fusion methods used in joining PE conduit are butt, socket and electrofusion. Butt and socket fusion joints are made using “hot irons” designed specifically for PE joining, and electrofusion supplies heat internally by electric current applied to a special fitting containing a wire coil. More specific information on heat fusion joining practices can be found in the chapter on “Joining” in
this Handbook, as well as in ASTM F 2620 for the hot iron methods (butt and socket fusion) and in
ASTM F 1290 for electrofusion. PPI recommends that the user precisely follow the qualified fusion
procedures established by the manufacturer of the particular heat fusion and joining equipment being
used.

**BUTT FUSION JOINING**

Butt fusion joints are produced without need of special fittings, using specially developed butt fusion
machines, that secure, face and precisely align the PE conduit for the flat face hot iron (not shown) fusion
process. It should be noted that the butt fusion process produces an internal bead of equal or larger size
than the visible outer bead. If internal restrictions are a concern for the cable installation, alternative
joining methods may be more appropriate.

**SOCKET FUSION JOINING**

This technique requires the use of specially designed hot irons to simultaneously heat both the external
surface of the pipe and the internal surface of the socket coupling. Specially designed hand tools are
available to maintain alignment and stab depth of the hot irons until the materials reach fusion
temperature. These tools also help secure the heated PE conduit end and coupling as the joint is made.
Design requirements for socket fusion can be found in ASTM D 2683 for fittings and in ASTM F 1056 for
socket fusion tools. As with butt fusion, socket-fused joints may have an internal bead that can interfere
with cable placement.

**ELECTROFUSION JOINING**

Electrofusion is somewhat different from the hot iron fusion method described previously, the main
difference being the method by which heat is applied. Electrofusion involves the use of a special
electrofusion fitting with an embedded wire coil. Electrical current supplied to the wire coil by an
electrofusion control box generates the heat for fusion. Special training in equipment use and
maintenance may be needed. For additional information consult the chapter on “Joining” in this
Handbook.

**REPAIR OPERATIONS**

Repair joints, as the name implies, are often designed specifically for use in repair situations. The nature
of the damage will often dictate what types of joints are needed for repairs. For example, one type of
design, a clamp-on style may be preferred when damage is limited and removal of the cable for repair is
not necessary. However, in more severe damage situations, where new cable and PE conduit sections
must be installed, many of the joining methods described earlier in this section may be suitable.
Ultimately, the type of repair fitting or joint installed should maintain the integrity of the PE conduit system,
prevent infiltration and provide sufficient resistance to thermal expansion/contraction.